

POLITECNICO DI TORINO

Master's Degree
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Smart buildings for people with disabilities



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1 ABSTRACT

The purpose of this thesis is to demonstrate how it is possible and feasible to start a home automation project within social structures and how to evaluate its impact through computer vision algorithms and artificial intelligence. In particular: search for funding which covers part of the structural expenses and which largely covers the necessary research; researches the suppliers and professionals necessary for the design, supply, installation, and maintenance of the necessary equipment; selection and implementation of a communication system between the home automation protocol and the computer vision algorithms; development of computer vision and artificial intelligence algorithms; home automation design and device programming.

2 INTRODUCTION

The care interface project arises from the need of the Minerva cooperative [1] to automate its services and at the same time measure their efficiency. In fact, the social cooperatives due to the pandemic are going through a period of change made by digitalization and remote assistance [2]. The objective set by the main administrative bodies is to provide a private tele-assistance service that can reduce costs and be provided on a larger scale. To these needs are added those deriving from the green economy, and the Minerva cooperative wants to be a promoter of this change by designing the new building in a LEED [3] perspective. In practice, the cooperative has purchased a nineteenth-century building and intends to renovate¹ it, respecting its historical value, to welcome and provide assistance to people with disabilities. In order to give greater autonomy and comfort to these people, the cooperative launched the Care-Interface project with the aim of combining home automation and artificial intelligence for flexible automation capable of adapting to the needs of patients and staff.

The project has an expected duration of 2 years and involves a plurality of professional figures, in this time there will be the installation, testing and reprogramming of the technological apparatus based on the needs encountered. The work described in this thesis therefore concerns the preliminary stages: the search for funding and the necessary professional figures; the development of the technology to be programmed in the last phase together with the neural network for emotion recognition which will not be the only neural network to be used but will be an example for the others; the design and programming of the home automation system that includes the basic functions required by the cooperative and necessary to access funding. Figure 1 shows the latest architectural project which is also thought to be the last.

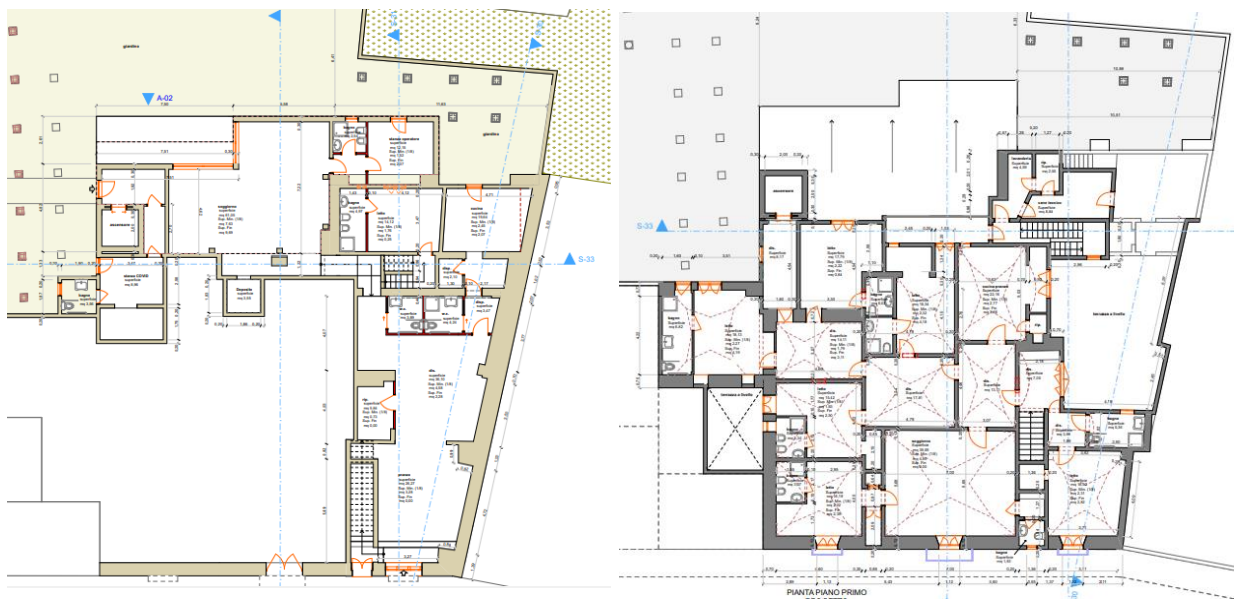


Figure 1 First floor on the right and ground floor on the left of the future structure.

¹ ATTACHED: DWG structure CAD project before and after design

Automation factors useful for acquiring points for LEED certification

ACRONIMS	DESCRIPTION
DLNN	Deep Learning Neural Network
TP	Twisted Pair
ETS	Engineering Tool Software
FEA	Facial Expression Analysis
EDA	Electrodermal activity
EEG	Electroencephalography
ECG	Electrocardiography
EMG	Electromyography
GUUE	Official Journal of the European Union
LFA	Logical Framework Approach
DALI	Digital Addressable Lighting Interface
LEED	Leadership in Energy and Environmental Design
BAC S	Building & Automation Control System
BAOS	Bus Access and Object Server
RF	Radio Frequency
IP	Internet Protocol
ARM	ARM Advanced RISC Machine
CRAP	Comunità Riabilitativa Assistenziale Psichiatrica
VOC	Volatile organic compounds

3 OBJECTIVES OF THE PROJECT

The home automation system has in input the measurement of the various sensors, the command from the different interfaces and the audio and video acquisition of the devices in the building. As output act on the thermal system, on the fixtures, on the lighting and through the audio and video devices. The actuators and sensors present together with the interfaces, power devices and couplings and together with the means of information transport constitute the home automation system KNX [4] based on the standard OSI [5].

All the devices present in the system are KNX [4] certified or are interfaced through the relative gateway or through a BI component [6]. Among these there is a Raspberry equipped with a camera and a touchscreen display connected to the system via KNX TP [7]. This component, in addition to providing a graphical interface, supervises the system, acquires images and processes data through DLNN (Deep Learning Neural Network), and also sends relevant data for supervision or for Machine Learning processes.

The ability to quickly configure each component is the main feature of this system which, together with the acquisition of data, their easy visualization and intelligent processing of them, is able to evolve and adapt over time. Specifically, the algorithm will detect the discomfort caused by the user through an emotion recognition algorithm and will performs two actions:

- Performs a local and specific regulating action for the subject recommended by a specialist (psychologist or psychiatrist). In FIGURE 2 the operation of the system is described through a block diagram, the entire cycle has a duration of the order of tens of seconds in order to keep the bus charge low.
- It communicates the acquired data and the status of the system to a central unit that analyzes them and allows them to be viewed by specialized personnel: pedagogists, psychologists and psychiatrists. This ability is essential because in addition to giving access to specific European funds, it allows you to fully exploit the difference between KNX [4] and other home automation systems on the market. In fact, once installed, the system will retain part of the flexibility possessed in the design phase [8]. Reprogramming old devices or installing new ones will not lead to high costs and will only require the intervention of a system specialist. This makes it possible to create a larger loop lasting months which will lead to a specific and dynamic development of the service and to the acquisition of skills and methods which in the future will make it possible to provide the service also in remote assistance Figure 3.

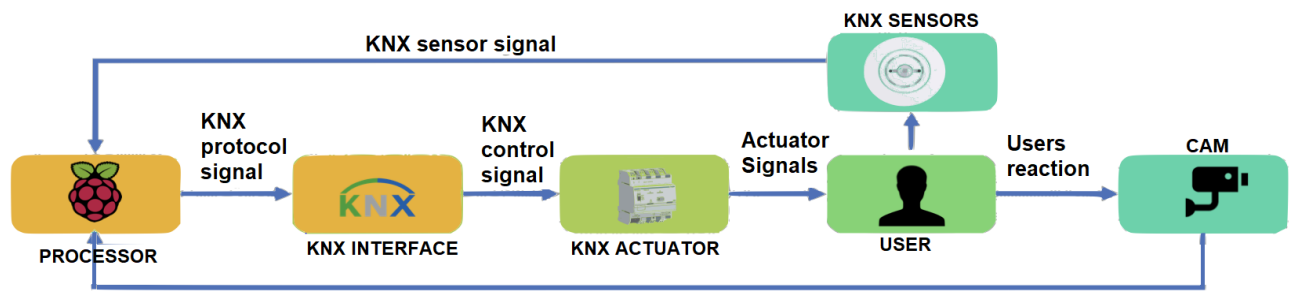


Figure 2 Quick system control algorithm that takes into account the intelligent analysis of the subject.

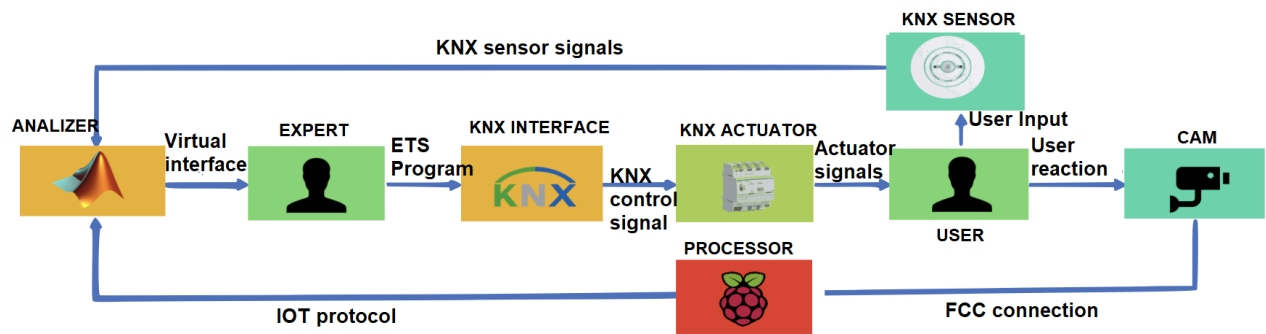


Figure 3Block diagram describing the growth of the system in these 2 years of research based on observation and analysis of automatically acquired data.

4 STATE OF THE ART

4.1 STANDARD KNX

To ensure maximum flexibility and compatibility and given the generality of the application, it is necessary to choose a reliable means of automation compatible with air conditioning and safety systems. For this purpose, the KNX [4] standard was chosen. Compared to proprietary systems, KNX provides greater flexibility and various guarantees: firstly, reduction of maintenance costs due to the fact that a proprietary system permanently binds the user to the supplier; a distributed architecture thanks to which the failure of a device does not imply the failure of the system; reduction of purchase costs given the size of the market of suppliers who adhere to the standard; quality guarantee provided by the association; wide compatibility with other communication protocols and systems. The KNX standard [4] distributes the application to multiple devices scattered throughout the home and communicating on different media, Figure 4. This allows for greater robustness and flexibility to the system as the failure of one device does not affect the operation of the others. Furthermore, if it is necessary to add extensions, simply add the new devices and program the interaction with those already present in the system [8]. In addition, the KNX protocol allows communication via TP [7], IP [9] and RF [10], which makes it possible to install the system in any situation. The devices certified by the system [11] have basic characteristics such as safety and reliability and have an ETS application [12] through which the software allows the serial programming of the device. The application [13] has the following characteristics: there is a list of parameters [12] through which it is possible to modify and adapt the functions of the device; it is possible to modify the communication flags [14], i.e. a device can transmit T, receive W, reply R and update the status of the datapoint U; finally, it is possible to add communication groups [15] to each of the Datapoints [16]. Each Datapoint is able to recite from the associated groups but is able to transmit only through the first. Datapoints have a specific and standardized type with a number of bits and a way of interpreting the representation and unit of measurement.



Figure 4 knx functions

4.2 EMOTION RECOGNITION

Emotional recognition is a complex mechanism and has several applications especially in the academic, advertising and commercial fields. The state of the art in this field is provided by Imotions [17]. A facial analysis through an image is not enough to obtain a safe classification of the emotion felt by the subject Figure 5, for this reason Imotions provides several packages with which the user can improve the fusion of data. Imotions deals with integrating data from different devices and processed by different algorithms on the market in a single database and provides the tools for analyzing this data. The packages provided by Imotions perfectly summarize the tools necessary for an excellent emotion recognition:

- Eye tracking: allows you to identify the object of the subject's attention and is based on three different technologies: Screen-based eye tracking, Eye tracking with Glasses, Eye tracking with VR.
- FEA - Facial Expression Analysis: this is a facial analysis using a neural network that differs according to the structure of the network and the type of incoming data: images of faces, images of subjects, images of environments with subjects and videos.
- EDA - Electrodermal activity (GSR): it is a recent technology based on the fact that according to the sensations experienced, the skin becomes moist, dilate or shrinks.
- EEG - Electroencephalography
- ECG - Electrocardiography
- EMG – Electromyography

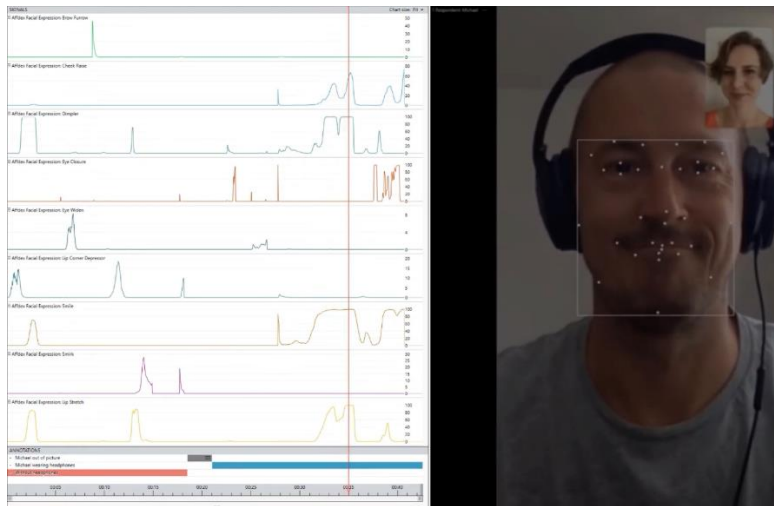


Figure 5 Standard demonstration of Imotion

By combining these different data, detailed and precise models can be obtained. Unfortunately, the purpose of Imotion is to study the subject individually and therefore does not have the possibility to monitor several subjects at the same time. So, the design choice is: to stay in contact with Imotion for a subsequent remote assistance project and in the meantime to design a more superficial and perhaps more suitable emotional recognition for the case.

4.3 LEED

The decision to allow further LEED [3] development for the project is a decision taken later due to the energy crisis still present. The energy advantages obtained through the eco-bonus are not sufficient to guarantee the autonomy of the building from the grid. To allowing it to achieve future goal of zero emissions it's necessary to integrate the KNX [4] system with a smart metering system and automate the storage and production system [18]. In anticipation of future funding for LEED [3] buildings, which are an increasingly concrete possibility, the project must allow for future extensions and adaptations. Come, you can see from table 1 the home automation itself allows you to increase the points necessary to access the LEED class.

Table 1 Automation factors useful for acquiring points for LEED certification. [18]

Sustainable Sites		
SSc4.3	Alternative transportation – low-emitting and fuel-efficient vehicles	3
SSc8	Light Pollution Reduction	1
Water Efficiency		
WEc1	Water efficient landscaping	4
WEc2	Innovative wastewater technologies	2
Energy and Atmosphere		
EAc1	Optimize energy performance	19
EAc2	On-site renewable energy	7
EAc4	Enhanced refrigerant Mgmt	2
EAc5	Measurement and verification	3
Material & Resources		
MRc1.2	Building reuse – maintain interior nonstructural elements	1
Indoor Environmental Quality		
EQc1	Outdoor air delivery monitoring	1
EQc2	Increased ventilation	1
EQc6.1	Controllability of systems – lighting	1
EQc6.2	Controllability of systems – thermal comfort	1
EQc7.1	Thermal comfort – design	1
EQc7.2	Thermal comfort – verification	1
EQc8.1	Daylight and views – daylight	1
Innovation		
IDc1	Innovation in design	5

4.4 UNEIEN 15232-1

The UNE-EN 15232 [19] standard aims to apply home automation in such a way as to reduce energy waste. According to the standard, a massive and intelligent use of home automation is able to reduce consumption by up to 40%, but for residential and starting from a C class, its near at 10%. The standard allows evaluating the impact of home automation on consumption through two methods: the detailed one and the one based on factors. The detailed one involves measuring consumption before the installation of home automation and subsequently through a simulation to predict the impact that home automation has on consumption. The factor method, on the other hand, allows you to calculate the reduction in consumption based on the home automation used and the functions present.

4.4.1 Assignment of the BAC efficiency class

To minimize consumption and maximize comfort, we have chosen to automate in class A, so the choice of devices or system specifications must meet the prerequisites of the "list of functions and assignment of BAC efficiency classes" [20].

It has been chosen to air-condition the rooms through heat pumps. Given that the eco-bonus applies to new plants, it is not possible to take into account the old one even if the combination of the tow systems leads to advantages in terms of energy savings. As for the home automation on the thermal fluid distribution and generation system, it is possible to reach the maximum class of BAC without using the KNX standard as the signals that allow an optimal and automatic regulation of the devices are contained in the thermic fluid: pressure, flow and temperature. What is possible to do is insert the "Self-learning" function in these devices. This function requires that the entire system be designed and needs temperature and pressure probes dispersed in the system that send data to a server which stores and processes this data by finding the ideal operating point.

Therefore, on this aspect, the design is limited to the choice of devices which will be made through a tender between suppliers limited by the characteristics present in the *Attachment 5*.

Finally, as reported in the standard, it is possible in some environments or under certain conditions not to take into account some functions if they do not lead to an energy improvement or are not practicable. For example: the regulation of light in environments where natural light does not enter or automatic windows where there is a small window as described in the paragraph relating functions and environments.

4.4.2 Calculation of energy consumption with the BAC factor method

The BAC factor method is based on the fact that it is possible to divide the total energy into common forms of energies sharing the same efficiency and multiply them by the factor between the desired class and the starting one. In this way it is possible to calculate the avoided expense and base the amortization of home automation on this.

Table 2 Table for calculating the energy expenditure following automation.

CALCOLO DEL CONSUMO DI ENERGIA PREVISTO SECONDO LA UNE-EN 15232					
Energy used	Energy demand	System leaks	Auxiliary energy	BAC factor	Reference BAC factor
Heating	= QH,nd	+ QH,ls		fBAC,H	fBAC,H,ref
		+	WH,aux	fBAC,el	fBAC,el,ref
Cooling down	= QC,nd	+ QC,ls		fBAC,C	fBAC,C,ref
		+	WC,aux	fBAC,el	fBAC,el,ref
Ventilation	=		WV,aux	fBAC,el	fBAC,el,ref
lighting	=		WL	fBAC,el	fBAC,el,ref
Domestic hot water	= QDHW,nd	QDHW,ls		fBAC,DH	
			W		fBAC,DHW,ref
	0 =			0,81	1
	0 =			0,92	1
	0 =			0,81	1
	0 =			0,92	1
	0 =			0,92	1
	0 =			0,92	1
	0 =			0,8	1

Table 3 Energy efficiency coefficients for residential buildings.

Efficiency class for BAC factor					
D	C	B	A	cost of electricity [W/h]	
1,09	1	0,88	0,81	Total energy [W]	0
1,08	1	0,93	0,92	Total savings	1
1,1	1	0,88	0,81	Payback time in years	#VALUE!
1,08	1	0,93	0,92		
1,08	1	0,93	0,92		
1,08	1	0,93	0,92		
1,11	1	0,9	0,8		

Total energy is calculated from the sum of all the energies of the first column from, the total saving is given by one minus the weighted average consumption of the ratios between coefficients of the desired class and the reference class, table 1

Depreciation is equal to the ratio between the expenditure incurred and the product between the cost of energy and the consumption saved.

5 FUNDING

Since the target of the project is a social cooperative, it is necessary to finance a part of the project through public funds. After a careful analysis of the possibilities offered by the territory, it was decided to focus on two strong points of the project through which it can be seen in a manner consistent with the means of financing proposed by the European Union Programming [21]: digitization and the energy and environmental impact Figure 6. To cover the costs and functions of the project as much as possible, it was divided into two parts: the first concerns the use of artificial intelligence and the construction of the distributed system of cameras and the second the design of the home automation system. To make the project more suitable for funding, it was necessary to expand the functionalities so that for the design it was necessary to contact professional figures who were in charge of filling in the missing parts. The funds chosen to draw on, respectively on the two parts described above, are: ERASMUS REDUCED SCALE PARTNERSHIPS (European) [22] and Superbonus and ecobonus [23] of the relaunch decree. It is important to define the times in which the project will take place based also on the timing provided by each loan. The necessity to attract external funds impose additional technical restrictions on the system.

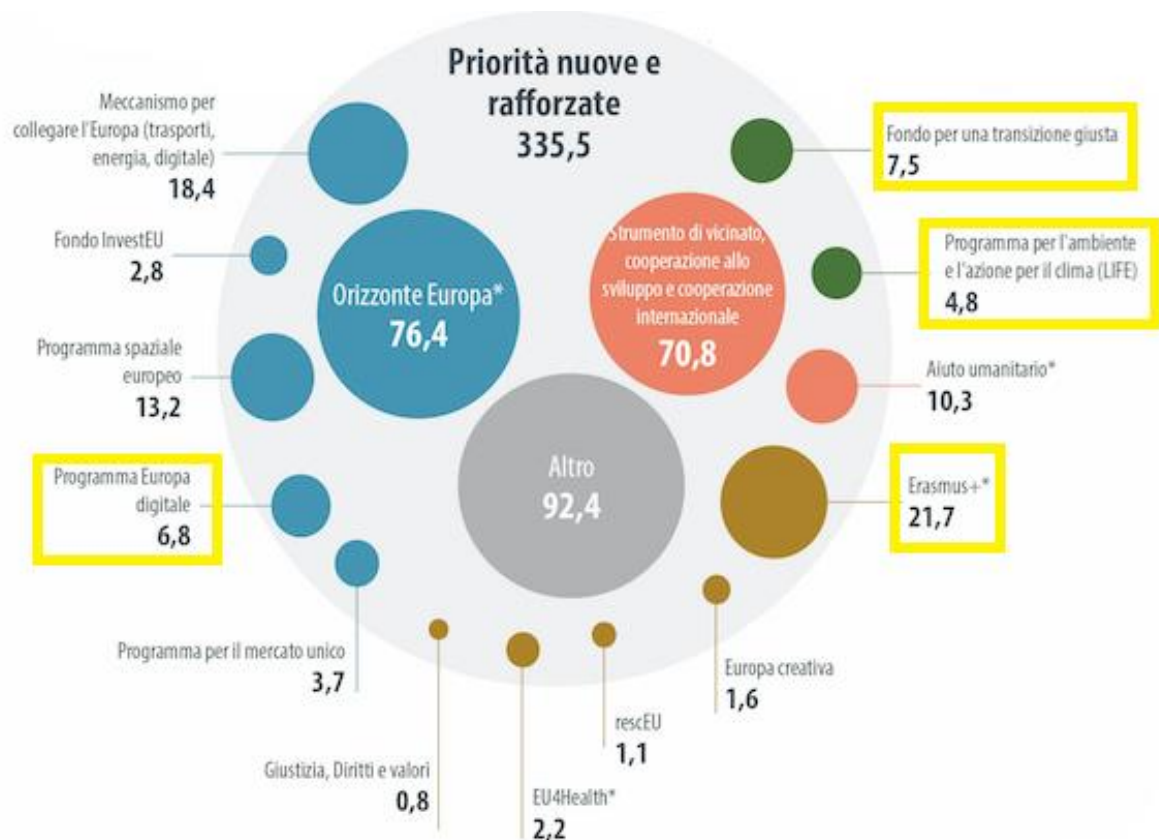


Figure 6 The new European programming has increased development funds in the categories of digitization, cohesion and ecological transition.

5.1 ERASMUS

The Erasmus project is a European project and as such must comply with the requirements of the Erasmus 2021 Call [23] and the directives published by the GUUE (Official Journal of the European Union) [21]. With reference at in the book Projecting in Europe [24], it was necessary to place the project in the economic and social dimension in which Europe is located, in particular the strengths of the project defined on the basis of the division of funding were taken. The project belongs to the financing category concerning digitization and automation [21]. It is necessary to consider that for projects funded by the union it is essential to allow the union to appear publicly as a partner [24], so the publicity of the results obtained will be necessary. Furthermore, it is necessary to follow an approach to programming through the LFA (Logical Framework Approach) [24] in order to ensure the achievement of the goals and the resulting social impact.

The project must comply with the directives expressed in the Erasmus + Program [23], so the funding concerns not only the patients of the facility but also the staff and must concern the training and tools necessary for it. With this in mind, the project takes the form of training in digitization and the recognition of emotions. So, the part of the project financed by the Erasmus call are:

- that of research concerning emotional recognition through the algorithm, in particular the specialization of the network through a transference learning from a generic emotional recognition network.
- the part concerning the training of personnel in managing the technology
- mounting the calibration of the cameras
- the analysis of the data collected and the modification of the home automation system based on the recognized needs for the specific type of disability present and for individual patients.

In particular, as described in the Erasmus Project Description [25], the project is divided into two parts, one for installation and monitoring and the other for data evaluation.

Furthermore, as required by the Erasmus call [23], it was necessary to answer the questions requested to assess the compliance of the project with the call, the resulting social impact and benefits regarding international cooperation.

Considering that for the Minerva cooperative [1] it is the first time that it participates in an Erasmus project and considering its size, it was decided to participate in the "small-scale art part" [26]. Unlike the other types of Erasmus, the latter is designed for companies that are moving towards European programming for the first time, although the maximum that can be financed is reduced compared to other projects (€ 60,000), it has the flexibility and the fact that the loans are provided non-repayable as its main advantages.

Erasmus projects require a minimum of 3 partners from different EU countries, however, as regards small-scale partnerships, only one partner in another country is sufficient. Therefore, based on the technological skills required in the project and given the experimental and research nature, the Polytechnic University of Madrid [27] was chosen as a partner and enthusiastically joined the project. The role of the polytechnic is fundamental during the second phase in which the technical skills of the polytechnic will provide support for data analysis and subsequent engineering by means of the results obtained.

The project was presented by a designer specialized in Erasmus Gianfranco Gatti who took care of the formal aspect and reduced its complexity in such a way as to be understandable even by non-

technical personnel as in the case of those who evaluate the projects. The project was presented on 25/10/21 through the dedicated platform through 4 documents: the abstract, the narrative part², and the documents of the responsibilities and commitments on the part of its parties (polytechnic and cooperative). The evaluation takes about 3-4 months and the duration of the project will be of 2 years.

5.2 ECOBONUS

To finance the necessary structural and plant interventions, it was necessary to draw on national funds through the "bonus edilizi" in particular given the cadastral structure of the property which is divided into 4 real estate units, two of which are totally independent, it is possible to obtain very advantageous ceilings for what it concerns the energy adaptation interventions envisaged by the eco-bonus and the super-bonus [23]. The loans provide for a reimbursement of up to 110% of the costs incurred for interventions on ceiling frames [28], photovoltaic panels, air conditioning systems, driving interventions and home automation. Given the complexity of the intervention, it was necessary to find a studio that dealt with the renovation, reducing the load on home automation. Home automation is part of financing as it allows an intelligent use of resources and allows consumers to be informed about costs and consumption through Smart metering and fixed or mobile display interfaces, making them aware of waste. Therefore, in addition to the components that allow the transmission and display of data that can't be financed, those components that relate to the heating system or the fixtures can be financed [29]. For example, the following are included: presence sensors because they allow you to turn on the air conditioning only if there is a person in the room; the shutter actuators as they allow isolation from the external environment; the opening sensors and the respective binary inputs as they allow you to block the heating in the event that the opening of a window is detected; valve actuators or relays connected to elements of the heating system as well as gateways that interface with air conditioners or boilers; The weather station, thermostats and thermal probes or humidity sensors as they allow efficient control of the thermal system. The following are excluded from financing although they also allow for a reduction in consumption: brightness, movement, and CO2 sensors, dimmers, buses, DALI components and interfaces, and relays that activate lights or windows. The requirements decree requires a home automation class A or B according to the UNE-EN 15232 [19] standard.

According to the annexes of the decree it is possible to finance 65% of the cost of home automation [30] considering the IVA up to a maximum of € 15,000 for each independent housing unit [31]. Of the housing units present only 2 are independent but according to the revision of the 2021 of the decree it seems that it may be possible for multi-family houses, in which category cooperatives fall, the partition into housing units by square footage. On the basis of this, reference must be made to the regional regulation for square footage but it is not precise regarding this, therefore we must wait for the regional provision that specifies it [32].

To access the eco-bonus, a qualified technician must certify [33] that the project follows the required specifications. Sworn statements must be issued based on the manner in which the bonus is received. If the bonus is fully acknowledged at the end of the work, the "Final Status [34]" form is used. Otherwise, you have to send the "work progress [35]" form during construction. It is also necessary to attach the technical documents³ that certify what is certified, in the case of home

² Attachment 7

³ Attachment 6

automation it is the certification of class B or A, according to UNI 15232 and the invoices of the devices or materials used.

5.3 SUPPLIER'S SEARCH

When choosing the devices, several aspects must be taken into account:

- The ceilings that can be financed by the eco-bonus (30'000-45'000€) [31].
- Furthermore, only the home automation related to the functions envisaged by 15232 [19] on the heating system can be financed [29], therefore the rest of the home automation must be purchased at a reduced price.
- The devices purchased with ecobonus [23] must have an invoice and the manufacturer must certify that the device provides the functions specified in the project and this restricts the field to Italian products given the complexity of the functions [36].
- Finally, it is necessary to choose a local supplier who knows the installed devices. Since I will provide my services only for the project implementation period. This narrows the field to Apulian suppliers.

Under all these restrictions, the only company able to supply the devices is Eelectron [37] which has suppliers in Puglia and is of Italian manufacture. As for the price, it is competitive but it is not ideal so you have to choose home automation devices with care. The selected suppliers are: "Agenzia Giuseppe Presicci" [38] for supplies from Eelectron and ACMEI [39] for the rest of the supplies. The advantage of buying from Eelectron is the warranty on the devices and the Italian customer service.

To minimize costs, the home automation that cannot be financed by the eco-bonus was purchased by means of two lots of home automation decommissioned from factories in Germany. The devices have been reconditioned by me testing the operation according to the specifications of the datasheets and reset by ETS to the factory values. This part of the system includes: Relay Actuators for Lights, Shutters Actuators, Push Buttons, Dimmers, Power Sources and Line Couplers.

The devices that can be financed, i.e. those concerning presence sensors, servers, thermostats, climate actuators and the relative valves, will be purchased within the time frame of the financing.

One of the lots included a number of high quality thermostats⁴ in insufficient quantity for the system and as they are still in production it will be possible to purchase them later.

4 ATTACHED: Knx component table

6 DEVICE DEVELOPING

List of components:

- Raspberry Pi 4 8GB
- BAOS 838 kBerry
- Raspberry Pi display 5 inches
- Raspberry Pi cam 2 Mp

In the market there are security cameras with facial recognition compatible with home automation systems, but there are no cameras capable of integrating artificial intelligence and computer vision algorithms. The development of a product compatible with safety standards and which can be integrated into an electrical system goes far beyond the possibilities of this project, therefore multi-platform and easily integrated languages and libraries have been chosen. And components that guaranteed greater robustness. The Raspberry pi 4 [40] was chosen as the development platform mainly for its reduced price but also because with its 8 GB of RAM and the enhanced processor the pi 4 lends itself easily to artificial intelligence algorithms and computer vision Figure 7.



Figure 7 Device complete with a display, an 8Mp video camera and communication interface with the bus.

To allow communication between the Raspberry and the KNX system it is necessary to take into account the different market offers: python modules [41], Calimero [42], ASCII gateway [43], microcontrollers, and programmable bus interface Modules [44]. As demonstrated by “Tecnologico de Monterrey” [45], communication not managed by servers as in the case of the first two alternatives is fallacious, the reception of telegrams is not guaranteed and the buses are overloaded. The ASCII gateway, designed for an industrial type application, is excellent for quality given the presence of an internal server but has a high cost. Microcontrollers are the lower-level alternative therefore they have excessive development time. Finally, the Modules bus interfaces represent the best alternative that balances costs, development times and communication

robustness. Among the various alternatives proposed in the KNX Cookbook [46], the BAOS [44] modules from WEINZIERL have the greatest number of features Figure 8.



Figure 8 Weinzierl BAOS devices compatible with different media and used by many companies to develop products that can be interfaced with the KNX system.

6.1 BAOS INTERFACE

BAOS [44] devices are a recent technology of about 5 years of age that allows rapid development of KNX products by providing a programmable and adaptable communication bus interface for different application modules. There are different BAOS servers based on the communication medium used: IP, TP and RF and with the exception of Wi-Fi all support the TX RX serial communication by means of the FT1.2 Figure 9, standard with the application [47].

PIN assignment

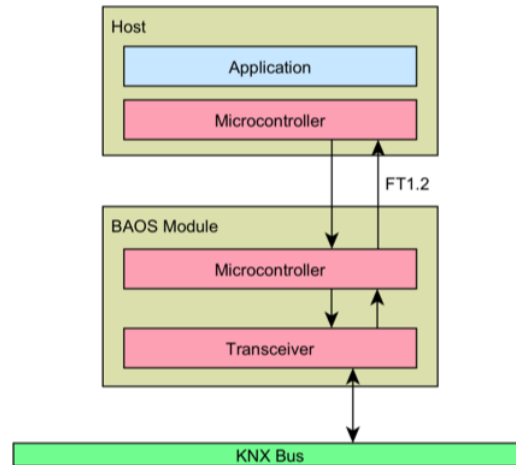
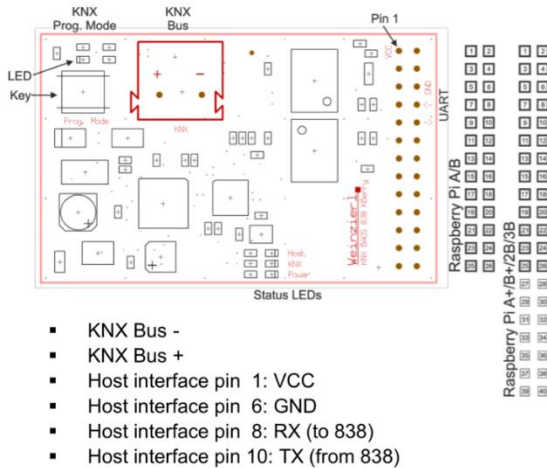


Figure 9 Weinzierl BAOS devices compatible with different media and used by many companies to develop products that can be interfaced with the KNX system.

The BAOS modules have 4 access levels: the one that can only be managed by the manufacturer, those accessible from the ETS application or from the other devices in the system and the one concerning programming through the FT1.2 protocol. The management of telegrams and serial messages is managed internally by the device based on the active flags [14]. The messages sent through the FT1.2 protocol that allow interfacing with Datapoints and parameters are standard for each BAOS device but each company can add a specific communication mode. The WEINZIERL company has created a C++ library, BAOS Library [48], which allows a device equipped with a processor to communicate with the modules through a serial port. The library also makes the management of Datapoints more similar to the application level as well as allowing the use of Times, serial tunneling [49], etc. The module used in this project is the KNX BAOS Modules 838 (TP, kBerry), it has a standard TP connector through which it communicates with the BUS system has an optical insulation between the TP voltage and that of the application module so it needs a power supply from both sides, it has one GND pin one 3.2V pin one TX pin and one RX pin respectively to transmit and receive messages. The module allows you to interface through programming with ETS Figure 12, 10 e 11, by means of a customized application by means of the Manufacturer Tool or by using a general application that contains up to one thousand Datapoints, it allows the management of the Flags, the choice of the type and the insertion of the description which will be saved inside the ROM of the BAOS device allowing an easy interpretation of the programming from both sides of the interface.

1.1.86 KNX BAOS 830 > General

General

Device Name

KNX BAOS 83x

Datapoint 1-10

Send Indications

☐ Disabled
 ☒ Enabled

Figure 10 General parameter that allows you to configure the name of the device

1.1.86 KNX BAOS 830 > Datapoint 1-10		
General	Datapoint type 1	DPT 9 - Float Value-2 Bytes
Datapoint 1-10	Datapoint description 1	<Stanza Letto Est> 8 Lux
Datapoint 11-20	Datapoint type 2	DPT 7 - Unsigned Value-2 Bytes
Datapoint 21-30	Datapoint description 2	<Stanza Letto Est> 29 Occuoazione
Datapoint 31-40	Datapoint type 3	DPT 9 - Float Value-2 Bytes
Datapoint 41-50	Datapoint description 3	<Stanza Letto Est> 100 Umidita
Datapoint 51-60	Datapoint type 4	DPT 9 - Float Value-2 Bytes
Datapoint 61-70	Datapoint description 4	<Stanza Letto Est> 107 Temperatura Attuale
Datapoint 71-80	Datapoint type 5	DPT 9 - Float Value-2 Bytes
Datapoint 81-90	Datapoint description 5	<Stanza Letto Est> 135 CO2
Datapoint 91-100	Datapoint type 6	DPT 7 - Unsigned Value-2 Bytes
	Datapoint description 6	<Stanza Letto Est> 156 Temperatura di Colore
	Datapoint type 7	DPT 9 - Float Value-2 Bytes
	Datapoint description 7	<Stanza Letto Est> 185 VOC

Figure 11 Choice of Datapoints

1	<Stanza Letto Est> 8 Lux	DPT 9	2 bytes	C	-	W	-	-	2-byte float value, t.
2	<Stanza Letto Est> 29 Occuoazione	DPT 7	2 bytes	C	-	W	-	-	2-byte unsigned val
3	<Stanza Letto Est> 100 Umidita	DPT 9	2 bytes	C	-	W	-	-	2-byte float value, t.
4	<Stanza Letto Est> 107 Temperatura Attuale	DPT 9	2 bytes	C	-	W	-	-	2-byte float value, t.
5	<Stanza Letto Est> 135 CO2	DPT 9	2 bytes	C	-	W	-	-	2-byte float value, t.
6	<Stanza Letto Est> 156 Temperatura di Colore	DPT 7	2 bytes	C	-	W	-	-	2-byte unsigned val
7	<Stanza Letto Est> 185 VOC	DPT 9	2 bytes	C	-	W	-	-	2-byte float value, t.

Figure 12 Group objects

It is important to note how group objects are categorized by environment. The purpose of the BAOS device as previously mentioned is also to collect data from the environment to allow its analysis. In this way the system is collecting and categorizing the measurements from the SPACE sensor based on position and time.

E' stata quindi disabilitata la bandiera di trasmissione in quanto ha il solo obbietto di diagnosi.

6.2 TEST THE DEVELOPED DEVICE

To test the device, a basic system was built consisting of an actuator, a push-button panel and a relay actuator connected through the same main line. The relays and the power source are connected to the mains. The device was asked to read its serial number within its parameters to test access to internal parameters, to read the items and to switch off and on instantly a light⁵ Figure 13. Furthermore, to test the communication with the bus, it was asked to repeatedly send telegrams for switching the light on and off with a frequency of 2 telegrams per second. If the bus is free, 100% of the telegrams are sent correctly. The bus was busy through messages coming from

⁵ Attachment 2

a push-button panel at approximately the same frequency, the result is that the device sent the correct messages 1.3 times.

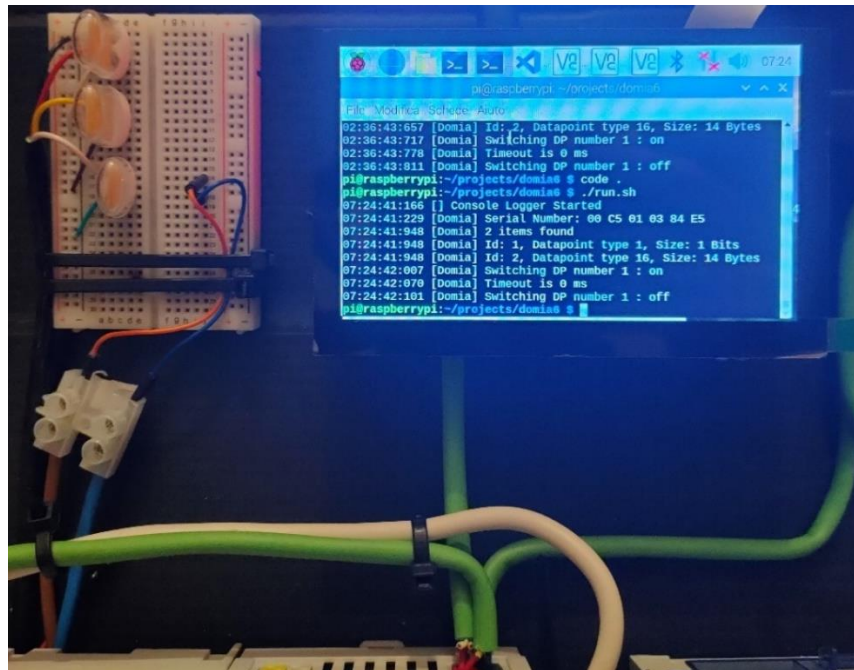


Figure 13 Device tested display showing read / write and test system event messages

6.3 MATLAB PROGRAM

The first algorithm was programmed in MATLAB through an existing network and better classification results were obtained because the network was created by a specialist in the sector and because it had the Caffe [50] architecture, a massive network too difficult to train with available resources. For reasons of code protection, it was not possible to import the network from MATLAB in the product development phases. Two applications have been modified and combined: Face, Age [51] and Emotion Detection and Streaming Face Detection, Training, Recognition [52].

The program allows you to automatically acquire a variable number of images through a webcam, these images are acquired in black and white Figure 14 and classified by means of the patient's identification in a subfolder. The images obtained will train a recognizer so the greater the number of images the better the result. There are also significant improvements if the image is acquired in the same conditions in which it is analyzed and if the orientation and expression of the faces change. The algorithm will also apply an automatic resizing and partial images or images in which a face is not detected will be eliminated.



Figure 14 images acquired to train the recognizer

The algorithm receives the frames coming from IP cams distributed throughout the structure, analyzes them by means of convolutional filters to search for the present faces, uses the emotion classifier to obtain an emotional spectrum of the probabilities of having a certain emotion. Then use the previously trained recognizer to recognize the patient. If the patient is recognized, the hourly spectrum of emotions displayed in streaming is updated Figure 15 and the date, place and spectrum of emotions are saved based on the person who feels them Figure 16. If it is not recognized it is likely that it is an operator or an external person, in this case for privacy reasons the faces are obscured and the emotional spectrum is not saved. A function of the tool is used to imprint the emotion, the age, the name in the streamming visualization by re-matching the recognized face Figure 17.

person1.txt	person2.txt	person3.txt	person4.txt	+																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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Figure 15 Personal files containing the spectra of emotion, the date and the camera that acquired them.

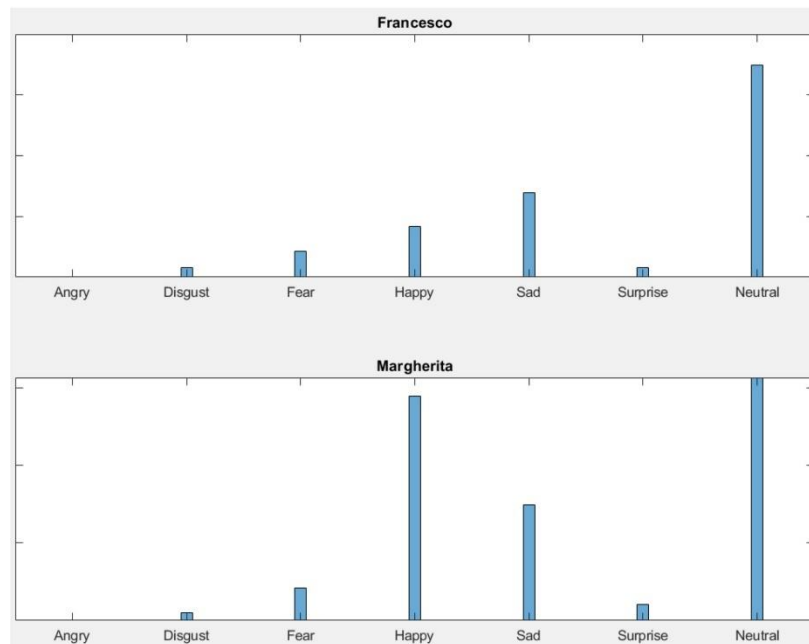


Figure 16 Histograms of the emotions experienced in the hour by the patients.

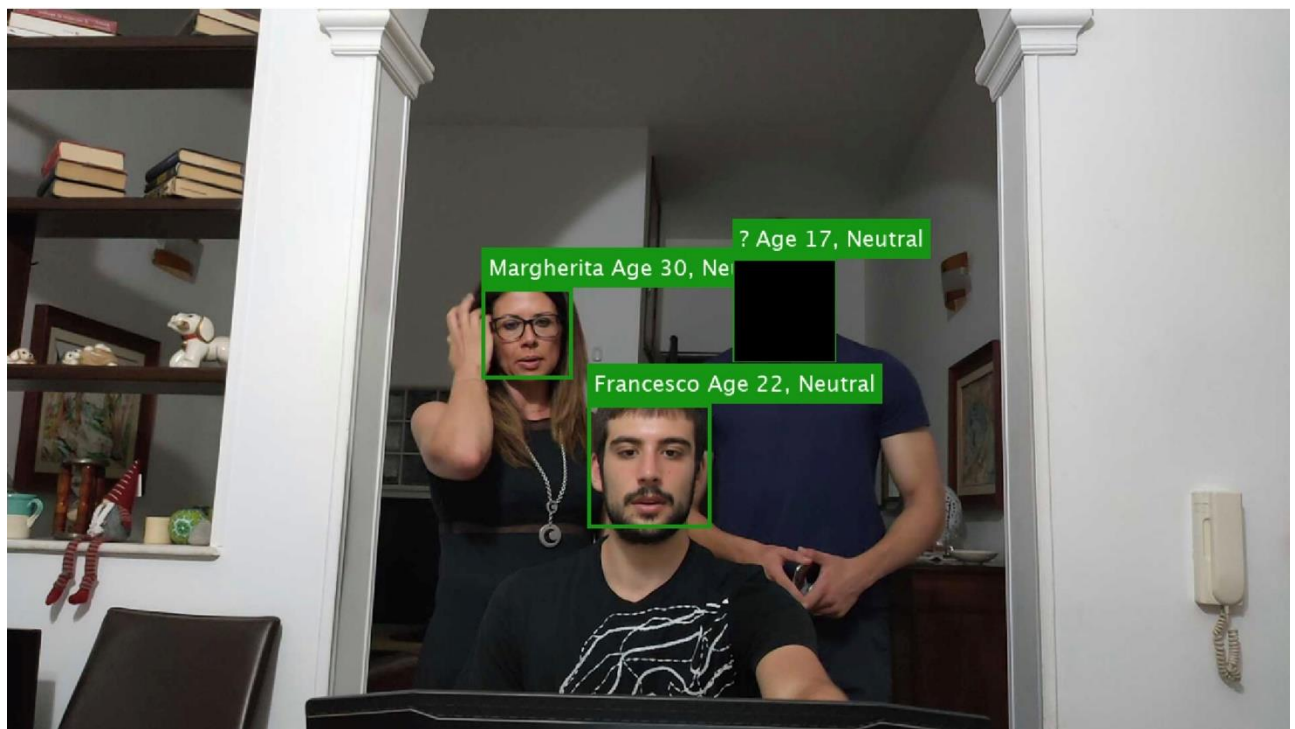


Figure 17 View of the camera that allows you to maintain privacy by obscuring people not present in the database

From the few measurements that have been made (it is an indicative and unscientific result), the algorithm positively correlates the emotion 80% for the emotion of happiness 90% for the neutral emotion, 50% for anger and sadness, 20% for disgust and 30% for fear. To use this algorithm, it is necessary to install IP cameras that send streaming images to a computer with the Matlab license that processes them, and sends, by means of a serial port, the update of the parameters of the

BAOS device. This is a centralized architecture that is difficult to expand and has been taken into account for its rapid development.

6.4 CMAKE FOR CROSSCOMPYLING

To ensure the integration on different platforms and the efficiency of the program, it was decided to program the source code in C++ and to manage the integration of the libraries with CMake [53]. In particular, through a CMakeList.txt⁶ file, the options necessary to integrate the libraries into a Linux system with an ARM architecture have been set. The libraries used are: Poco [54], TensorFlow-lite [55], BAOS, Python and OpenCV. The compilation takes place in the build subfolder and the libraries have been imported and through the GIT submodules in the external folder [53].

6.5 TENSORFLOW LITE

To facilitate the integration of the DL model in the C++ language and in ARM devices, it was necessary to use the TensorFlow lite [55] library which allows the export of the model in FlatBuffer Figure 18. After compatibility, the main advantage of the library is a significant reduction in the computational cost and memory required by the model through tools such as topological reorganization and quantization. This allows the use of large and complex tensors in compilers with small RAM and non-parallel computing. It also allows weight reduction from float type to int8 type for devices that cannot support floats.

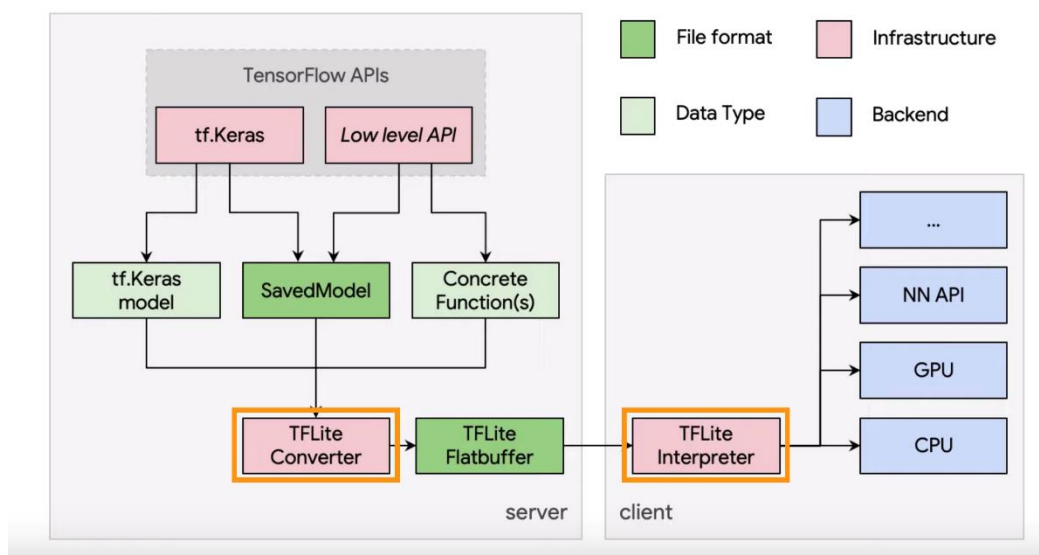


Figure 18 Flatbuffer conversion mechanism used by TensorFlow

6.6 TRAINING DATASET

To train the neural network, a varied dataset was chosen with images from multiple sources, different orientations and different subjects distinguishable by gender and somatic traits. Being emotional recognition, the subjects are essentially human faces categorized according to the emotion they feel at the moment of the photo. The dataset named “fer 2013” [56] is public and published in KAGGLE. It contains 30,000 images also divided into training and test sets and represents the state of the art for emoticon recognition. The images are in black and white and have the size of 48x48 pixels Figure 19.

⁶ Attachment 1



Figure 19 Images from the fer database with their respective categories

6.7 LAYOUT AND TRAINING⁷

The neural network that allows the classification of emotions has been programmed and trained through TensorFlow [57] since at the moment it represents the state of the art of Machine Learning.

To build and train the neural network it was necessary to take into account various factors such as the type of data, the input size, the size of the dataset, the number of final classes, the type of features present in the images and the relevant ones. Eyes and mouth are the most relevant indices to classify emotions and they are also in strong contrast with the rest of the face.

Considering similar problems, it can be seen that the size of the penultimate layer is about 500 and this is the layer that allows you to associate the extracted features and each of these 500 combinations involves a certain increase in the 7 neurons of the final layer. If the penultimate layer is used to combine the features present in the previous layer, the third to last layer is used to group the features coming from the flatter. This is why this last layer must be smaller than the next layer which has the purpose of combining the results. To get an idea of the dimensions of the latter, it is sufficient to imagine in what size the pixels of the features relevant to recognition can be inserted by considering the variation of their orientation, then considering some images it has been determined that the features can enter a matrix of 16x16 or 256 pixels consequently the next layer will be 512 neurons. The first layers are instead an alternation of convolutions, normalization and pooling up to a size of 3x3x512, obviously the size of the filter and the number of relevant filters Figure 20.

⁷ Attachment 9

```

Found 22968 images belonging to 7 classes.
Found 1432 images belonging to 7 classes.
Model: "sequential"

```

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 48, 48, 32)	320
conv2d_1 (Conv2D)	(None, 48, 48, 64)	18496
batch_normalization (Batch Normalization)	(None, 48, 48, 64)	256
max_pooling2d (MaxPooling2D)	(None, 24, 24, 64)	0
dropout (Dropout)	(None, 24, 24, 64)	0
conv2d_2 (Conv2D)	(None, 24, 24, 128)	204928
batch_normalization_1 (Batch Normalization)	(None, 24, 24, 128)	512
max_pooling2d_1 (MaxPooling2D)	(None, 12, 12, 128)	0
dropout_1 (Dropout)	(None, 12, 12, 128)	0
conv2d_3 (Conv2D)	(None, 12, 12, 512)	590336
batch_normalization_2 (Batch Normalization)	(None, 12, 12, 512)	2048
max_pooling2d_2 (MaxPooling2D)	(None, 6, 6, 512)	0
dropout_2 (Dropout)	(None, 6, 6, 512)	0
conv2d_4 (Conv2D)	(None, 6, 6, 512)	2359808
batch_normalization_3 (Batch Normalization)	(None, 6, 6, 512)	2048
max_pooling2d_3 (MaxPooling2D)	(None, 3, 3, 512)	0
dropout_3 (Dropout)	(None, 3, 3, 512)	0
flatten (Flatten)	(None, 4608)	0
dense (Dense)	(None, 256)	1179904
batch_normalization_4 (Batch Normalization)	(None, 256)	1024
dropout_4 (Dropout)	(None, 256)	0
dense_1 (Dense)	(None, 512)	131584
batch_normalization_5 (Batch Normalization)	(None, 512)	2048
dropout_5 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 7)	3591

```

Total params: 4,496,903
Trainable params: 4,492,935
Non-trainable params: 3,968

```

Figure 20 Neural network architecture trained

To train the network in the end it is necessary to define and control the flow of data coming from the training set and choose the ways in which this flow influences the best parameters present in the network.

6.7.1 Transfert Learning⁸ [57]

To apply transfer learning, it is necessary to take into account the differences between the first layer of the original network and the data used for learning. In this case the MobileNetV2 network has been chosen which has a 104 layer, it is a network belonging to the pre-set models of keras and its purpose is the classification of images. Therefore, it is suitable for extracting features and for this reason it has a huge number of convolutions and together with specific architectures at the beginning, different relu at the end and a classification layer of size equal to 1000 which means that it is able to classify 100 different objects. The input layer has the dimensions of 224x224x3, therefore these are square RGB images with a side of 224, the images of the dataset used instead

⁸ Attachment 10

have a dimension of 48x48, it will therefore be necessary to resize them to bring them to the size of the network. Furthermore, the desired classes are not those of the last layer, so it is necessary to remove it. After the removal of the last layer, the weights between the latter and the previous one are random, while the other weights of the network have the purpose of extracting and combining the features the weights of the last layer have the purpose of classifying according to the 1000 categories, for that the last layer should be trained and the others should be blocked because they continue to have a usefulness. This training can be done at a higher learning-rate while it is possible to specialize the entire network with a subsequent training at a lower learning rate. Transference learning is a possibility to be strongly considered both to design a model and to create it, but it is not always the most suitable choice. In this case, the network generated by means of transfer learning, in addition to requiring an enormous learning time, has an accuracy of 0.49 during the Training phase and 0.46 during validation, furthermore, according to the metric used (categorical cross entropy), there are losses respectively of 1.34 and 1.38 Figure 21. For this first phase of learning, the algorithm took a day to achieve these results, which means that it is useless to train the rest of the network for months, obtaining slightly better results. For this reason, it was decided to train the net from scratch.

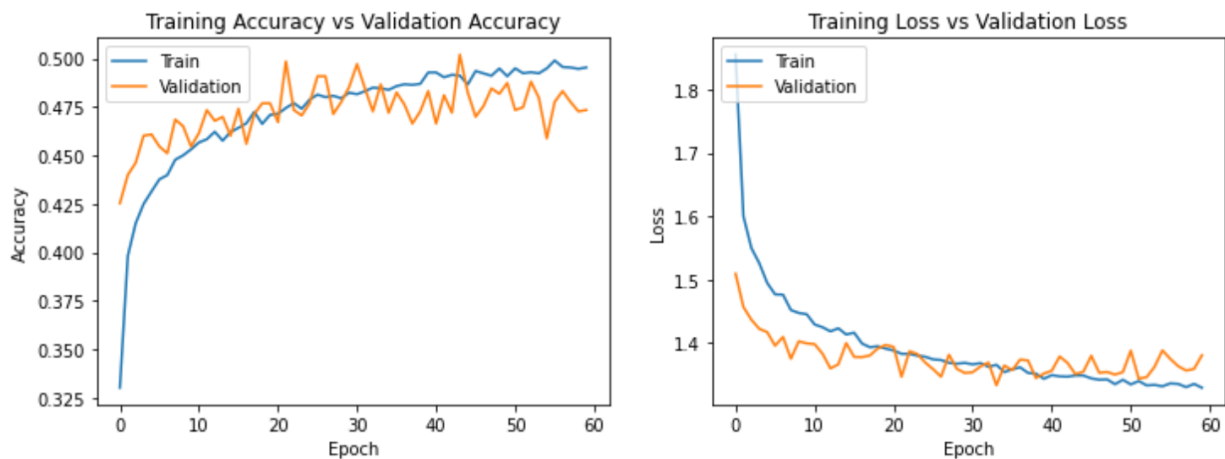


Figure 21 Accuracy and Losses During Training for Transfer Learning

6.7.2 Data Augmentation [57]

The dataset used is large enough to address the problem, however it is possible to increase the size of the training data stream without further affecting the memory. In fact, it is sufficient to take into account the possible transformations by which an image belonging to a dataset continues to belong to the dataset and if this does not affect the difference between the accuracy during validation and that of the test, it follows that the dataset has been positively increased. The transformations that have been taken into account are: rotation 15 degrees corresponding to the possible inclinations of a face, shift in height and width of 10% corresponding to the fact that it is often not possible to frame the entire face and horizontal flip corresponding to the fact that the facies have axial symmetry. Zoom was not taken into account as it depends on the face detection algorithm. These transformations are applied during the loading of the data so they do not prejudice either the RAM or the ROM they affect the graphics card that would otherwise be underused.

6.7.3 Batching the data [57]

During learning, the use of RAM is a condition to be taken into consideration, in addition to the network weights, the necessary data of the training set are added, which is why it is not always possible to load the training set in the form of a matrix but it is necessary to create a flow of data

from the folder in which it is contained and divide it into batches in such a way as to make the most of the available RAM without overflowing. In this case the batch used is equal to 64 images.

6.7.4 Dropout [57]

The greatest risk in training a large neural network is that some neurons become so specialized that they cause a loss of generality in the network. It often happens that in the same layer many neurons increase their weights to the detriment of their neighbors. The risk is therefore to lose the robustness that is the foundation of parallel computation, therefore it is necessary to ensure that the result does not depend on a few specific neurons and to distribute the computation on all available neurons. This phenomenon occurs in the densest and most internal layers and it is therefore necessary to randomly turn off a percentage of these neurons during the learning phase. A 25% dropout was then added after each dense layer.

6.7.5 Type of Classification, Optimizer and Epochs [57]

Since it is a 7-class classification, the categorical metric was chosen with losses evaluated in categorical cross entropy and as optimizer we chose to use Adams because it is light and accuracy increases as learning progresses. For the learning rate used, we started with a learning rate of 0.1 to quickly reach the optimum up to one of 0.000001 for finishing. As regards the epochs used, they must be consistent with the size of the incoming data and their augmentation, so it was decided to use 100 epochs that also allow a fine improvement of the weights.

6.8 RESULTS

The learning outcomes are in line with the state of the art. We have reached 76.7% accuracy with losses of 0.767 during training and 70.7% accuracy with losses of 1.08 during the validation phase Figure 22 Figure 23, which is the best result among those published in Kaggle Figure 24 .

Unfortunately it is slightly below the matlab algorithm and far below that of Imotions. In any case it must be considered that it is not possible to recognize emotions in a certain and objective way only by using a flat image, therefore Imotion has used more sensors and more algorithms at the same time.

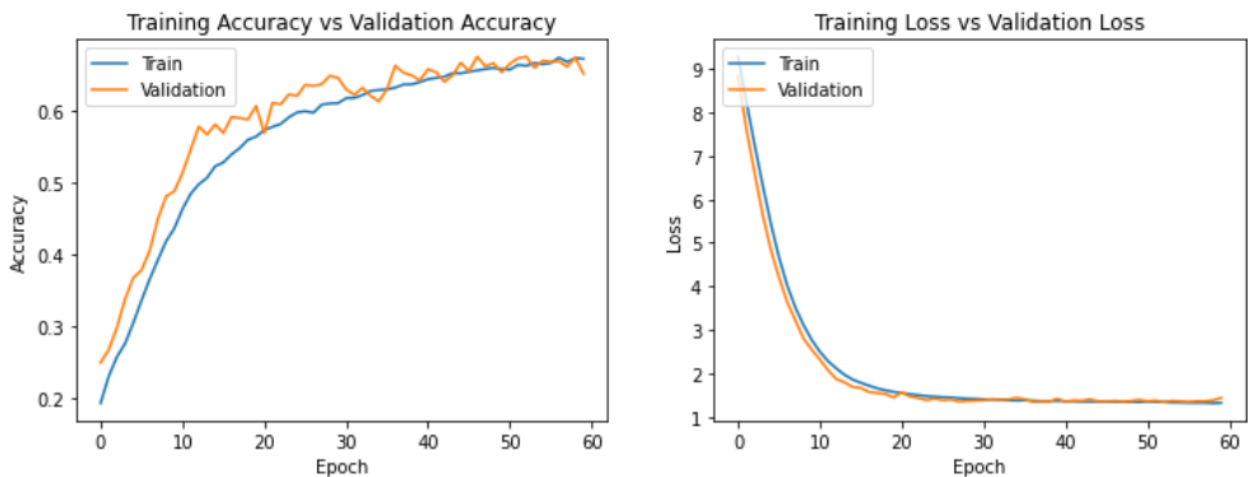


Figure 22 Accuracy and Losses During Training from epoch 1 to epoch 60

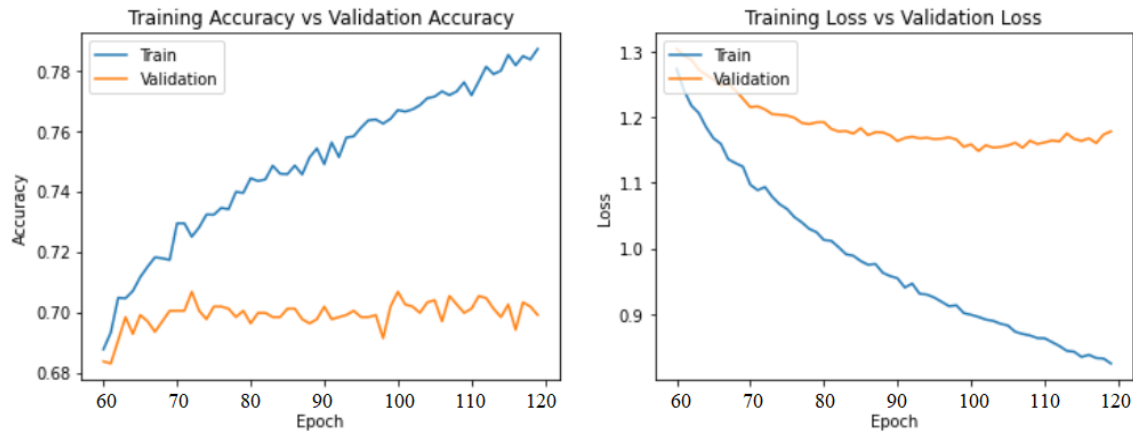


Figure 23 Accuracy and Losses During Training from epoch 60 to epoch 120

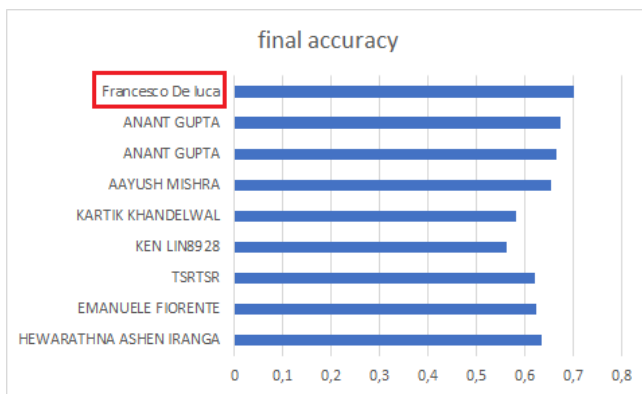


Figure 24 Comparison with the results published in Kaggle

To crop and analyze streaming Figure 25 images we have chosen to use python's OpenCV⁹. To identify the position of the faces, a specific Cascade Classifier was used for the front faces [58]. The images were analyzed in black and white and were modified by inserting text and a rectangular delimiter through the coordinates obtained from the Cascade.

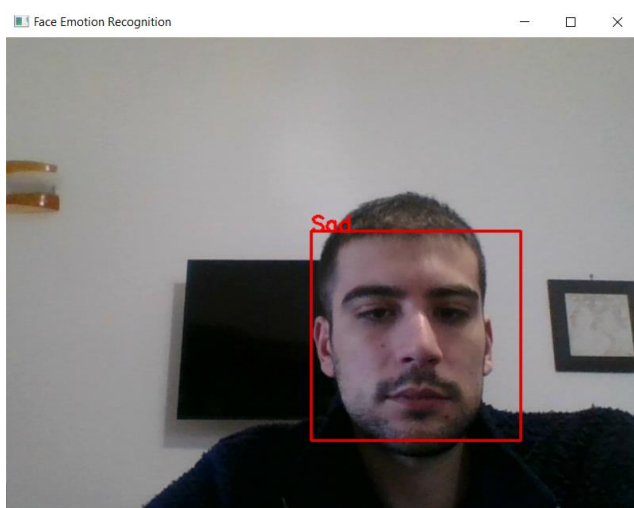


Figure 25 Neural network visualization interface with real-time capture

⁹ Attachment 8

7 SYSTEM DESIGN

A home automation project allows you to adapt an environment to different needs. Nevertheless, a distinction must be made between standard requirements and additional requirements. For the initial phase of the project, it is necessary to foresee the implementation of the standard requirements and those of the automation class A or B according to the provisions of the 15232 standard [19]. It is also necessary to foresee possible extensions or specializations of the project, for this it is necessary analyze the characteristics that the structure could have in the future.

7.1 DIMENSIONING

To correctly size the system it is necessary to know the number of devices and their spatial distribution [59]. System constraints concern:

- the maximum number of devices in a line: and the total number of devices is about half
- the maximum number of devices in a line segment and the necessary power sources: in this case the main line on the first floor has a line segment to be slightly extended
- the maximum distance between devices or between power sources: also for this reason the longest line is 90m long
- the size of home automation panels: this topic will be dealt with later.
- The number of external devices: external devices require a dedicated line with different protections in order to prevent the internal system from being affected by these damages in the event of wear.

7.2 EXAMPLE OF A DAY CENTER FOR AUTISM

As already explained above, the type of structure is indefinable as it is closely related to local needs which will change during the adaptation of the property. However, it was asked to adapt the system to the most stringent requirements, which are the requirements of a residential facility for autism. For this we turned to experts in the sector who explained the needs of this type of user through a guided tour in the E. Micheli Center [60] in Bari.

The result of this visit are important considerations regarding the functionality of the structure and facilities that the daily environment of an autistic person must have:

- Autistics are sensitive to temperature, brightness and noise. For some, the brightness of the environment must not be too high for others the temperature must remain constant over time and between rooms.
- Direct light is a source of discomfort, it is advisable that the lights are directed from the bottom up.
- For some the rooms must be restricted by the presence of walls or even through delimiting elements such as the change of color of the floor.
- The learning process and psychological therapy is based on repetitive activities defined by the psychologist by means of periodic tests and observation of behavior.
- The observation process takes place in several structured environments one of which is the room with a false mirror
- To carry out these activities, autistic people need a structured environment and strict procedures such as those of the production chain of a factory.

- The lights used in the environment must not be cold and must not be neon as the noise is a source of disturbance for the subject.
- Floors must be resilient to reduce footsteps.
- Autistics are different in the severity of their disorder and on the basis of this it varies: the staff needed to manage them, the environments that become simpler and more structured as the disorder increases, isolation or interaction with other subjects, skills and activities performed.

These characteristics will be taken into consideration when choosing the functions to be included in the environments.

7.3 DIVISION INTO ZONES

Following the client's requests and after an inspection, a topological structure of the environments was created Figure 26, Figure 27, Figure 28, Figure 29. There are: 3 floors, one of which is intermediate on the first and second floors; 7 bedrooms with bathroom on the first floor; a room with bathroom on the middle floor; a room on the ground floor; a living room on the first floor; a living room on the ground floor; an area divided into a dining area and workshops on the ground floor; a kitchen on the ground floor; 3 corridors on the ground floor; 8 corridors on the first floor, 3 of which are habitable and 2 are very small; 2 terraces, one of which is very large and divided into 3; an elevator; a garden; a bathroom in the living room on the first floor; a bathroom in the laboratory area; 3 closets on the first floor; 2 storage rooms on the ground floor; 2 stairs, one of which is an entrance; an entrance with garage; a COVID room with bathroom.

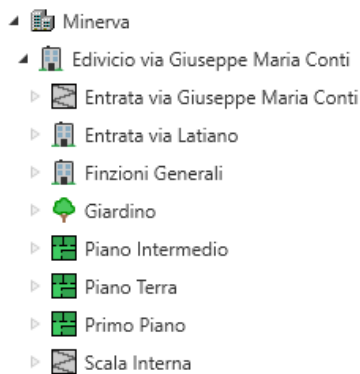


Figure 26 Topology of floors and buildings

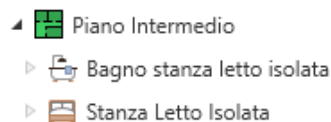


Figure 27 Intermediate Floor Topology















- ▶  Piano Terra
 - ▶  Bagno Disabili
 - ▶  Bagno stanza COVID
 - ▶  Cucina
 - ▶  Deposito
 - ▶  Disimpegno cucina stanza laboratori
 - ▶  Disimpegno soggiorno stanza COVID
 - ▶  Disimpegno stanza laboratori scala interna soggiorno
 - ▶  Disimpegno zona pranzo stanza laboratori
 - ▶  Ripostiglio
 - ▶  Soggiorno
 - ▶  Stanza COVID
 - ▶  Stanza Laboratori
 - ▶  Zona Pranzo

Figure 28 Ground Floor Topology





























- ▶  Stanza Letto Est
- ▶  Stanza Letto Interna con terrazza
- ▶  Stanza Letto Nord
- ▶  Stanza Letto Nord-Est
- ▶  Stanza Letto Nord-Ovest
- ▶  Stanza Letto Sud-Est
- ▶  Stanza Letto Sud-Ovest
- ▶  terrazza Est
- ▶  Terrazza Nord stanza da letto interna
- ▶  terrazza Sud
- ▶  terrazza Sud-Est
- ▶  WC soggiorno
- ▶  Zona Filtro letto nord-ovest soggiorno
- ▶  Zona Filtro WC soggiorno soggiorno
- ▶  Stanza Letto Est
- ▶  Stanza Letto Interna con terrazza
- ▶  Stanza Letto Nord
- ▶  Stanza Letto Nord-Est
- ▶  Stanza Letto Nord-Ovest
- ▶  Stanza Letto Sud-Est
- ▶  Stanza Letto Sud-Ovest
- ▶  terrazza Est
- ▶  Terrazza Nord stanza da letto interna
- ▶  terrazza Sud
- ▶  terrazza Sud-Est
- ▶  WC soggiorno
- ▶  Zona Filtro letto nord-ovest soggiorno
- ▶  Zona Filtro WC soggiorno soggiorno

Figure 29 Topology First floor

7.4 POSITIONING OF FUNCTIONS IN THE ZONES

Taking advantage of the new functions of ETS6 [61] it was possible to insert the applications of the main actuators in the building window, that is: on / off light, dimmable light, sun protection (shutter), on / off thermal actuator. It's also important for the auto programming function of Thinka. To simplify the installation, the functions have been inserted on the map in cyan Figure 30, Figure 31.

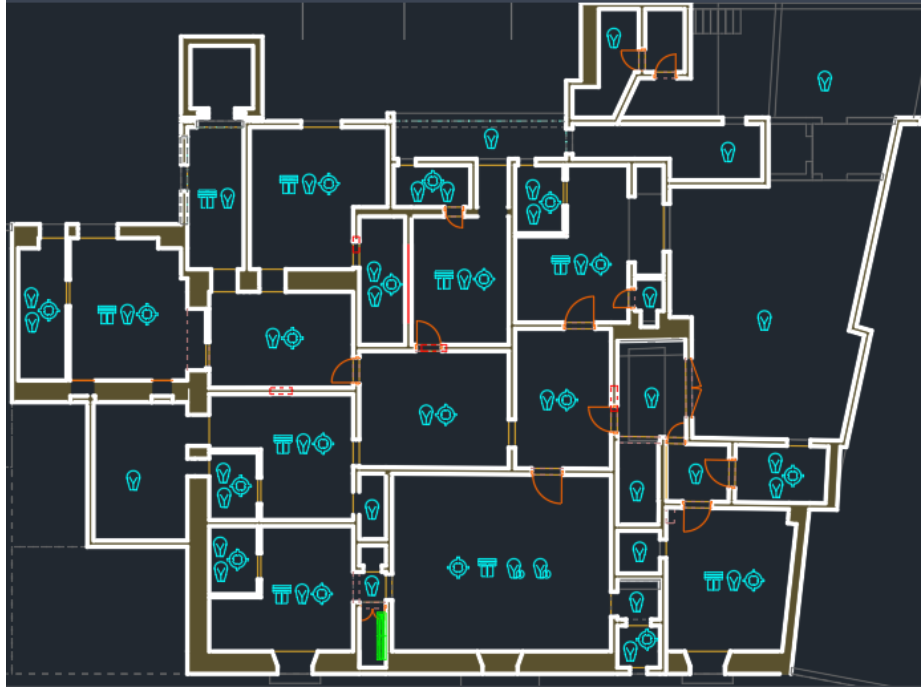


Figure 30 Home automation function First Flor

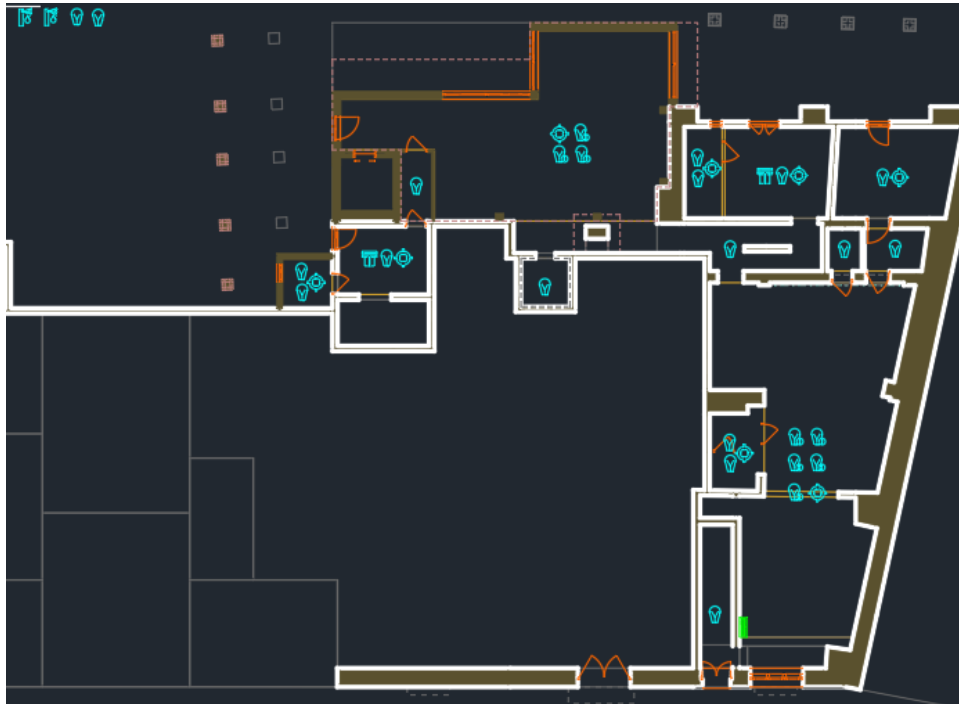


Figure 31 Home automation function Zero Flor

7.4.1 Rooms

We have chosen to guarantee maximum autonomy in the rooms Figure 32, and therefore considering possible future expansions the following functions have been introduced: Main Light (light on / off), Radiator (thermal actuator on / off by means of a thermostatic servo valve) and Shutter (protection solar). All this must be considered from the point of view of a class A automation with respect to the 15232 standard [19], that is, the presence of 2 thermal probes, one in the thermostat and one in the SPACE sensor, allows you to control the temperature by means of a PID, the time setting can be adjusted centralized by the operator or by means of a thermostat present in the same room as the patient (albeit with a limitation of intervals to protect consumption and prevent an uncomfortable environment from being created unknowingly by less autonomous patients). The brightness sensor allows the lights to be switched off if the light passing through the shutter is sufficient, furthermore the presence sensor with the "Virtual Pocket" [62] Logic connected to the door opening sensor allows the light to be switched off if the person leaves the door. room forgetting to switch off. By means of an opening sensor connected to the fixtures it is possible to turn off the heating automatically in case the user or the staff leaves the window open and by means of the CO2 sensor [62] it is possible to open the sun protections just to ensure clean air. Finally, the SPACE sensor allows you to calculate the occupancy index [19] of the environment by providing useful data for calculating consumption using the 15232 factors [19] method and useful for monitoring the patient's well-being.




















- ▶  Stanza Letto Est
 - ▶  ALLARME CO2
 - ▶  ALLARME FUMO
 - ▶  ALLARME VOC
 - ▶  CO2
 - ▶  COLORE
 - ▶  FANCOIL
 - ▶  LUCE PRINCIPALE
 - ▶  LUMINOSITA
 - ▶  OCCUPAZIONE
 - ▶  PANNELLO DI CONTROLLO
 - ▶  PERSIANA
 - ▶  SPACE INPUTS
 - ▶  TEMPERATURA
 - ▶  UMIDITA
 - ▶  VOC
 - ▶  1.1.1 6127/01 Sens. a pulsante solo Standard 4x, INC
 - ▶  1.1.9 9025 KNX Termostato Capacitivo/Umidostato - Nero
 - ▶  1.1.70 Sensore di Presenza SPACE E03

Figure 32 Room functions

7.4.2 Bathrooms

Each bedroom has a bathroom Figure 33, always in order to guarantee autonomy, there are 2 common bathrooms and the rest is associated with the rooms so being in communication only with

the associated room, they need a presence sensor to allow the "Virtual Pocket" logic [62]. All bathrooms except one have a window frame, however, given the low occupancy index [19], there is no need for sun protection, however, they have an on / off light function and a radiator with an on / off valve connected to the KNX system. For this you need an opening sensor as regards the fixtures in order to turn off the heating, a door opening sensor as if the bathroom fixture is open if the door is also open it will be necessary to turn off the heating even in the room. Finally, the bathroom lights turn off after a period of 10 minutes if the presence sensor in the bathroom does not detect any presence.







- ▲  Bagno stanza letto con terrazza
 - ▶  LUCE PRINCIPALE
 - ▶  LUCE SPECCHIO
 - ▶  TERMOARREDO
 - ▶  1.1.18 Tastsensor 2fach mit Beschriftungsfeld
 - ▶  1.1.32 Pannello interruttore automatico Comfort 1,10 m

Figure 33 Bath functions

7.4.3 Passage hallways

The passageways Figure 34, have a communication function between the various areas; however, they are too small for a person to stay there. For this they have on / off lights that are activated when passing and are heated with a minimum temperature only during specific hours of the day when a greater influx of people is expected. In these places, as in the whole upper floor, with the exception of bathrooms and rooms, there are passage lights, low voltage and intensity LEDs with hourly programming that allow you to see the path during the passage during the night without the need to turn on the lights. led lights.







- ▲  Disimpegno Ascensore
 - ▶  FANCOIL
 - ▶  LUCE PRINCIPALE
 - ▶  PERSIANA
 - ▶  1.1.25 Tastsensor 2fach mit Beschriftungsfeld
 - ▶  1.1.39 Pannello interruttore automatico Comfort 1,10 m

Figure 34 Passage hallways functions

7.4.4 Habitable hallways

The habitable hallways Figure 35, are internal areas, although they have a high occupancy index [19] and serve as a daily place, they do not have adjustable lights as there is no natural light so it is possible to maintain a constant brightness. They have presence sensors by means of which it is possible to activate climate functions such as radiators, and have an automatic shutdown time longer: 30 minutes long. Finally, like all common areas, they are monitored and managed centrally by the operator.




















-  Disimpegno letto sud-est soggiorno
 - ▶  ALLARME CO2
 - ▶  ALLARME FUMO
 - ▶  ALLARME VOC
 - ▶  CO2
 - ▶  COLORE
 - ▶  FANCOIL
 - ▶  LUCE DI PRINCIPALE
 - ▶  LUMINOSITA
 - ▶  OCCUPAZIONE
 - ▶  PANNELLO DI CONTROLLO
 - ▶  SPACE INPUTS
 - ▶  TEMPERATURA
 - ▶  UMIDITA
 - ▶  VOC
 - ▶  1.1.29 Tastsensor 2fach mit Beschriftungsfeld
 - ▶  1.1.43 Pannello interruttore automatico Comfort 1,10 m
 - ▶  1.1.47 9025 KNX Termostato Capacitivo/Umidostato - Nero
 - ▶  1.1.78 Sensore di Presenza SPACE E03

Figure 35 Habitable hallways functions

7.4.5 Living rooms, laboratory area and dining area

The living rooms and the large room that includes the laboratory area and the dining area are the rooms with the highest occupancy index [19] and are also rooms in which activities take place and therefore the environment must be controlled to be as comfortable as possible. For this reason, the lights are adjustable especially since in each of these rooms there is a considerable portion of natural light coming from windows and windows of different sizes. The rooms have SPACE sensors that allow precise monitoring of the environment and users. Each of these rooms, in addition to being remotely controlled, has a thermostat that adjusts the valves of several radiators in such a way as to ensure uniformity of light and heat. Since the environments are very different from each other, it is necessary to study them individually:

- First floor living room Figure 36: The living room on the first floor is a large area of 40 m² with a window to the west. To heat the area there are 2 radiators controlled by the same climate actuator. The ceiling is star shaped so there are two quads of lights each adjustable, one at the natural corners and one at the center of the walls, respectively of natural light and warm light. This makes the environment ideal for the use of smart cameras to monitor the status of patients in the environment. Then the intelligent camera¹⁰ is placed behind the window, in order to have the illuminated face of the user recovered.

¹⁰ It refers to the device developed in the development chapter






















- 4  Soggiorno
 - ▷  ALLARME CO2
 - ▷  ALLARME FUMO
 - ▷  ALLARME VOC
 - ▷  CO2
 - ▷  COLORE
 - ▷  FANCOIL
 - ▷  LUCE ANGOLI
 - ▷  LUCE LATI
 - ▷  LUMINOSITA
 - ▷  OCCUPAZIONE
 - ▷  PANNELLO DI CONTROLLO
 - ▷  PERSIANA
 - ▷  SPACE INPUTS
 - ▷  TEMPERATURA
 - ▷  UMIDITA
 - ▷  VOC
 - ▷  1.1.8 6127/01 Sens. a pulsante solo Standard 4x, INC
 - ▷  1.1.16 9025 KNX Termostato Capacitivo/Umidostato - Nero
 - ▷  1.1.77 Sensore di Presenza SPACE E03
 - ▷  1.1.86 KNX BAOS 830

Figure 36 First floor living room functions

• Living room Ground floor Figure 37: the living room on the ground floor will be the most recent part of the structure, it is a large open space with flat vaults and 3 windows overlooking the internal garden that point north to east and south. As there is a strong luminosity gradient and a considerable variation in orientation, it was necessary to place 3 rows of natural LED lights in order to ensure uniformity of light. From a modern perspective, instead of the shutter regulator, there are 3 rows of EC glass connected to 3 separate RELAYS to ensure variable solar protection according to the angle of incidence of sunlight. Finally, like the living room on the first floor, this too is configured as a suitable place for the study and monitoring of the patient, in fact by inserting an intelligent camera in the wall between the north-facing window and the south-facing one, it is possible to obtain images. defined that they film the patient in a daily moment and in a very different environment than the others present in the structure.

- 4  Soggiorno
 - ▶  ALLARME CO2
 - ▶  ALLARME FUMO
 - ▶  ALLARME VOC
 - ▶  CO2
 - ▶  COLORE
 - ▶  EC GLASS ALTO VETRATA EST
 - ▶  EC GLASS ALTO VETRATA NORD
 - ▶  EC GLASS ALTO VETRATA SUD
 - ▶  EC GLASS BASSO VETRATA EST
 - ▶  EC GLASS BASSO VETRATA NORD
 - ▶  EC GLASS BASSO VETRATA SUD
 - ▶  EC GLASS MEDIO VETRATA EST
 - ▶  EC GLASS MEDIO VETRATA NORD
 - ▶  EC GLASS MEDIO VETRATA SUD
 - ▶  FANCOIL
 - ▶  LUCE LONTANA VETRATA
 - ▶  LUCE MEDIA VETRATA
 - ▶  LUCE VICINA VETRATA
 - ▶  LUMINOSITA
 - ▶  OCCUPAZIONE
 - ▶  PANNELLO DI CONTROLLO
 - ▶  SPACE INPUTS
 - ▶  TEMPERATURA
 - ▶  UMIDITA
 - ▶  VOC
 - ▶  1.1.52 9025 KNX Termostato Capacitivo/Umidostato - Nero
 - ▶  1.2.31 KNX BAOS 830
 - ▶  1.2.32 6127/01 Sens. a pulsante solo Standard 4x, INC
 - ▶  1.2.33 Sensore di Presenza SPACE E03

Figure 37 Living room Ground floor functions

• Dining Area Figure 38 and Laboratories Area Figure 39: as previously mentioned this is a single area divided by a movable divider, for this reason the heating must be unique by means of many radiators connected to a single actuator as in the previous cases. The area has a window that faces west towards via Giuseppe Maria Conti, for this reason of little reserve it is essential to insert a blackout and this is done for constructive consistency with 3 rows of EC glass. As in the living room, even in this area there is a strong lack of homogeneity light which must therefore be compensated for by means of 3 rows of LEDs that can be adjusted to a scale of light. The part dedicated to the laboratories, on the other hand, is poorly lit by an attic overlooking the internal staircase, but given the purpose of the area, it was still chosen to insert 2 rows of adjustable LEDs. To study the effect of the laboratories on patients, it is also necessary to insert the intelligent camera here. In addition, to ensure the reserve between the isolated bedroom and in any case allow the passage of light, it is necessary to obscure the glasses with EC glass on command.

- ▶ Stanza Laboratori
 - ▶ ALLARME CO2
 - ▶ ALLARME FUMO
 - ▶ ALLARME VOC
 - ▶ CO2
 - ▶ COLORE
 - ▶ EC GLASS
 - ▶ FANCOIL
 - ▶ LUCE LONTANA FINESTRA
 - ▶ LUCE VICINA FINESTRA
 - ▶ LUMINOSITA
 - ▶ OCCUPAZIONE
 - ▶ PANNELLO DI CONTROLLO
 - ▶ SPACE INPUTS
 - ▶ TEMPERATURA
 - ▶ UMIDITA
 - ▶ VOC
 - ▶ 1.1.54 9025 KNX Termostato Capacitivo/Umidostato - Nero
 - ▶ 1.2.26 Sensore di Presenza SPACE E03
 - ▶ 1.2.28 6127/01 Sens. a pulsante solo Standard 4x, INC
 - ▶ 1.2.29 KNX BAOS 830

Figure 38 Laboratories Area functions

-
- ▶ Zona Pranzo
 - ▶ Quadro Piano Terra
 - ▶ ALLARME CO2
 - ▶ ALLARME FUMO
 - ▶ ALLARME VOC
 - ▶ CO2
 - ▶ COLORE
 - ▶ EC GLASS ALTO
 - ▶ EC GLASS BASSO
 - ▶ EC GLASS MEDIO
 - ▶ FANCOIL
 - ▶ LUCE LONTANA VETRATA
 - ▶ LUCE MEDIA VETRATA
 - ▶ LUCE VICINA VETRATA
 - ▶ LUMINOSITA
 - ▶ OCCUPAZIONE
 - ▶ PANNELLO DI CONTROLLO
 - ▶ SPACE INPUTS
 - ▶ TEMPERATURA
 - ▶ UMIDITA
 - ▶ VOC
 - ▶ 1.1.55 9025 KNX Termostato Capacitivo/Umidostato - Nero
 - ▶ 1.1.56 Sensore di Presenza SPACE E03
 - ▶ 1.2.30 6127/01 Sens. a pulsante solo Standard 4x, INC

Figure 39 Dining Area functions

7.4.6 Terraces

The terraces Figure 40, are a versatile place it is possible that in the future there may be a gazebo, chairs etc. Obviously, each terrace is secured and monitored by motion sensors (as being an outdoor area, the lights for the wind or birds must not be activated) and outdoor video cameras,

also as a passage area it is necessary to insert lights on / off can be switched on by means of a motion sensor. In order to foresee a possible dedicated CRAP, it is necessary to take into account the patients' need to smoke and therefore the lights must not be active until a certain time and their switch-off time must not last more than a cigarette. These are external areas, so the line that connects the devices must be an external line the same as that used for the garden as the BUS cover must be resistant to external agents [63]. On the South-East terrace there is the laundry room which is not insulated and has only a timed light that can be turned on by means of a switch, also on the laundry in an easily accessible point exposed to the climate to the north, south, east and west the weather station is positioned.

The weather station allows the monitoring of the external temperature necessary for the correct calculation of the delivery temperature of the thermal fluid and the calculation of the thermic energy necessary in each environment, it allows to alert harmful atmospheric events such as too high knots, storm of UV rays and lateral rain which activate the automatic closing of the shutters. Finally, it allows you to identify the position of the sun in order to regulate the internal brightness in the rooms.

- ▲ 🏠 terrazza Est
 - ▶ 💡 LUCE PRINCIPALE TEMPORIZZATA
 - ▶ 📺 1.3.15 Pannello interruttore automatico Comfort 1,10 m

Figure 40 Terraces Functions

7.4.7 Garden

For the garden Figure 41, the same considerations apply as for the terraces for which there are lights that can be activated by motion sensors in the path and lights that can be activated by a push-button panel that illuminate the facade of the building for special occasions. In addition, several relays activate pop-ups and drop systems based on the time and season of the year. The bus line runs through all the presence sensors, crossing the garden to the entrance to via Latiano, in these conditions it is necessary to have a pre-inverter and a protection against lightning in addition to weather protection [63].

- ▲ 🌳 Giardino
 - ▶ 💡 IMPIANTO A GOCCIE
 - ▶ 💡 IMPIANTO POPUP
 - ▶ 💡 LUCE FACCIATA
 - ▶ 💡 LUCE PERCORSO
 - ▶ 📺 1.3.1 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.2 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.3 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.4 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.5 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.6 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.7 Pannello interruttore automatico Comfort 1,10 m
 - ▶ 📺 1.3.8 Pannello interruttore automatico Comfort 1,10 m

Figure 41 Garden functions

7.4.8 Stairs

The stairs Figure 42, are a place of passage or entry so only in the internal staircase there are passage lights, in the staircase at the west entrance as well as in the whole ground floor it is not necessary to insert the passage lights as they are restricted areas only to staff at night. However, each staircase has a light connected to a presence sensor and radiator for well-suited areas.

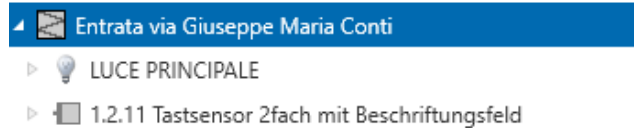


Figure 42 Stairs functions

7.4.9 COVID room

The COVID room is not present in any health regulation but given the emergency it has become a requirement well seen by the bodies that provide authorizations to the point that it is seen as an indispensable requirement to obtain an authorization. To be such, the covid room must have a private bathroom and a hallway that acts as a filter area where the operator can prepare to enter by changing and sterilizing. For this reason, the main difference lies in guaranteeing a virtual pocket logic in the hallway that allows you to ensure the passage of a single person at a time.

7.4.10 Garage

The garage is not a necessary utility for the structure, despite the fact that the municipal regulation obliges to insert a garage for each home. It is located in the entrance of via Latiano and is not currently affected by home automation as it is not part of the financing at the cadastral level, however, it is necessary to bring the BUS line and prepare a cabinet for future expansion.

7.5 SAFETY AND FIRE PREVENTION

As far as safety is concerned, the KNX system is not a certifiable system [64], however it is possible to guarantee a certain level of safety. For this reason, part of the presence detectors are prepared (I cannot say which ones, always for safety reasons) to send a periodic signal to an alarm that will activate if the periodic signal stops being sent or if movement is detected in an area where it should not be seen [64]. The reason why only part of the motion sensors can perform this function is due to the BUS occupation [49]. In addition, the sensors of the external doors and windows and the glass break sensors [64] of the windows will also be connected to the alarm.

As regards the fire-fighting system, smoke detectors have been provided in almost all internal and habitable environments, in all passageways and in the bathrooms. In addition, a gas detector has been installed in the kitchen in addition to the smoke detector. In addition to the standard detectors to be inserted by law [65] and the luminous signs and emergency lighting independent of the KNX system, the space sensors monitor CO₂ in the main rooms and provide additional protection against fires. Figure 43, Figure 46, Figure 44, Figure 45.

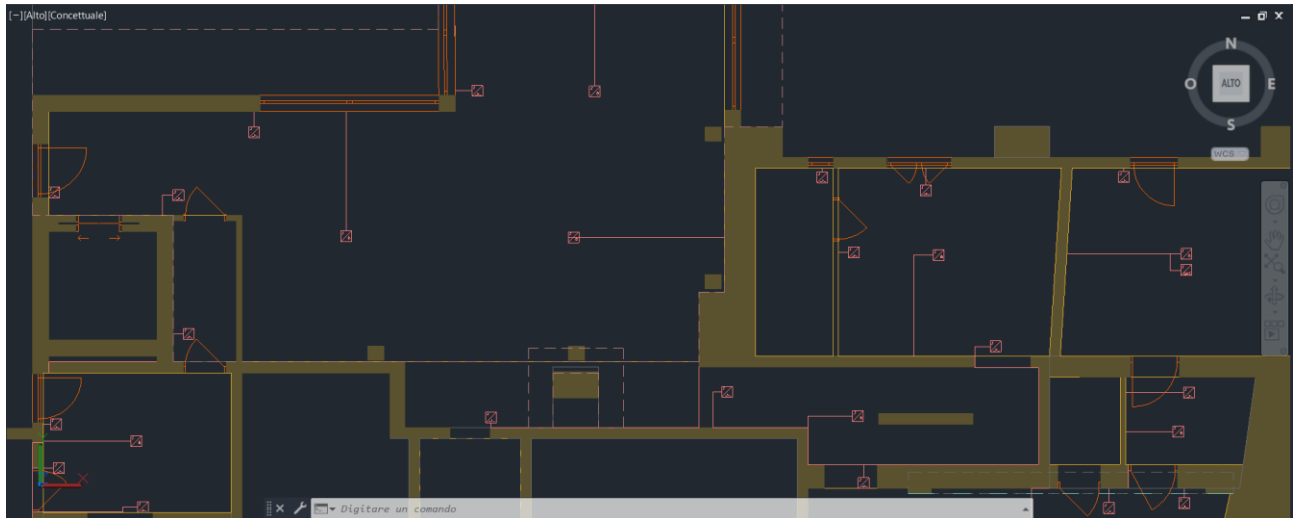


Figure 43 Binary entrances for smoke detectors, opening and gas detectors in the east area ground floor

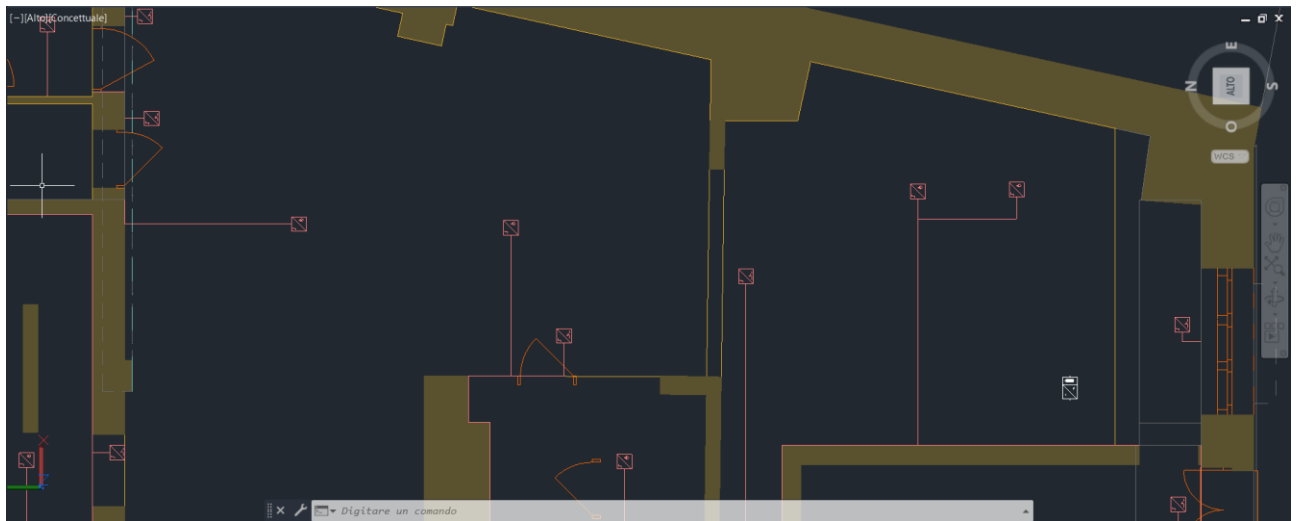


Figure 44 Binary entrances for smoke detectors, opening in the west area ground floor

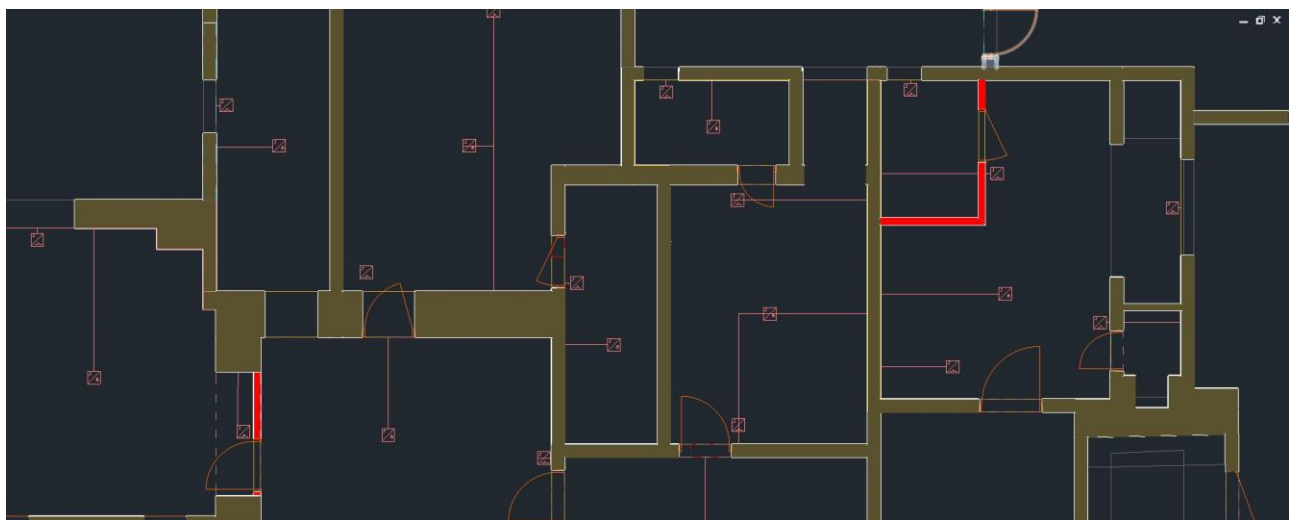


Figure 45 Binary entrances for smoke detectors, opening in the east area first floor



Figure 46 Binary entrances for smoke detectors, opening in the west area first floor

7.6 GROUPING OF ACTUATORS IN HOME AUTOMATION PANELS AND POSITIONING

To group the devices in the electrical panels *Attachment 3 Attachment 4*, the size, capacity and type of panels were taken into account, it was decided to consider a distributed positioning, or a centralized one on the first floor while a centralized placement was required on the ground floor. The reasons for adopting a distributed placement are: to give autonomy to the independent units and to reduce the wiring where there are star vaults and therefore an ancient and inflexible building, reduce the cost and increase safety, with many small cables it reduces the wiring with consequent reduction of costs, maintenance complexity and probability of breakage. As for the centralized positioning, the advantages are: reduction of the system complexity, less invasive maintenance, the possibility of placing the switchboard in the most suitable point and above all reduction of the risk of tampering by patients. Following an event concerning the last case, the management pushed towards a centralized installation on the first and second floors. On the lower floor this discourse loses its relevance for several reasons: the architecture is more modern, the vaults are flat, there is space for the passage of cables, a lot of space is needed to place the server network architecture, coupled and sources power supply, it is necessary to insert the electrical devices for low-potential user systems and it is necessary to consider the possible expansion of the system due to the addition of functions or the purchase of adjacent properties. In the end it was decided to use 3 large paintings of 56 units, two on the first floor and one on the ground floor. In addition, it has been calculated that 5 small panels with two DIN rails of 21cm each are sufficient. Most of the devices have a length of 7cm and correspond to 4 units, the coupler between the data DIN and TP is 2.3 cm thick and since the shutter actuators are from the data DIN it is necessary to provide one for each panel. Wanting to use small distributed boards, the DIKD1.5 connectors have been chosen to minimize the space occupied since they allow you to connect 3 pairs of cables with a thickness of 6mm, while for large boards the space is sufficient for standard connectors with a single channel. Using a spreadsheet, the autonomously controlled utilities were counted and on the basis of this the number of relays and the subdivision according to the type of control were deduced: on / off, step and stop, dimming or climate. On the basis of this calculation, the actuators already present in the lot were taken into account and those to be purchased from Eelettron [37] were added to these. The placement of the panels is linked to the absence of humidity and is conditioned to reduce the wiring as much as possible, this was done by taking the coordinates of

the functions in the cad project, inserting them in the spreadsheet¹¹ and calculating the distance in norm 1 from the reference panel. The two electrical panels on the first floor have been placed side by side in a maintenance area between the north-west bedroom. In the large cabinet positioned in the dining area to interface with the meter, the actuators that control: garden, terraces, intermediate floor, ground floor, stairs and enters must be present. For this, not yet taking into account the entrance in via Latiano, it was necessary to place, again by means of the calculation with Excel, the following actuators: 3 for relays, 2 for shutters, and 1 for climate. This result shows how the number of functions increases within the users as, as already mentioned, it's tried to provide maximum autonomy and individuality to the needs of patients.

7.7 ASSIGNING GROUPS TO OBJECTS

The assignment of groups to devices is simplified by the design choice of programming by functions, in fact it is sufficient to assign the functions to the actuators based on the spatial proximity of the actuator to the function, in order to minimize wiring. Finally, always based on the position, assign the corresponding sensor. The general functions concern the opening and closing scenes of the windows, for them it is sufficient to assign a single group for each scene.

Furthermore, as it has been noted, among the functions in the rooms there are also customized functions, the alarms are connected to a single binary group. In the control panel there are the communication groups of the setpoints and the HVAC objects explained in the Parameters chapter. Finally, the other customized functions contain a single group to which the objects of the SPACE sensor relating to the measured quantities and the objects of the BAOS module are connected. With the exception of the control panel all other functions will be displayed from the graphical interface by means of Thinka for this reason they are programmed as functions.

7.8 TESTS

As already mentioned, refurbished devices need testing to ensure their operation. As described in the development chapter, the devices consist of an application module and an interface to the data bus [6] and each of these parts must be tested to ensure correct operation.

The apparatus used to test the devices Figure 47, is the same used to test the device developed in the Development chapter. it can be seen that a connector is free to connect to other devices and that a 6-channel relay is mounted on it which is testing the first 3. The serial communication interface is a blue Weinzierl USB key.

¹¹ **ATTACHED**: The Excel tables containing the dimensioning are attached in the

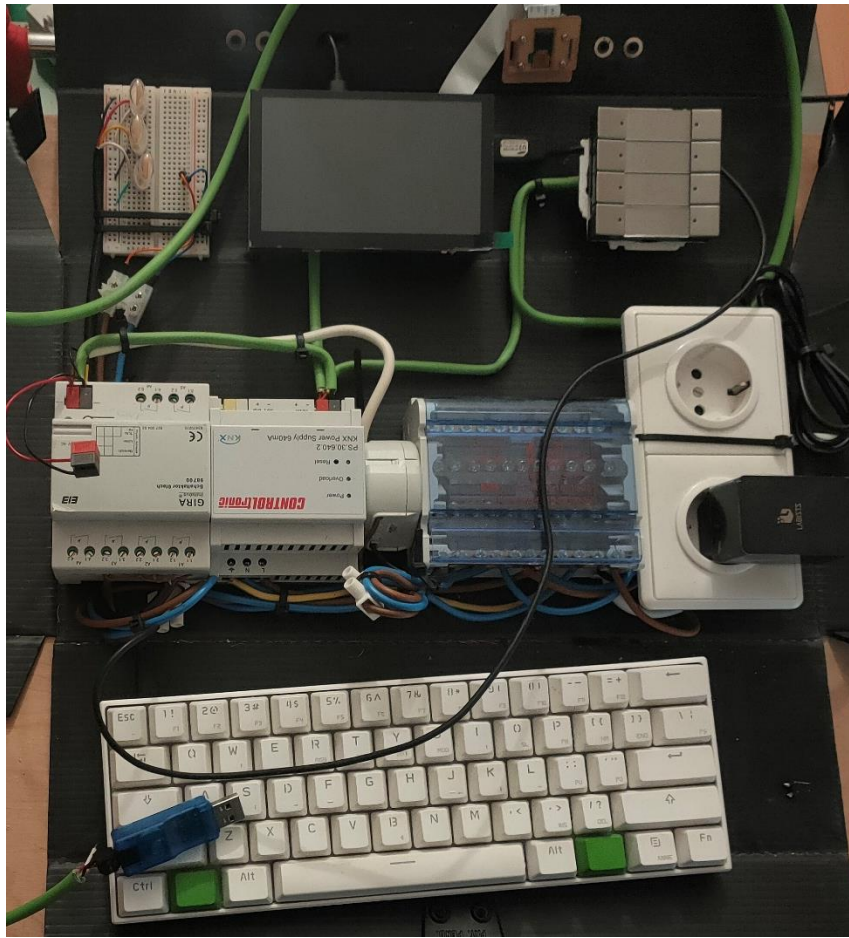


Figure 47 System built to test devices

7.8.1 Communication test between devices

To ensure communication, each device object must be associated with a group in ETS and then the defendants must be tested in the case of a sensor, otherwise it is necessary to communicate the values to the Write objects and determine if the corresponding feedback object sends a message. For temperature, presence and movement sensors, it is necessary to ensure that the performances shown on the datasheet are the same, for example by measuring the detection of a movement at a different distance or angle or by placing the thermal probe in ice (with the necessary precautions!).

7.8.2 Operation test of the application

While the communication test perfectly characterizes the functioning of the sensors, to guarantee the performance of the actuators it is necessary to test their implementation. In fact, it is often very common that a relay inside the device breaks or that a dimmer does not allow the off state due to an eddy current resulting from a break in a transistor. This test is carried out on dimmers by connecting them to an adjustable light while for the rest of the actuators that work from the relay it is sufficient as well as safer to check the resulting potential difference before and after switching on the relay by means of a multimeter. Then one pole of the multimeter is connected to a battery, the other to a relay input and finally the other relay input to the other pole of the battery. This test showed that a 16 relays actuator channel was not functional.

7.9 THINKA

The choice of orienting the programming in rooms and functions, as well as having an advantage in terms of security, allows the use of modern and self-configurable KNX IP routers [9]. In this case, given the knowledge in Alexa development [66], it was decided to use the Thinka PRO router [67], with the interface with Alexa and Apple home kit [68]. To configure the router it is necessary to upload the ETS project via the local network to the IP address of Thinka and it automatically takes into account the features present in each room. If you want to remotely control or by means of voice commands a light or any other actuator present in the home automation system, simply click or name the function preceded by the status and followed by the name of the room in which it is located, for example: "Alexa turn on COVID room light ". You can even change the names based on where alexa is in the house. For example if alexa is in the living room it would be unnatural to say to turn on the light in the living room by inserting other "utterances" [66] for example: "alexa turn on the light". It is also possible to create scenes in the ETS project in Thinka by linking groups and assigning names. Although it is not necessary to access the eco bonuses, it is necessary to allow remote control of the home automation system. At the request of the president, the device used as an interface is an iPhone. Thinka Figure 48, allows you to fully exploit the potential of the aforementioned device. Through an iOS application it is possible to configure Apple home kit automatically and directly from the device, guaranteeing a simple and pleasant interface together with an audio interface by means of Siri. In addition, this allows a tablet to be made available to the operator that allows monitoring of the structure from his room, and therefore allows him to intervene in the event of problems.



Figure 48 Thinka server

7.10 SPACE SENSOR

The main device of the installation is Eelectron's SPACE sensor Figure 49 [69]. The sensor has been designed in order to manage all the functions of the environment. It is therefore a multiple sensor that acts as: temperature probe, air humidity sensor, air quality and CO2 sensor, presence and movement sensor and tone sensor. It has 3 inputs configurable as analog or digital through which you can connect a probe or a push-button panel. The inputs can be configured for the control of the shutters, the management of the brightness, the activation of multiple scenarios and the change of HVAC mode. Furthermore, the sensor acts as a thermostat integrating the "Virtual holder" function in it, allowing the control of a fan coil by means of ventilation, activating it only if necessary. The sensor allows you to adjust the light and its quality as well as manage several rows of lights and lights of different shades at the same time. Finally, the sensor has 12 complete logic functions, which however are reduced as the functions increase until reaching the average of only 2 logics per sensor. With these characteristics, the space sensor becomes the center of home

automation programming. For this to describe the programming of the system it is sufficient to refer to this sensor.

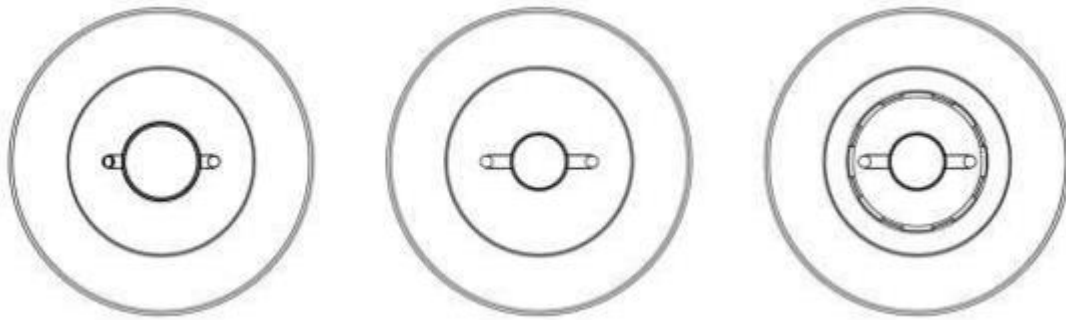


Figure 49 Eelectron multy sensors

7.11 AIRZONE INTERFACE

The airzone programming interface Figure 50 [70] is an alternative considered but ultimately not used. The main reason is that the thermal fluid of the system is air, and therefore it becomes difficult to pass the ventilation channels through the star vaults. In Airzone the entire home automation system is programmed through the interface. It defines the zones to be air-conditioned, the set points, and the interface of the approved thermostats. The entire system is managed through a specific bus, but it is possible to integrate the KNX system's opening, presence, time programming and logic sensors through the interface.



Figure 50 Airzone thermostat and gateway

7.12 EELECTRON CAPACITIVE THERMOSTAT

While for Thinka, the SPACE sensor, the pushbutton panels and the various actuators is an obligatory choice for economic and fictional reasons [71] doubts remain on the eelectron thermostat Figure 51. The reasons for these doubts are: The high cost, The easy replacement, the little need and the low functionality. In fact, the thermostat is not used with an adjustment function but as a control panel for the adjustment made by the SPACE sensor. A measure of how little its functionalities are exploited is given the number of logics present, which is inversely proportional to the functionalities, which has remained unchanged. Furthermore, with 5 logics it is limited as a Logic module. It has the possibility to vary the functionality of the keys in an evident way but the

capacitive and multifunction keys are too complicated for the user and would remain unused. In addition, any thermostat has the group addresses necessary for controlling the SPACE sensor and, as will be described in the parameters chapter, the functions of the thermostat are very limited as it is desired to limit the control of the climate control by the user. Finally, the most important reason is that considering the cost of the device and considering that the user can be violent, it is not worth the risk of having to buy the device bac



Figure 51 thermostat eelectron

7.13 DEVICE PROGRAMMING

7.13.1 SPACE sensor

As previously said, it is sufficient to show the choice of parameters of the SPACE sensor to fully describe the functionality of the system, so let's start from that. Referring to the Figure 52, the general parameters define which functions to use in the space sensor, in yellow the parameters changed from the factory settings.

7.13.1.1 General parameters

The 1st parameter refers to the sending time of the telegrams when the voltage is restarted in the BUS, it is necessary that this time be as different as possible between the devices belonging to the same line, and that it takes into account the number of messages to be sent. in order to keep the BUS charge low.

The 2nd parameter enables the essential sound sensor for functions such as the calculation of the occupancy index of an environment or for the combined presence detection.

The 3rd parameter is more suitable for sensors located in public areas or during the testing phase as the LED can disturb guests, especially if guests are autistic.

The 4th parameter allows you to select the functionality of the 3rd input which can act as an analogue input, using a temperature probe. In this project h = we have 2 temperature probes per room so it is more useful to have 3 digital inputs to be connected to opening sensors.

The 5th parameter allows the measurement and control of humidity. It has been enabled to allow cyclical sending of the values in order to acquire data for the analysis envisaged by the project, but it is not necessary to use the humidity control. The reason for this is of an economic and environmental nature, in fact with the fan coil system it is possible to simultaneously control the temperature and humidity of the outgoing air but it is necessary to use double coil fan coils which cost twice as much and heat pumps with recovery mechanisms which are also too expensive, the pipes should be doubled with an increase in costs and space, in the end the use of two fluids leads

to a substantial increase in the energy required for heating with economic consequences and environmental.

The 6th parameter enables the internal management of the temperature control. Changing this parameter would transform the device into a thermal probe for another device that manages the local heating control. This would certainly cause a greater distribution of the functions but this is compensated by the difficult accessibility of the device compared to a thermostat.

The 7th parameter enables the day / night telegram which allows programming by means of two times. This is not necessary as once the structure has been started and the target has been chosen, an hourly programming will be necessary. In fact, it is possible that the lower floor of the structure becomes a day center and therefore the hours of activity and the areas concerned become defined and precise.

The 8th parameter enables the use of the CO2 sensor, which has several purposes: to monitor the quality of the air, define the use of the room, allow the automatic change of air through the opening of the shutters, reduce the risk of fires by means of an alarm.

The 9th parameter enables the Circadian Rhythm, this function is present only in the hall on the first floor and is potentially also present in the laboratory room, based on the presence or not of attics. The purpose of this function is to regulate the relationship between warm and cold light following the circadian rhythm. In fact, it has been shown that this function has significant benefits regarding sleep and rest. Unfortunately, to manage a light with these characteristics it is necessary to use at least two Dimming channels for this is too expensive and is therefore suitable for common areas with a high utilization factor, in which it is not possible to insert several rows for adjust the brightness. For this reason, the living room is the only suitable place as the star vaults and the non-extendable surface of the window do not allow the insertion of more rows of lights.

The acquisition of the date and time is adjusted from the 10th to the 14th parameter. The date and time will be sent via Thinka's network synchronization.

The 15th parameter sends a request to Thinka in case the bus power failure restarts the device. This parameter is important since Thinka and the sensor are not on the same line and since in the Main line there is only Thinka it is possible that following a short power failure of the BUS only Thinka remains on. Per Thinka does not know that the other devices have lost their time data.

The 16th parameter enables the Virtual holder function, this function allows a combination of the presence, sound, opening and brightness sensors coming from both the SPACE sensor and other remote sensors and from the binary Inputs of the sensor itself connected to opening sensors. With these data the sensor is able to accurately guarantee the presence of a person in the room in order to activate the utilities only in case of need. It also allows the management of reservations and requests such as: room service or cleaning. These functions have been created for a hotel but can be useful if the structure is addressed to the Anxious and remote assistance.

The 17th parameter enables the VOC function which concerns the measurement of the quality of the air used, as well as the automatic opening of the shutter, for research purposes.

The 18th parameter enables the communication object "temperature alarm". The object which, as a diagnostic and maintenance purpose, in fact detects the malfunction of the space sensor or of the temperature probe possibly connected to the entry 3. This, together with the other alarms, are connected to fictitious group addresses (i.e. not connected to actuators) to the diagnostic purpose. In fact, these group addresses will implement virtual LEDs present in Thinka which will therefore allow an alarm message through alexa and a quick localization of the fault through apple home.

For the 19th parameter the same considerations apply as for the 3rd.

The 20th parameter enables the Test function of the device. To set the calibration parameters, to position the sensor so that it covers the desired area and to detect any defects, it is necessary to test the sensor in the environment before its installation.

1.1.84 Sensore di Presenza SPACE E03 > Parametri Generali > Parametri Generali

+	Parametri Generali	Ritardo invio telegrammi all'accensione [s]	6
+	Presenza	Sensore suono	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
+	Illuminamento	Usa led per evento suono	<input checked="" type="radio"/> no <input type="radio"/> sì
+	Presenza Remota	Tipo ingresso 3	digitale
+	Illuminamento Remoto	Sensore umidità	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
+	Sensore Suono	Funzione temperatura	termostato
+	Configurazione Canali	Oggetto giorno/notte	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
+	Ingressi	Usa sensore CO2	<input type="radio"/> no <input checked="" type="radio"/> sì
+	Umidostato	Usa ritmo circadiano	<input type="radio"/> no <input checked="" type="radio"/> sì
+	Temperatura	Formato data ora	<input checked="" type="radio"/> Data e Ora <input type="radio"/> DataOra
+	Termostato	Fuso orario è	<input checked="" type="radio"/> GMT + offset <input type="radio"/> GMT - offset
+	Sensore CO2	Ore offset fuso orario	1
+	Ritmo Circadiano	Minuti offset fuso orario	0
+		Richiedi orario all'accensione	<input type="radio"/> no <input checked="" type="radio"/> sì
+		Usa virtual holder	<input type="radio"/> no <input checked="" type="radio"/> sì
Oggetti di gruppo Canali Parametri			
+	Virtual Holder (funz. Presenza...	Usa sensore VOC	<input type="radio"/> no <input checked="" type="radio"/> sì
-	Sensore VOC	Oggetto allarme temperatura	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
	Riferimento	Usa led per evento presenza	<input checked="" type="radio"/> no <input type="radio"/> sì
		Abilita modalità test	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato

Figure 52 General space sensor parameters

The group objects associated with the general channel are those of Figure 53, as to be considered the objects correspond to datapoint 19.001, they will be associated with a fictitious group address as it will not be programmed through ETS but through Thinka Figure 54. Through this group address Thinka will send the date and time.

2	<Generale> Data Ingresso	Data	3 bytes	C	-	W	T	U	date
3	<Generale> Ora Ingresso	Tempo	3 bytes	C	-	W	T	U	time of day

Figure 53 Group objects associated with the General channel in the SPACE sensor

DateTime address

Thinka can act as a KNX datetime server. Please specify what group address you want Thinka to publish the datetime (DPT 19.001) to.

Time zone: Europe/Amsterdam

DateTime address: 7/7/7

[Change](#)

Figure 54 scheduling of DataOra sending through thinka

7.13.1.2 Presence

The presence sensor has standard parameters Figure 55:

The 1st concerns the sensitivity of the sensor and essentially depends on the type of activity and user as well as on the position of the sensor, since these design parameters are not clear at the moment, it has been chosen to leave it normal in all environments.

The 2nd and 3rd parameters specify the type of message to be sent, given that the management of the users is done inside the sensor this parameter concerns a binary object that will be connected only through the interface so that the operator can monitor attendance in the rooms.

4th, 5th and 6th parameters concern the Follow up time. In choosing this parameter, it must be taken into account that if the time is short, consumption is reduced but comfort risks diminishing. Therefore, in transit areas the Follow up time has been reduced to 5min while in the areas of prolonged presence the time is 10 minutes. The operation is described by the Figure 56.

The 7th parameter, on the other hand, concerns safety. In fact, through a cyclic sending, the system is protected against any tampering [72] the choice of this time depends on the Bus charge, therefore not all devices are equipped with it, in fact only the most vulnerable devices (those towards the end of the bus) are provided with it and it has been calculated a sending of 5min for the more exposed ones and 10min for the less exposed ones.

Figure 55 Presence channel parameters

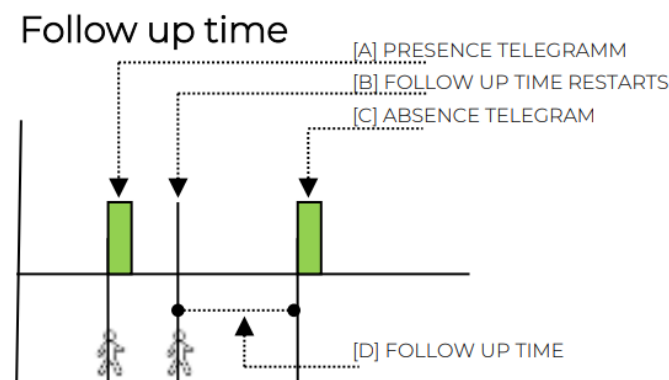


Figure 56 Follow up time

Figure 57, group object that sends the presence, not connected as we have the occupancy parameter and since its management is internal to the SPACE sensor

Figure 57 Presence / absence object

7.13.1.3 Illuminance

The brightness control is not a function Figure 58, applicable only where there are dimmers, in fact it is possible to program a brightness control in each room, that is: when the brightness exceeds a certain threshold and the person is present in the environment, if the light is not off, it switches on automatically. This is in fact the function implemented in rooms where natural light is present but artificial light is not regulated. Therefore, the illumination channel must be configured in each sensor.

The 1st parameter concerns the calibration mode, it is possible to choose between manual, 2-point and 4- point adjustment. The first is obtained by comparing it with a luxmeter, the second is done by simply inserting the brightness detected. In the 2-point calibration it is necessary, as in the Figure 59, to detect the brightness on the ceiling and on the surface directly below the sensor. In the 4-point calibration it is also necessary to measure the brightness on the walls (from the 2nd to the 5th parameter), the advantage is a greater calibration precision. The position of the sensor must be central in the room and the measurements must be made at night since the reference light must be the same.

The 6th parameter represents the speed of the control algorithm. The speed must be high enough to allow the person to adjust the light visually, but it must be low enough to prevent abrupt response to slight variations in brightness given for example by closing a door. For this reason the normal speed has been left during the testing phase, it can be changed according to the customer's needs.

The 7th and 8th parameters represent the scale limits, after which it makes no sense to send the value. Clearly the lowest is 0 otherwise if you close the window quickly the light would remain off, and the highest is 100 Lux since there is no need to adjust the light to 10000Lux.

The 9th parameter represents the minimum light variation for which it makes sense to send the brightness telegram.

The 10th parameter obviously set on no cyclical sending as the brightness control is done internally.

1.1.84 Sensore di Presenza SPACE E03 > Illuminamento > Illuminamento

Parametri Generali	Metodo regolazione	2 punti
Parametri Generali	Valore misurato al soffitto PT1 [* 10 Lux]	0
+	Valore misurato al piano PT1 [* 10 Lux]	0
Presenza	Valore misurato al soffitto PT2 [* 10 Lux]	0
-	Valore misurato al piano PT2 [* 10 Lux]	0
Illuminamento	Algoritmo media lux	normale
Illuminamento	Valore minimo uscita [* 10 Lux]	0
+	Valore massimo uscita [* 100 Lux]	100
+	Invia su variazione minima [Lux]	50
+	Tempo invio ciclico	nessun invio ciclico

Figure 58 Channel parameters Illuminance

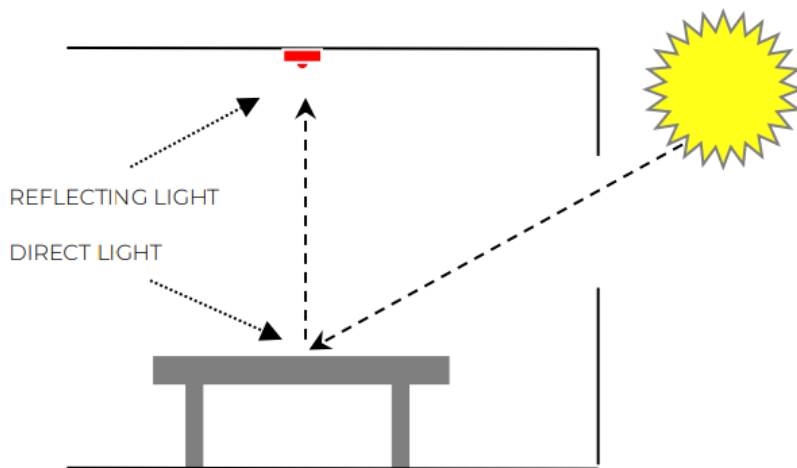


Figure 59 2-point calibration method

The resulting object is none other than the brightness DPT 9.004 Figure 60, but the calibration will also have an effect on the channels that will allow internal regulation. The purpose of this object is to be viewed through the Apple home interface for Thinka. For this reason, a specific reception-only group address has been programmed for each room.



Figure 60 Luminosity transmission object

7.13.1.4 Remote Presence

In large environments where it is not possible to use a single presence or movement sensor, it is necessary to insert the classic presence sensors in fact they will be connected through a binary input to the SPACE sensor and therefore the SPACE sensor must consider the data detected by these sensors as their own to cover the whole area. It is possible to enable up to 4 remote sensors Figure 61. The applications concern the largest spaces such as the living room and the dining-laboratory area, the passage areas that can be grouped, and the rooms with their respective bathrooms to apply the Virtual holder logic.

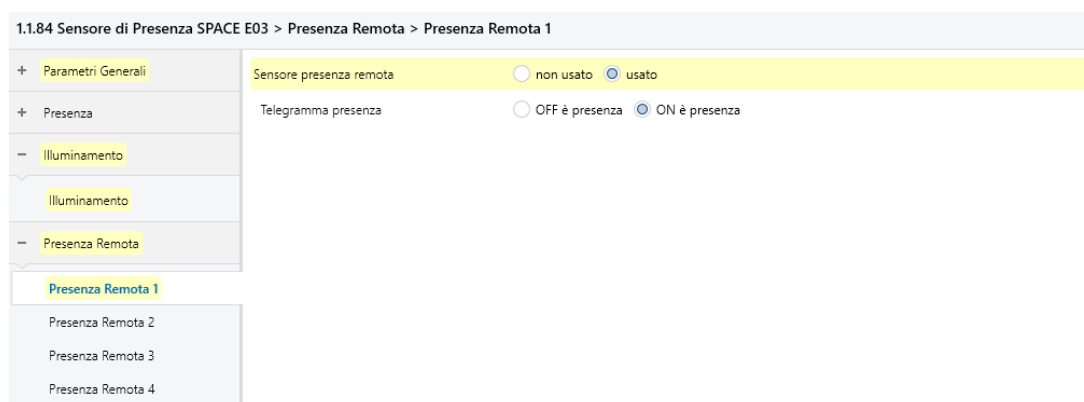


Figure 61 Parametri Presenza Remota

The resulting group object Figure 62, e will 'collect' the resistance information detected by another sensor but since it comes from a binary input of the sensor itself it will be managed locally.



Figure 62 Group object for receiving a telegram from a remote source

7.13.1.5 Remote Illumination

The Figure 63 remote illumination is not necessary in this application as despite having its importance in a large area such as the living room on the ground floor. It would lead to a huge increase in costs. As for the dining-laboratory area, this was treated as two distinct areas from the point of view of lighting due to the partition.

Figure 63 Remote Illuminance channel parameters

7.13.1.6 Sound Sensor

The parameters of the sound sensor are the same as those of the presence sensor, but some considerations must be made: the sensitivity must be lower as the sound is transferred from room to room, especially if the target is autism. In this way, more precise measurements will be obtained. Furthermore, he has no need to use the "Follow up" Figure 64.

Figure 64 Sound Sensor channel parameters

The purpose of these Figure 65, channels is like in the persistence one a monitoring purpose of the patient, on the other hand the safety purpose has less sense as the noise may not be correlated to the presence. For monitoring, on the other hand, it is more important as a patient can call the operator's attention remotely, for this the monitoring interface is more important therefore always through Thinka a voice message is sent through Alexa. Given that in some cases the call waiting could be unnecessary or annoying, it is possible for the operator to disable the object from the Ipad interface, he will then have to account for the reason why he has disabled the reception of the message as it has been activated. the T flag and the disabling message will be sent to the employer. Therefore, the Enable object is connected to two groups, one for enabling / disabling and the other for information on enabling / disabling.

4	<Sensore Suono> Uscita	Off/On	1 bit	C	R	-	T	-	switch	Basso
5	<Sensore Suono> Abilita	Disabilita/Abilita	1 bit	C	-	W	T	-	enable	Basso

Figure 65 Sound Sensor channel objects

7.13.1.7 Channel configuration with semi-automatic presence function, dependent on lighting

As already mentioned, the brightness control in the rooms takes place through the Channel Configuration channel (1st parameter Figure 66). It has also been anticipated that there are 2 ways to control brightness, one through a relay and the other through dimming. By setting the channel in "semi-automatic presence, dependent on lighting" it is possible to control a relay in such a way that it switches on only when it is switched on by the switch, there is a person in the room and there is a lower brightness at the threshold appropriate for that environment.

From the 3rd to the 7th parameter the device allows you to apply the already discussed remote presence. The reason why it gives the possibility of choice lies in the fact that it is possible to create very interesting logics allowing the adaptation of the environment according to the position of the individual and the light coming from a specific area. Unfortunately, it is too early from the design point of view to insert these complex functions, therefore it is possible to select all the inputs without distinction.

The 8th parameter is the equivalent of the 3rd but with remote lighting and as we have already commented it is not present.

The 9th parameter configures the light switch-on command that will be connected by means of a group address to the communication object of a push-button panel. The pushbutton panels have been configured in standard mode and to make it easier for users to understand the operation, symmetrical pushbutton panels with clear symbols have been chosen. a button has been deficient at on the symmetrical at off so they do not even need a status response from the actuator. The complex and global functions, on the other hand, are managed by the operator from a tablet.

Channels 10, 11 and 12 parameterize the Follow Up time already commented on previously.

The parameters between the 13th and the 15th are used to activate the standby and stop block functions. The standby function is related to the presence keeping the lights in case the follow up time ends, the block function is related to the channel block, and the stop function is related to the possibility of switching to non-automatic mode by controlling the light in a simple way from the channel. The resulting group object Figure 66, will be available to the operator who in particular needs to keep the light on in the environment.

The parameters 17 ° and the correlated 18 ° allow the monitoring of the occupation and with it also the monitoring of the operation of the device. The resulting objects will be put in communication with the BAOS device which will memorize their acquisition. Clearly, for reasons of bus occupation, the cyclic sending time is not enormous since these messages do not have a safety function.

The 19 ° parameter has already been commented in the illuminance channel.

The parameters 20 ° 21 ° allow a limitation to the brightness of the environment Figure 67, this is useful not only to safeguard expenses but also to have an eye towards photosensitive subjects like many autistic ones.

Parameter 22 ° allows you to create an illuminance hysteresis as shown in Figure 68. It is important that this hysteresis is correct because if it is too low it can cause rapid switching on and off which can be dangerous and harmful. If it is too high it can lead to situations where the light is not comfortable.

The 23 ° parameter is interesting and is the main reason why the sensitivity of the sound sensor is lowered. With this parameter it is possible to combine sound and presence to consistently increase

the number of events for the Follow up and if necessary it is possible to disable the sensor as previously explained.

1.1.84 Sensore di Presenza SPACE E03 > Configurazione Canali > Canale 1

+	Illuminamento Remoto	Tipo funzione	presenza semi-automatica, dipendente dall'illuminamento
+	Sensore Suono	Nome canale	
-	Configurazione Canali	Usa presenza remota	<input type="radio"/> no <input checked="" type="radio"/> sì
Canale 1		Presenza	<input type="radio"/> non usare <input checked="" type="radio"/> usa
<Canale 1> Uscita		Presenza remota 1	<input type="radio"/> non usare <input checked="" type="radio"/> usa
<Canale 1> Blocco		Presenza remota 2	<input type="radio"/> non usare <input checked="" type="radio"/> usa
Canale 2		Presenza remota 3	<input type="radio"/> non usare <input checked="" type="radio"/> usa
Canale 3		Presenza remota 4	<input type="radio"/> non usare <input checked="" type="radio"/> usa
Canale 4		Usa illuminamento remoto	<input checked="" type="radio"/> no <input type="radio"/> sì
Canale 5		Telegramma attivazione comando manuale	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
+	Ingressi	Tempo follow-up	
+	Umidostato	Ore	0
+	Temperatura	Minuti	10
		Secondi	0
+	Presenza	Funzione standby	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
-	Illuminamento	Funzione stop	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
	Illuminamento	Funzione blocco	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
+	Presenza Remota	Funzione monitoraggio	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
+	Illuminamento Remoto	Telegramma attivazione trigger	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
+	Sensore Suono	Tempo ciclico monitoraggio (0 = mai) [min]	60
-	Configurazione Canali	Algoritmo media lux	normale
	Canale 1	Soglia illuminamento [* 10 Lux]	100
	<Canale 1> Uscita	Ignora soglia illuminamento su evento semi-automatico	<input checked="" type="radio"/> no <input type="radio"/> sì
	<Canale 1> Stop	Isteresi illuminamento	300 Lux
	Canale 2	Configurazione Sensore Suono	
	Canale 3	Usa sensore suono durante il tempo di follow-up	<input type="radio"/> no <input checked="" type="radio"/> sì
		Tempo di ascolto del sensore suono in stato assenza (0 = nessuna reazione) [s]	0

Figure 66 Channel parameters Channel configuration with semi-automatic presence function, dependent on lighting

AMBIENTES	ILUMINANCIA EN SERVICIO (lux)
Viviendas	
Dormitorios	
- general	50
- cabecera de cama	200
Baños	
- general	100
- área de espejo	500
Salas	
- general	100
- área de lectura	500
Salas de estar	100
Cocinas	
- general	300
- áreas de trabajo	500
Área de trabajo doméstico	300
Dormitorio de niños	100

Figure 67 typical brightness for environments

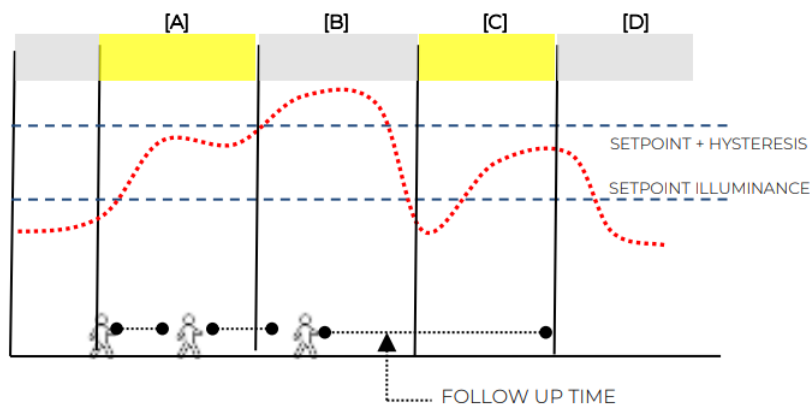


Figure 68 Semi-automatic presence operation, dependent on lighting

The activation of a channel generates the output parameters Figure 69, which will then be linked to the previously described switchable lighting functions. Only the first output needs to be connected. But it is possible in the future to associate the second output with specific applications. The third output is configurable, that is, it is possible to send information of your choice of different sizes.

1.1.84 Sensore di Presenza SPACE E03 > Configurazione Canali > <Canale 1> Uscita

Parametri Generali	Uscita A	
Presenza	Esegui azione assenza	<input type="radio"/> no <input checked="" type="radio"/> sì
Iluminamento	Esegui azione presenza	<input type="radio"/> no <input checked="" type="radio"/> sì
Iluminamento	Telegramma presenza	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
Presenza Remota	Uscita B	
Presenza Remota	Esegui azione assenza	<input type="radio"/> no <input checked="" type="radio"/> sì
Iluminamento Remoto	Esegui azione presenza	<input type="radio"/> no <input checked="" type="radio"/> sì
Sensore Suono	Telegramma presenza	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
Configurazione Canali	Uscita C - configurabile	
Canale 1	Tipo uscita C	nessuno
<Canale 1> Uscita	Invio ciclico presenza	nessun invio ciclico
<Canale 1> Stop		
Canale 2		

Figure 69 Semi-automatic presence operation, dependent on lighting

By enabling the Stop parameter, the respective Figure 70, parameters are generated. It is possible to start the function after a certain time.

1.1.84 Sensore di Presenza SPACE E03 > Configurazione Canali > <Canale 1> Stop

Parametri Generali
Parametri Generali
Presenza
Illuminamento
Presenza Remota
Illuminamento Remoto
Sensore Suono
Configurazione Canali
Canale 1
<Canale 1> Uscita
<Canale 1> Stop
Canale 2

Stato stop dopo il download
☒ attivo ☐ stop

Stato stop all'accensione
attivo

Telegramma per attivo
☐ telegramma "0" ☒ telegramma "1"

Telegramma per riavvio
☐ telegramma "0" ☒ telegramma "1"

Tempo riavvio automatico (0 = non temporizzato) [min]
4

Figure 70 Stop channel configuration, semi-automatic presence function, dependent on lighting

As it is possible to notice from the Figure 71, the objects from 17 to 29 allow the functions that have been chosen by means of the parameters. The object 17 is connected to the push-button panel, the objects 19 to 21 allow to stop the semi-automatic operation by means of telegrams with different datatypes. Object 22, on the other hand, allows the function to be restarted, while object 23 warns that the function has been restarted. The 24 and 25 are connected to the actuators while the rest are used for monitoring as previously commented.

17	<Canale 1> Comando Semiautomatico	Off/On	1 bit	C - W - -	switch	Basso
19	<Canale 1> Stop 1 Bit	Stop 1 Bit	1 bit	C - W - -	switch	Basso
20	<Canale 1> Stop 4 Bit	Stop 4 Bit	4 bit	C - W - -	dimming control	Basso
21	<Canale 1> Stop 1 Byte	Stop 1 Byte	1 byte	C - W - -	percentage (0..100%)	Basso
22	<Canale 1> Riavvio	Off/On	1 bit	C - W - -	switch	Basso
23	<Canale 1> Attivo/Stop	Attivo/Stop	1 bit	C R - T -	switch	Basso
24	<Canale 1> Uscita A	Off/On	1 bit	C R - T -	switch	Basso
25	<Canale 1> Uscita B	Off/On	1 bit	C R - T -	switch	Basso
27	<Canale 1> Trigger Monitoraggio	Off/On	1 bit	C - W - -	trigger	Basso
28	<Canale 1> Monitoraggio Utilizzo	Valore 0-100%	1 byte	C R - T -	percentage (0..100%)	Basso
29	<Canale 1> Monitoraggio Occupazione	Occupazione	2 bytes	C R - T -	pulses	Basso

Figure 71 Semi-automatic presence operation, dependent on the lighting of group objects

7.13.1.8 Channel configuration with semi-automatic presence function, dependent on lighting

If the first parameter of the channel is changed to: "semi-automatic presence function, depending on the lighting" the configured parameters remain the same until the 17th absent in the new channel Figure 72.

The 17th parameter is the speed of the medialux algorithm the same as in the previous case.

The 18th parameter indicates the brightness setpoint to be kept constant, obviously this parameter can be overwritten by the operator.

The 19th parameter indicates the speed with which the light is regulated, since the operator is required to regulate the light at a distance, a rapid regulation as you would like in presence is annoying for the user who is in the regulated area for this is set to normal.

The 18th and 19th parameters are the same last two parameters of the previous chapter

1.1.84 Sensore di Presenza SPACE E03 > Configurazione Canali > Canale 2

+ Presenza	Tipo funzione	illuminamento automatico, dipendente dalla presenza, semi-automatica
+ Illuminamento	Nome canale	
+ Presenza Remota	Usa presenza remota	<input type="radio"/> no <input checked="" type="radio"/> sì
+ Illuminamento Remoto	Presenza	<input type="radio"/> non usare <input checked="" type="radio"/> usa
+ Sensore Suono	Presenza remota 1	<input type="radio"/> non usare <input checked="" type="radio"/> usa
- Configurazione Canali	Presenza remota 2	<input type="radio"/> non usare <input checked="" type="radio"/> usa
Canale 1	Presenza remota 3	<input type="radio"/> non usare <input checked="" type="radio"/> usa
<Canale 1> Uscita	Presenza remota 4	<input type="radio"/> non usare <input checked="" type="radio"/> usa
<Canale 1> Stop	Usa illuminamento remoto	<input checked="" type="radio"/> no <input type="radio"/> sì
Canale 2	Telegramma attivazione comando manuale	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
<Canale 2> Uscita	Tempo follow-up	
<Canale 2> Stop	Ore	0
Canale 3	Minuti	10
Canale 4	Secondi	0
- Configurazione Canali	Funzione standby	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
Canale 1	Funzione stop	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
<Canale 1> Uscita	Funzione blocco	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
<Canale 1> Stop	Algoritmo media lux	normale
Canale 2	Setpoint dopo download [* 10 Lux]	50
<Canale 2> Uscita	Velocità regolazione	normale
<Canale 2> Stop	Configurazione Sensore Suono	
Canale 3	Usa sensore suono durante il tempo di follow-up	<input type="radio"/> no <input checked="" type="radio"/> sì
Canale 4	Tempo di ascolto del sensore suono in stato assenza (0 = nessuna reazione) [s]	0

Figure 72 Channel parameters Channel configuration Automatic lighting, with semi-automatic presence function, depending on the lighting

Since it is a dimmer adjustment, the parameters of the outputs Figure 73, are totally different.

The 1st parameter is a delay which has the purpose of synchronizing the channels in order to regulate the charge in the bus.

The 2nd parameter indicates the brightness when the subject enters the room and is set at 50% for a modern lighting effect.

The 3rd parameter allows you to turn on the lights even if the external brightness is always sufficient to give that "modern" effect which, however, in this case loses its practicality, therefore it is set to off.

The 4th parameter is interesting as it would allow to maintain a minimum brightness in the rooms and even if there would be no high consumption, a faster wear of the dimmer would be obtained with a consequent impact on maintenance costs. For this it is set to 0% which for the dimmer is equivalent to off.

The 5th parameter is important as it allows uniform control of the brightness applied in the lounge on the ground floor and in the dining area. It is possible to control up to 5 distinct rows of lights, in this case 3 rows for the living room and 2 for the dining area will be controlled.

The following 5 parameters allow to relate the rows of lights to the brightness they generate in the sensor area [73] and are therefore to be programmed through a careful calibration on site.

The next 3 parameters concern the behavior upon switching on as the sensor is semi-automatic.

The last parameter concerns the sending of the detected brightness which is irrelevant as the brightness is already memorized at each variation of 50 lux.

1.1.84 Sensore di Presenza SPACE E03 > Configurazione Canali > <Canale 2> Uscita		
+ Presenza	Ritardo minimo telegramma uscita	5 s
+ Illuminamento	Luminosità iniziale in presenza	50%
+ Presenza Remota	Invia luminosità iniziale quando sopra il setpoint	<input checked="" type="radio"/> no <input type="radio"/> si
+ Illuminamento Remoto	Valore assenza	0%
+ Sensore Suono	Numero di zone controllate	2
- Configurazione Canali	Zona master	<input checked="" type="radio"/> zona 1 <input type="radio"/> zona 2
Canale 1	Valore minimo zona 1	0%
<Canale 1> Uscita	Valore massimo zona 1	100%
<Canale 1> Stop	Offset zona 2	0%
Canale 2	Valore minimo zona 2	0%
<Canale 2> Uscita	Valore massimo zona 2	100%
<Canale 2> Stop	Offset dopo download	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
Canale 3	Offset all'accensione	prima del power OFF
Canale 4	Telegramma attivazione offset	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
	Invio ciclico luminosità	nessun invio ciclico

Figure 73 Outputs channel configuration, semi-automatic presence function, dependent on lighting Channels Automatic lighting, with semi-automatic presence function, dependent on lighting outputs channel configuration, semi-automatic presence function, dependent on lighting

The stop parameters are the same as in the previous chapter.

The group objects created Figure 74, are very similar to the previous ones, the monitoring objects are missing, but the setpoint object is present which can always be configured by means of an Ipad interface and by means of an ABB dimming channel. There is an object that create an offset between the rows of lights, which will not be connected, and the status values, one for each controlled row, to be connected to a group to allow viewing via the interface.

31	<Canale 2> Comando Semiautomatico	Off/On	1 bit	C	-	W	-	-	switch	Base
33	<Canale 2> Stop 1 Bit	Stop 1 Bit	1 bit	C	-	W	-	-	switch	Base
34	<Canale 2> Stop 4 Bit	Stop 4 Bit	4 bit	C	-	W	-	-	dimming control	Base
35	<Canale 2> Stop 1 Byte	Stop 1 Byte	1 byte	C	-	W	-	-	percentage (0..100%)	Base
36	<Canale 2> Riavvio	Off/On	1 bit	C	-	W	-	-	switch	Base
37	<Canale 2> Attivo/Stop	Attivo/Stop	1 bit	C	R	-	T	-	switch	Base
38	<Canale 2> Setpoint Illuminamento	Lux	2 bytes	C	-	W	-	-	lux (Lux)	Base
39	<Canale 2> Offset Luminosità Uscita	Abilita/Disabilita	1 bit	C	-	W	-	-	enable	Base
40	<Canale 2> Luminosità Uscita Zona 1	Valore 0-100%	1 byte	C	R	-	T	-	percentage (0..100%)	Base
41	<Canale 2> Luminosità Uscita Zona 2	Valore 0-100%	1 byte	C	R	-	T	-	percentage (0..100%)	Base

Figure 74 Semi-automatic presence function, dependent on lighting Channels Automatic lighting, with semi-automatic presence function, dependent on lighting or group objects

7.13.1.9 Input Channels Configuration

The inputs can be configured in various ways, one of the most economical possibilities is to configure them for the opening and closing sensors of doors or windows and for the smoke detector.

For opening sensors it is necessary that they send a message when the contact is opened and closed. Furthermore, in the case of the door opening sensor, to make it compatible with the VH function, it is necessary that at closing there is an off and at opening it must be on Figure 75. The above considerations do not apply to the window opening sensor as the "Thermostat" channel has a parameter that allows you to consider the event from both on and off. An important consideration is the fact that the window opening sensor has a relevant function in the security against theft, for this reason it must have enabled cyclic sending and for reasons of bus charge considering the number of windows it must be no less than 1min Figure 76.

Finally, with regard to the smoke detector, it is sufficient that it sends a message if it detects a fire and therefore closes the contact. Furthermore, since it is a relevant element from the point of view of people's safety, it is necessary that there is a periodic check of its operation for this reason every 4 hours Figure 77, it will send if this message is not sent a message will be triggered in the maintenance page.

1.1.84 Sensore di Presenza SPACE E03 > Ingressi > Ingresso 1

+ Parametri Generali	Funzione	attivazione su chiusura/apertura contatto
+ Presenza	Nome ingresso	
+ Illuminamento	Tempo antirimbombo lettura ingressi	80 ms
+ Presenza Remota	Oggetto abilita/disabilita	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
+ Illuminamento Remoto	Telegramma associato	<input checked="" type="radio"/> 1 bit <input type="radio"/> 1 byte
+ Sensore Suono	Comando associato a chiusura	off
+ Configurazione Canali	Comando associato all'apertura	on
- Ingressi	Oggetto comunicazione su apertura	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
	Oggetto stato attuatore	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
	Tempi ciclici lunghi brevi	<input checked="" type="radio"/> corti <input type="radio"/> lunghi
	Ingresso 1	
	Ingresso 2	
	Ingresso 3	
+ Umidostato	Invio ciclico con contatto chiuso	mai
	Invio ciclico con contatto aperto	mai

Figure 75 Parameter input for door opening

1.1.84 Sensore di Presenza SPACE E03 > Ingressi > Ingresso 2

Parametri Generali	Funzione	attivazione su chiusura/apertura contatto
Presenza Remota	Nome ingresso	
Illuminamento Remoto	Tempo antirimbombo lettura ingressi	80 ms
Sensore Suono	Oggetto abilita/disabilita	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
Configurazione Canali	Telegramma associato	<input checked="" type="radio"/> 1 bit <input type="radio"/> 1 byte
Ingressi	Comando associato a chiusura	off
Ingresso 1	Comando associato all'apertura	on
Ingresso 2	Oggetto comunicazione su apertura	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
Ingresso 3	Oggetto stato attuatore	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
Umidostato	Tempi ciclici lunghi brevi	<input type="radio"/> corti <input checked="" type="radio"/> lunghi
Temperatura	Invio ciclico con contatto chiuso	5 minuti
Termostato	Invio ciclico con contatto aperto	mai

Figure 76 Ingresso parametri per apertura finestra

1.1.84 Sensore di Presenza SPACE E03 > Ingressi > Ingresso 3

Parametri Generali	Funzione	attivazione su chiusura contatto
Presenza	Nome ingresso	
Illuminamento	Tipo di contatto	<input checked="" type="radio"/> normalmente aperto <input type="radio"/> normalmente chiuso
Presenza Remota	Tempo antirimbombo lettura ingressi	80 ms
Illuminamento Remoto	Oggetto abilita/disabilita	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
Sensore Suono	Telegramma associato	<input checked="" type="radio"/> 1 bit <input type="radio"/> 1 byte
Configurazione Canali	Comando associato a chiusura	on
Ingressi	Tempi ciclici lunghi brevi	<input type="radio"/> corti <input checked="" type="radio"/> lunghi
Ingresso 1	Invio ciclico con contatto chiuso	4 ore
Ingresso 2		
Ingresso 3		
Umidostato		

Figure 77 Ingresso parametri per rilevatore di fumo

As it is possible to notice from the Figure 78 the writing flag has been removed from the group objects in this way the system is less susceptible to tampering or tampering attempts or false alarms. If the flag had not been removed, anyone connecting to the bus could make sure to cancel the detection of the opening using the debounce time, set off the fire alarm etc.

87	<Ingresso 1> Chiusura - Apertura	Off/On	1 bit	C	R	-	T	-	switch
91	<Ingresso 2> Chiusura - Apertura	Off/On	1 bit	C	R	-	T	-	switch
95	<Ingresso 3> Chiusura	Off/On	1 bit	C	R	-	T	-	switch

Figure 78 Inputs group objects

7.13.1.10 Humidistat Channel Configuration

As previously mentioned, humidity control is expensive and therefore a luxury function since the project is financed by public funds it is not possible to include this function. Therefore, as far as the parameters are concerned, they must be chosen in such a way as to guarantee the measurement of humidity in uncontrollable conditions. For this the lower and upper thresholds have been moved and the control or alert functions have been blocked Figure 79.

1.1.84 Sensore di Presenza SPACE E03 > Umidostato > Umidostato

+ Parametri Generali	Telegramma attivazione per abilita	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
+ Presenza	Stato dopo download	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
+ Illuminamento	Invio umidità su variazione	1% ▼
+ Presenza Remota	Invio periodico umidità	no invio periodico ▼
+ Illuminamento Remoto	Isteresi	0.5% ▼
+ Sensore Suono	Taratura sensore	nessuno ▼
+ Configurazione Canali	Soglia superiore	70 ▲▼
+ Ingressi	Telegramma con misura sopra soglia	nessuna azione ▼
- Umidostato	Telegramma con misura sotto soglia	nessuna azione ▼
Umidostato	Telegramma con umidostato disabilitato	nessuna azione ▼
+ Umidostato	Soglia inferiore	20 ▲▼
+ Temperatura	Telegramma con misura sopra soglia	nessuna azione ▼
+ Termostato	Telegramma con misura sotto soglia	nessuna azione ▼
	Telegramma con umidostato disabilitato	nessuna azione ▼
	Controllo punto di rugiada	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato

Figure 79 Parameter humidistat

Of the 4 generated Figure 80, group objects, only number 100 will be used. Like many parameters it is used for monitoring via Thinka and storage for analysis via the BAOS module. It might be interesting to find that humidity affects a particular disability.

99	<Umidostato> Abilita	Disabilita/Abilita	1 bit	C	-	W	-	-	enable
100	<Umidostato> Umidità	Umidità %	2 bytes	C	R	-	T	-	humidity (%)
101	<Umidostato> Comando Soglia Superiore	Off/On	1 bit	C	R	-	T	-	switch
102	<Umidostato> Comando Soglia Inferiore	Off/On	1 bit	C	R	-	T	-	switch

Figure 80 Group objects humidistat

7.13.1.11 Temperature Channel Configuratio

In each room there are two temperature probes: that of the sensor itself and that of the control panel. To obtain a global measurement of the temperature in the room it is possible to use both of them by means of the 1st parameter Figure 81.

The 2nd parameter enables the group object to send the temperature measured excellent for monitoring and diagnostics.

The 3rd parameter refers to cyclical sending and given that the object for monitoring the sensor fault is already present it is not necessary for the purposes of diagnostics and therefore sending upon variation of the 4th parameter is sufficient.

The 4th parameter must be greater than the accuracy of the control (0.1 oC) and greater than the sending on variation of the control panel to avoid distorting the measurement.

The 5th parameter refers to the weight of the internal probe for the purpose of an average weighted with the external probe. We have chosen to reduce the weight of the internal probe as, unlike the control panel, the SPACE sensor is located on the ceiling and therefore is clearly subject to higher temperatures than those in which the subject is.

The last parameters concern the calibration of the sensor which is a complex mechanism as the temperature is a slow variable to measure, so it is better to trust the manufacturer.

1.1.84 Sensore di Presenza SPACE E03 > Temperatura > Temperatura di riferimento

Sorgente temperatura	mix tra sonda interna e sonda via KNX
Oggetto misura temperatura	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
Intervallo di invio	mai
Invio su variazione	0.5°C
Peso misura sonda interna	30%
Calibrazione sensore interno [0.1°C]	0
Calibrazione sensore KNX [0.1°C]	0
Tempo di sorveglianza sonda KNX (0=disabilitato) [min]	15

Temperatura di riferimento

Figure 81 Temperature parameters

The group objects Figure 82, generated include the object W for acquiring the external temperature, the object T for sending the average temperature and the alarm object previously described among the general parameters.

106	<Temperatura> Allarme	Off-On	1 bit	C R - T -	alarm	Basso
107	<Temperatura> Temperatura Attuale	Valore °C	te... 3... 2 bytes	C R - T -	temperature (°C)	Basso
108	<Temperatura> Sonda temperatura KNX	Valore °C	2 bytes	C - W - -	temperature (°C)	Basso

Figure 82 Temperature Group Object

7.13.1.12 Thermostat Channel Configuration

The thermostat function allows you to control a fan coil through the shit temperature obtained from the previous channel and through the setpoints sent from the control panel. At this moment it is not possible to define the fan coil rest but let's assume a 3 speeds fan coil. In this case any relay actuator is able to control the machine. Furthermore, for technical reasons it was decided not to insert the regulation valve in the fan coil. The valve tends to wear rapidly, moreover the losses caused in the environment by the absence of the valve remain in the environment. For this reason, by balancing losses and maintenance, given the complexity of the system, it was decided not to use it. Let's analyze the parameters in Figure 83:

The 1st parameter selects the thermal machine to be controlled.

The 2nd parameter defines the type of fan coil, as previously mentioned since we do not have to control the humidity, the fan coil selected is the 2-pipe one.

The 3rd parameter defines the type of valve, usually they are on / off valves but in this case the parameter is irrelevant since the fan coil will not have the valve.

The 4th parameter allows mixed control of the environment in case there is another actuator. Due to the eco bonus, as explained above, it is not possible to keep the old system, therefore the parameter is disabled.

The 5th is essential because if it were set automatically the thermostat would activate the heating or cooling mode independently of the other thermostats and above all independently of the fluid generated by the heat pump. This would easily protect the system from instability, therefore it is necessary to synchronize the thermostats by means of a command coming from the heat pump itself. The parameter also defines the type of control whether on heating, cooling or both. The advantage of heat pumps is that they act as generators for both ways.

The 6th and 7th parameters define the modalities in which the system enters after the application download.

The 9th parameter is used to modify the setpoints. This is a choice of the menu and is therefore inaccessible from the interface and from the control panel, so it can be accessed via ETS direct programming and not to program the devices every time the group objects have been enabled and connected to groups that are not associated and to be deleted from Thinka's automatic programming.

The 10th parameter allows the air conditioning to be blocked if the window is opened. This is done by connecting the object generated with the previously configured input in the same group. Furthermore, the 11th parameter is configured consistently with what has been said before.

The 12th and 13th parameters allow you to switch off the thermostat in case of breakdowns or special needs as the best way to switch off the heating is from the generator.

Figure 83 Parameters Settings Thermostat

The Setpoint HVAC heating / cooling panel Automatic allows you to manage the setpoints, obviously the choice of these setpoints must be made together with the management Figure 84.

1.1.84 Sensore di Presenza SPACE E03 > Termostato > Setpoint HVAC risc./raffr. Automatico

+ Configurazione Canali	Banda morta	2°C
+ Ingressi	Setpoint antigelo	7°C
+ Umidostato	Setpoint protezione alte temperature	35°C
+ Temperatura	ATTENZIONE!: Tch>=Tsh>=Teh	
- Termostato	Setpoint economia riscaldamento (Teh)	16°C
	Setpoint standby riscaldamento (Tsh)	18°C
	Setpoint comfort riscaldamento (Tch)	20°C
Impostazioni Termostato	Azione da eseguire per il setpoint	<input type="radio"/> modifica relativo <input checked="" type="radio"/> modifica assoluto
Setpoint HVAC risc./raffr. Au...	Setpoint comfort	<input checked="" type="radio"/> setpoint H/C <input type="radio"/> centro banda morta
Variazione Setpoint		
Fan Coil – Controllo ON OFF		

Figure 84 Parameters Settings Thermostat

The Setpoint variation panel Figure 85 allows you to limit the variation of the setpoints by users in order to contain expenses.

The 1st and 2nd parameters allow you to reset the setpoint to that defined in the previous panel. To reduce waste to a minimum, we have chosen to reset the setpoint when the economy mode is activated, which is a more frequent and homogeneous event than the change in heat / cool.

The 3rd parameter defines the setpoint variation interval which has been limited to 2 degrees but could also decrease according to the patient's ability to manage the environment.

The 4th parameter defines a format compatible with the control panel.

1.1.84 Sensore di Presenza SPACE E03 > Termostato > Variazione Setpoint

+ Configurazione Canali	Reset variazione setpoint al cambio risc./raffr. <input checked="" type="radio"/> no reset <input type="radio"/> reset
+ Ingressi	Reset variazione setpoint con HVAC economia <input type="radio"/> no reset <input checked="" type="radio"/> reset
+ Umidostato	Regolazione consentita -/+ 2°C
+ Temperatura	Variazione setpoint - formato oggetto <input type="radio"/> oggetto 1 bit - incrementa / decrementa <input checked="" type="radio"/> oggetto 2 bytes - valore temperatura
- Termostato	Variazione SP - mantieni all'accensione <input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
Impostazioni Termostato	
Setpoint HVAC risc./raffr. Auto...	
Variazione Setpoint	
Fan Coil – Controllo ON OFF	

Figure 85 Thermostat Parameters Setpoint variation

The generated group objects allow communication between the thermostat and the control panel as well as the interface generated by thinka. As previously explained, the SP objects can be modified by the management via ETS, the object 1 09 is controlled exclusively by the generator, the window contact is connected to one of the inputs and the last 3 remaining (112 113 114) are connected to the symmetrical content generated by the control panel. It is possible to notice that the HVAC mode Transmission flag has been activated in such a way as to send feedback to the control panel Figure 86.

109	<Termostato> Modalità Risc./Raffr.	Risc./Raffr.	1 bit	C	-	W	-	-	cooling/heating	Base
110	<Termostato> Contatto Finestre	Chiuso/Aperto	1 bit	C	-	W	-	-	window/door	Base
112	<Termostato> Modo HVAC	Comf/Standby/Eco/Protezione m...3...	1 byte	C	R	W	T	-	HVAC mode	Base
113	<Termostato> Setpoint Attuale	Valore °C	te...3... 2 bytes	C	R	-	T	-	temperature (°C)	Base
114	<Termostato> Variazione Setpoint	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base
115	<Termostato> SP Economia Riscaldamento	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base
116	<Termostato> SP Standby Riscaldamento	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base
117	<Termostato> SP Comfort Riscaldamento	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base
118	<Termostato> SP Economia Raffrescamento	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base
119	<Termostato> SP Standby Raffrescamento	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base
120	<Termostato> SP Comfort Raffrescamento	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Base

Figure 86 Thermostat group objects

The last panel of the Thermostat channel is in turn a channel and allows the control of the Fan Coil Figure 87, in speed since it is on / off.

The 1st parameter decides whether to control in heating or cooling or in both ways. The choice is obvious.

The 2nd parameter as previously considered determines the type of fan coil.

The 3rd parameter is not defined as it is still necessary to select the machine but usually if the ventilation is controlled by a DC motor it has 3 independent windings and therefore 3 speeds.

The following parameters are used to define the choice of speed based on the temperature difference and are parameters to be modified according to the machine, its ventilation power and its noise.

The last 3 parameters allow the user to adjust the ventilation speed and the valves. Unfortunately, this adjustment is useless in front of the valve and the air conditioning is practically given only by the ventilation, therefore it is impossible to air condition the room if the ventilation is off.

1.1.84 Sensore di Presenza SPACE E03 > Termostato > Fan Coil – Controllo ON OFF

+ Configurazione Canali	Abilita accensione velocità fancoil	risc. / raffr.
+ Ingressi	Tipo di impianto	<input checked="" type="radio"/> 2 tubi <input type="radio"/> 4 tubi
+ Umidostato	Numero di velocità	3 velocità
+ Temperatura	Differenziale regolazione V1-SP riscaldamento	0°C
- Termostato	Differenziale regolazione SP-V1 raffreddamento	0°C
Impostazioni Termostato	Differenziale regolazione V1-V2 riscaldamento	0.8°C
Setpoint HVAC risc./raffr. Auto...	Differenziale regolazione V2-V1 raffreddamento	0.8°C
Variazione Setpoint	Differenziale regolazione V2-V3 riscaldamento	0.8°C
Fan Coil – Controllo ON OFF	Differenziale regolazione V3-V2 raffreddamento	0.8°C
+ Sensore CO2	Gestisci valvole in modo indipendente	<input checked="" type="radio"/> no <input type="radio"/> sì
+ Ritmo Circadiano	Valore iniziale oggetto MAN (0) / AUTO (1)	<input type="radio"/> 0 <input checked="" type="radio"/> 1
	Abilita oggetto ventilazione on/off	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato

Figure 87 Fan Coil Parameter Thermostat - ON OFF Control

The parameters in the Fan Coil channel are used to control the FIGURE fan coil, in this case a universal actuator with relay is sufficient to perform the control function. The 3 speed channels are sufficient as there is no valve. As just specified, object 121 is not connected but the effect is compensated by the imposition of the mode by the generator as explained previously. Objects 125,

126 and 127 are linked to the switching channels of the actuator. The choice of whether or not to force the ventilation by means of the last 4 channels is to be defined on the basis of the noise of the fan coil.

121	<Fan Coil> Valvola Riscaldamento/Raffresca...	Off/On	1 bit	C R - T - switch	Basso
125	<Fan Coil> Velocità 1	Off/On	1 bit	C R - T - switch	Basso
126	<Fan Coil> Velocità 2	Off/On	1 bit	C R - T - switch	Basso
127	<Fan Coil> Velocità 3	Off/On	1 bit	C R - T - switch	Basso
128	<Fan Coil> Imposta Modalità Manuale/Auto...	Manuale (0) / Auto (1)	1 bit	C - W - - switch	Basso
129	<Fan Coil> Forzatura Velocità 1	Off/On	1 bit	C - W - - switch	Basso
130	<Fan Coil> Forzatura Velocità 2	Off/On	1 bit	C - W - - switch	Basso
131	<Fan Coil> Forzatura Velocità 3	Off/On	1 bit	C - W - - switch	Basso

Figure 88 Fan Coil group objects

The control algorithm used is explained in the Table 4; reference is made to the of the parameters concerning the HVAC heating / cooling setpoint. Automatic.

Table 4 Fan Coil speed control algorithm

	HEATING	COOLING
<p>Tsp : Target setpoint temperature TdrV1SP : regulation differential for V1-SP TdrV1V2 : regulation differential for V1-V2 TdrV2V3 : regulation differential for V2-V3</p> <p>INCREASING OF TEMPERATURE</p>		
<p>DECREASING OF TEMPERATURE</p>		

7.13.1.13 CO2 Sensor Configuration

The CO2 sensor ensures good air quality and prevents fires. The sensor should not be substituted for normal smoke detectors, it has an air quality monitoring function. Furthermore, with the present

pandemic, the sensor has a health benefit. In fact, with CO2 the healthiness of the air is indirectly monitored to avoid the formation of the aerosol which allows the virus to easily circulate in the environment. With reference to the Figure 89, the parameters are analyzed.

The 1st parameter enables CO2 monitoring.

The 2nd parameter defines the monitoring cycle.

The 3rd parameter blocks the sending on variation that could lead to the BUS overload

The 5th parameter allows the calibration of the sensor which is clearly impossible.

The 6th refers to an external probe that is not present.

Finally, the last parameter enables the alarm function in case the CO2 exceeds the maximum measurable with consequent damage to health. Or if the sensor is found to be malfunctioning.

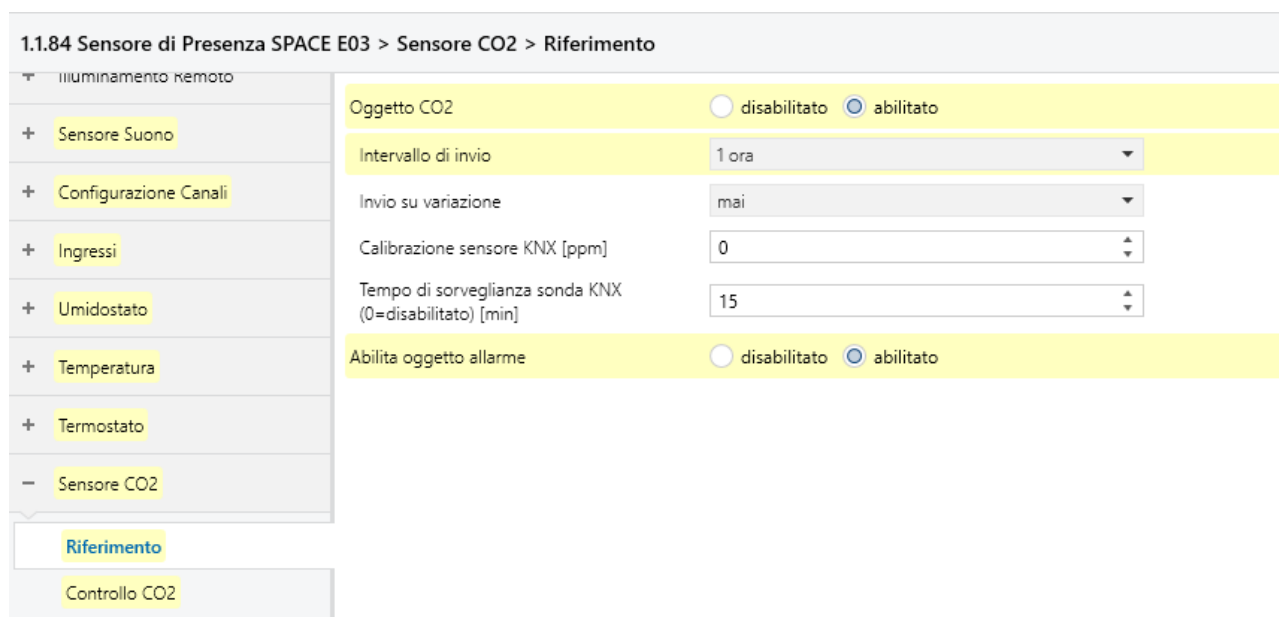


Figure 89

The alarming CO2 levels are defined in the Figure 91, control panel and for which action is required.

The 1st parameter enables the thresholds

The 2nd, 3rd and 4th parameters define basic functions already seen previously.

The next 3 classes of parameters represent the thresholds to be kept under control FIGURE. The first 2 represent the purpose of sending an alarm or warning message and the 3rd is intended to allow proportional control of CO2. Unfortunately, forced ventilation is required to ensure proportional control and as explained above it is not possible to pass the ventilation channels between the walls of the building. Therefore, this function will also be used as an alarm ignoring the proportional control object.

1.1.84 Sensore di Presenza SPACE E03 > Sensore CO2 > Controllo CO2

+ Configurazione Canali

+ Ingressi

+ Umidostato

+ Temperatura

+ Termostato

- Sensore CO2

Riferimento

Controllo CO2

+ Ritmo Circadiano

+ Virtual Holder (funz. Presenza...

- Sensore VOC

Riferimento

Controllo VOC

Tipo sensore

Telegramma di attivazione

Stato dopo download

Isteresi [ppm]

Soglia 1

Valore soglia [ppm]

Telegramma con misura sopra soglia

Telegramma con misura sotto soglia

Telegramma quando sensore viene disabilitato

Soglia 2

Valore soglia [ppm]

Telegramma con misura sopra soglia

Telegramma con misura sotto soglia

Telegramma quando sensore viene disabilitato

Soglia 3 - Controllo proporzionale

Valore soglia [ppm]

Larghezza banda [ppm]

Banda proporzionale [Bp] [ppm]

Controllo invertito

Tempo di invio ciclico dei telegrammi

Invia su variazione minima

☐ disabilitato

☒ abilita soglie

☐ telegramma "0"

☒ telegramma "1"

☐ disabilitato

☒ abilitato

40

Soglia 1

5000

on

nessuna azione

nessuna azione

Soglia 2

1000

on

nessuna azione

nessuna azione

Soglia 3 - Controllo proporzionale

450

100

350

☒ no

☐ sì

nessun invio ciclico

2 %

Figure 90 CO2 sensor parameters CO2 control

Typical Concentrations and Effects	
Effect	CO ₂ Concentration
Typical atmosphere	350 - 450 ppm
Acceptable indoor air quality	600 - 800 ppm
Tolerable indoor air quality	1000 ppm
Average exposure limit over 8 hours	5000 ppm
Concern, short exposure only	6000 - 30000 ppm
Increased respiration and headache	3 - 8 %
Nausea, vomiting, unconsciousness	10 % +
Sudden unconsciousness, death	20 % +

Figure 91 Effects CO2 concentration in the air

Of the generated group objects, only half must be used, the current measurement is sent to BAOS for data collection, The Alarm is sent as a maintenance message, threshold 1 together with the alarm become the input objects of a generated logic from the control panel so that if both are active, a fire alarm telegram is sent. Thresholds 1 and 2 open the window, if available, and threshold 3 closes the window.

135	<Sensore CO2> Misura Attuale	Valore ppm	2 bytes	C	R	-	T	-	parts/million (ppm)	Bass
136	<Sensore CO2> Misura KNX	Valore ppm	2 bytes	C	-	W	-	-	parts/million (ppm)	Bass
137	<Sensore CO2> Allarme	No Allarme/Allarme	1 bit	C	R	-	T	-	alarm	Bass
138	<Sensore CO2> Abilita	Abilita/Disabilita	1 bit	C	-	W	-	-	enable	Bass
139	<Sensore CO2> Soglia 1	Valore ppm	2 bytes	C	-	W	-	-	parts/million (ppm)	Bass
140	<Sensore CO2> Valore Soglia 1	Off/On	1 bit	C	R	-	T	-	switch	Bass
141	<Sensore CO2> Soglia 2	Valore ppm	2 bytes	C	-	W	-	-	parts/million (ppm)	Bass
142	<Sensore CO2> Valore Soglia 2	Off/On	1 bit	C	R	-	T	-	switch	Bass
143	<Sensore CO2> Soglia 3	Valore ppm	2 bytes	C	-	W	-	-	parts/million (ppm)	Bass
144	<Sensore CO2> Valore Soglia 3	0-100%	1 byte	C	R	-	T	-	percentage (0..100%)	Bass

Figure 92 CO2 sensor group objects

7.13.1.14 Parameters Circadian rhythm

Given the experimental aspect of the project, the use of the circadian rhythm aims to test the possible benefits of a natural rhythm on specific disabilities. It is possible to create a combination of lights by means of two dimmers using a warm lamp and a cold lamp. The relevant parameters in this general figure 93, channel are:

Parameter 5: Output mode which, set on hot / cold lamp, allows to reduce the number of dimmers to be used with respect to RGB.

The parameter 6, 7, 8 and 9: the temperature of the hot and cold lamp and their efficiency to be adjusted according to the lamps purchased

Parameter 11 which represents the precision with which the cycle is followed.

1.1.84 Sensore di Presenza SPACE E03 > Ritmo Circadiano > Generale

+ Configurazione Canali	Algoritmo circadiano	<input checked="" type="radio"/> normale <input type="radio"/> forzato
+ Ingressi	Telegramma attivazione	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
+ Umidostato	Stato dopo download	<input type="radio"/> off <input checked="" type="radio"/> on
+ Temperatura	Curva elevazione	normale
+ Termostato	Modalità uscita	lampada calda/fredda
+ Sensore CO2	Temperatura di colore lampada calda [* 100 K]	5
- Ritmo Circadiano	Temperatura di colore lampada fredda [* 100 K]	65
	Efficienza lampada calda [%]	100
	Efficienza lampada fredda [%]	100
Generale	Tempo invio ciclico uscita	5 minuti
Corcadiano normale	Invio uscita su variazione	1 %
Configurazione Temperatura...		
Configurazione Luminosità		

Figure 93 General parameters Circadian rhythm

The normal Circadian page allows to define the circadian rhythm by means of the geographical location and taking into account the hourly variations as in figure 94.

1.1.84 Sensore di Presenza SPACE E03 > Ritmo Circadiano > Corcadiano normale

+ Configurazione Canali	Latitudine	Tropico del Cancro
+ Ingressi	Longitudine	17,74
+ Umidostato	Telegramma per attivazione ora legale	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
+ Temperatura	Stato ora legale dopo il download	<input checked="" type="radio"/> non attivo <input type="radio"/> abilitato
+ Termostato	Variazione ora legale [* 10 min]	6
+ Sensore CO2	Telegramma per evento alba	<input type="radio"/> telegramma "0" <input checked="" type="radio"/> telegramma "1"
- Ritmo Circadiano	Variazione evento alba [min]	0
	Variazione evento tramonto [min]	0

Generale

Corcadiano normale

Configurazione Temperatura...

Configurazione Luminosità

Figure 94 Normal Circadian Rhythm Parameters

The Temperature configuration page and the Brightness page must be configured on site and possibly in a mild season. That makes them pretty much the last thing configurable.

Of the many group objects figure 95, generated only 6 are used: the brightness value received from the graphic interface; The color temperature controlled by means of the interface; the adjustment objects sent to the push button panel; the warm and cold glows sent to the two dimmers.

145	<Ritmo Circadiano> Abilita/Disabilita	Abilita/Disabilita	1 bit	C - W - -	enable	Basic
146	<Ritmo Circadiano> Luminosità Auto/Man	Manuale/Auto	1 bit	C - W - -	switch	Basic
147	<Ritmo Circadiano> Luminosità Forzata	Valore %	1 byte	C - W - -	percentage (0..100%)	Basic
148	<Ritmo Circadiano> Variazione Luminosità	Più Chiaro/Più Scuro	4 bit	C - W - -	dimming control	Basic
149	<Ritmo Circadiano> Reset Variazione Luminosità	Reset	1 bit	C - W - -	reset	Basic
150	<Ritmo Circadiano> Temperatura di Colore Auto/M...	Manuale/Auto	1 bit	C - W - -	switch	Basic
151	<Ritmo Circadiano> Temperatura di Colore Forzata	Valore K	2 bytes	C - W - -	absolute colour te...	Basic
152	<Ritmo Circadiano> Variazione Temperatura di Col...	Più Fresco/Più Caldo	4 bit	C - W - -	dimming control	Basic
153	<Ritmo Circadiano> Reset Variazione Temperatura...	Reset	1 bit	C - W - -	reset	Basic
154	<Ritmo Circadiano> Ora Legale	Off/On	1 bit	C - W - -	switch	Basic
155	<Ritmo Circadiano> Luminosità	Valore %	1 byte	C R - T -	percentage (0..100%)	Basic
156	<Ritmo Circadiano> Temperatura di Colore	Valore K	2 bytes	C R - T -	absolute colour te...	Basic
157	<Ritmo Circadiano> Evento Alba/Tramonto	Off/On	1 bit	C R - T -	switch	Basic
158	<Ritmo Circadiano> Luminosità Caldo	Valore %	1 byte	C R - T -	percentage (0..100%)	Basic
159	<Ritmo Circadiano> Luminosità Freddo	Valore %	1 byte	C R - T -	percentage (0..100%)	Basic

Figure 95 Circadian Rhythm group objects

7.13.1.15 Virtual Holder Function Parameters

The Virtual Holder function makes it possible to support the client's requests, recent and not well defined, regarding remote assistance. The goal of the Virtual Holder function is to provide assistance and modify the scenarios present based on the type of assistance provided. For example it is possible to allow a button to call the operator in a situation of need or it is possible to open or close the automatic lock of the door of a room in the case of dedicated CRAP. Or it is possible to modify the environments and the scenes according to the user instead of placing the user in a different room, which would increase the offer of a quality service. Unfortunately it is impossible to program this function without a precise definition of the needs, it is possible to program all the possibilities as the functions are limited.

7.13.1.16 VOC Sensor Parameters

The VOC sensor has a very similar functionality to the CO2 sensor and it is useless to report the sensor parameters as they are exactly the same as the CO2 sensor. What changes are the alert thresholds that refer to Figure 96. It also changes the purpose of these alerts, as opening the window does not mean that the situation will improve. There may be cleaner air on the side of the house facing the garden, the cause may be a device malfunction or a purifier may be needed. Whatever the cause, if ever there is, the groups will be ready to be connected to a future solution.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects

Figure 96 Air quality related to VOC factor

7.13.2 Capacitive Thermostat

The capacitive thermostat has the function of control panel and logic module, the device parameters follow the optics of the SPACE sensor, it has an input and 5 configurable buttons.

7.13.2.1 General parameters

Being products created by the same company, the thermostat and the space sensor do not differ much, the only parameters that are really different Figure 97, that are worth commenting are:

The 3rd parameter that allows you to configure the device not as a thermostat but as a control panel as previously explained.

The 4th and 5th parameters that change the display configurations. The function that shows humidity or setpoint periodically is disabled as it is better if the thermostat is not noticed.

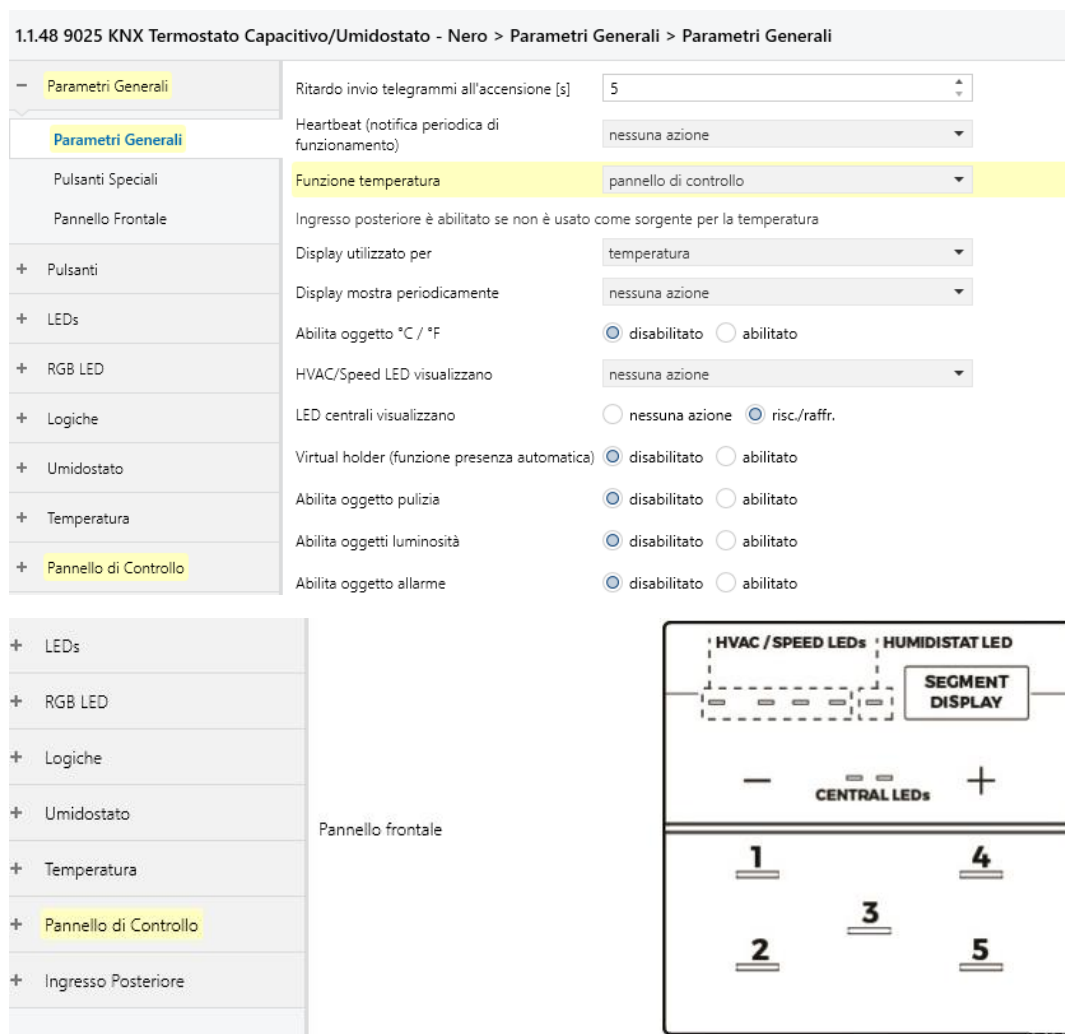


Figure 97 General parameters of the Capacitive Thermostat

7.13.2.2 Control panel

The purpose of the control panel parameters is to match the parameters of the SPACE sensor thermostat channel of the respective room. Therefore, in Figure 98, the necessary parameters are highlighted.

The 1st parameter enables setpoint management.

The 2nd parameter must be the same as the SPACE sensor

The 3rd parameter defines the type of variation of the Set point to be sent, since in the SPACE sensor the format is in absolute coordinates, this parameter must also be.

The 4th and the following 3 parameters are left unchanged as in the SPACE sensor

The 5th parameter has been set in the same way as the SPACE.

1.1.48 9025 KNX Termostato Capacitivo/Umidostato - Nero > Pannello di Controllo > Configurazione

+ Parametri Generali	Abilita gestione setpoint	<input type="radio"/> disabilitato <input checked="" type="radio"/> abilitato
+ Pulsanti	Massima variazione setpoint permessa da bus	-/+ 2°C
+ LEDs	Variazione setpoint - formato oggetto	<input type="radio"/> oggetto 1 bit - incrementa / decrementa <input checked="" type="radio"/> oggetto 2 bytes - valore temperatura
+ RGB LED	Riferimento setpoint è	<input type="radio"/> base <input checked="" type="radio"/> attuale
+ Logiche	Abilita gestione OFF	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
+ Umidostato	Abilita gestione risc./raffr.	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
+ Temperatura	Abilita gestione automatico/manuale	<input checked="" type="radio"/> disabilitato <input type="radio"/> abilitato
- Pannello di Controllo	gestione HVAC	HVAC
Configurazione	Comfort	<input checked="" type="checkbox"/>
	Standby	<input checked="" type="checkbox"/>
	Economia	<input checked="" type="checkbox"/>
	Protezione edificio	<input checked="" type="checkbox"/>
+ Ingresso Posteriore	gestione fan coil	nessuno

Figure 98 Control Panel Parameters

The current setpoint and the setpoint variation are linked to the respective homonyms with opposite flag of the SPACE. The HVAC feedback object is connected to the first group of the SPACE write object Figure 99, while the HVAC command is connected to the second group address. The command reset is inactive as it is possible to send the same commands to SPACE by reducing the sending of telegrams.

76	<Pannello Controllo> Riferimento SP	Valore °C	2 bytes	C	-	W	-	-	temperature (°C)	Basso
77	<Pannello di Controllo> SetPoint Attuale	Valore °C	2 bytes	C	R	-	T	-	temperature (°C)	Basso
78	<Pannello di Controllo> Variazione Setpoint	Valore °C	2 bytes	C	R	W	T	-	temperature (°C)	Basso
79	<Pannello di Controllo> Reset Variazione SP	Reset	1 bit	C	-	W	-	-	reset	Basso
85	<Pannello di Controllo> HVAC Feedback	HVAC	1 byte	C	-	W	-	-	HVAC mode	Basso
86	<Pannello di Controllo> Comando HVAC	HVAC	1 byte	C	R	-	T	-	HVAC mode	Basso
87	<Pannello di Controllo> HVAC Decrementa/Incr...	Decrementa/Incrementa	1 bit	C	-	W	-	-	step	Basso

Figure 99 Control Panel Group Objects

7.13.2.3 Buttons

As already specified, the Buttons allow complex Figure 100, functions, so these functions have been applied in the living room on the ground floor and in the dining area.

The 1st parameter selects the function that allows you to alternate sequences of values for 3 groups of one-bit objects

The 4th parameter defines the number of objects and in this case, given that the relays that activate the ECGs are 3, the number 3 is selected.

The 5th parameter selects the number of states that allow an alternation of switching on and off similar to a shutter. To cover the stages 4 elements are enough but to give the effect of ascent and descent there are 6 which are the last 6 parameters. As you can see, the sequence has a central symmetry.

1.1.48 9025 KNX Termostato Capacitivo/Umidostato - Nero > Pulsanti > Pulsante 1

Parametri Generali
Parametri Generali
Pulsanti Speciali
Pannello Frontale
Pulsanti
Pulsante Speciale Sup. Sinistro...
Pulsante Speciale Sup. Destro...
Pulsante 1
Pulsante 2
Pulsante 3
Pulsante 4
Pulsante 5
LEDs

Funzione: comandi in sequenza (1 bit)
Nome pulsante:
Oggetto abilita/disabilita: ☒ disabilitato ☐ abilitato
Numero di oggetti: ☐ 2 oggetti ☒ 3 oggetti
Numero di elementi della sequenza: 6
Pressione lunga per restart sequenza: ☒ disabilitato ☐ abilitato
Invia oggetti solo se valore cambia: ☒ disabilitato ☐ abilitato
Valore step 1: a=on b=off c=off
Valore step 2: a=on b=on c=off
Valore step 3: a=on b=on c=on
Valore step 4: a=on b=on c=off
Valore step 5: a=on b=off c=off
Valore step 6: a=off b=off c=off

Figure 100 Channel parameters Buttons

The resulting group objects Figure 101, will be connected to the relays as they are not toggles and they do not need the status object.

4	<Pulsante 1> Oggetto A	Off/On	1 bit	C	R	-	T	-	switch	Basso
5	<Pulsante 1> Oggetto B	Off/On	1 bit	C	R	-	T	-	switch	Basso
6	<Pulsante 1> Oggetto C	Off/On	1 bit	C	R	-	T	-	switch	Basso
8	<Pulsante 2> Oggetto A	Off/On	1 bit	C	R	-	T	-	switch	Basso

Figure 101 Channel group objects Buttons

7.13.2.4 Logics

The logics present in the device are important from several points of view: to implement a missing function in a device, to combine states in alert messages or specific functions, or even for safety and diagnostic issues. The logics will be even more important at the time of system specialization.

The Figure 102, shows an example of transformation of a "Night" scene into a binary value that brings an old shutter actuator, which does not have the scene module, to the DOWN state. The value 128 is not the value actually used for security reasons.

1.1.48 9025 KNX Termostato Capacitivo/Umidostato - Nero > Logiche > Logica Funzione 1

<ul style="list-style-type: none"> Parametri Generali Parametri Speciali Pulsanti Speciali Pannello Frontale Pulsanti LEDs RGB LED Logiche <ul style="list-style-type: none"> Logica Funzione 1 Logica Funzione 2 Logica Funzione 3 	<p>Funzione logica: conversione byte in bit</p> <p>Nome logica: <input type="text"/></p> <p>Ritardo logica: 0</p> <p>Numero di ritrasmissioni sull'uscita: 1</p> <p>Tempo della ritrasmissione: <input checked="" type="radio"/> corti <input type="radio"/> lunghi</p> <p>Ritardo sulla ritrasmissione: 2 s</p> <p>Valore byte: 128</p> <p>Valore bit inviato quando ricevo byte: 1</p> <p>Valore bit inviato negli altri casi: 0</p>
---	--

In the Figure 103, a logic AND function which allows to combine the CO2 alarm with the highest CO2 threshold as previously commented. The transmission delay is reduced to a minimum but it is necessary to guarantee the sending of the message.

Figure 103 Logic of deduction of the critical level of CO2

1.1.48 9025 KNX Termostato Capacitivo/Umidostato - Nero > Logiche > Logica Funzione 3

Pannello frontale

+ Pulsanti
+ LEDs
+ RGB LED
- Logiche

Logica Funzione 1
Logica Funzione 2
Logica Funzione 3
Logica Funzione 4
Logica Funzione 5

Funzione logica: sorveglianza
Nome logica:
Ritardo logica: 0
Tempo sorveglianza [min]: 6
DPT sorveglianza/stato: 1 bit
Controllo stato: qualsiasi valore
Stato cancella anche l'allarme: ☒ no ☐ sì
Telegramma allarme: ☐ telegramma "0" ☒ telegramma "1"
Invio ciclico allarme: nessun invio ciclico
Telegramma reset: ☐ telegramma "0" ☒ telegramma "1"

Figure 104 Window opening sensor surveillance logic

These functions Figure 105 are repeated for almost all environments. And for this they almost completely saturate the available logics. The group addresses of the first 2 functions are clear not enough.

103	<Logica 1> Uscita	1 Bit	1 bit	C R - T -	boolean	Bassi
104	<Logica 1> Ingresso	1 Byte	1 byte	C - W - -	counter pulses (0..2...	Bassi
108	<Logica 2> Uscita	Logica	1 bit	C R - T -	boolean	Bassi
109	<Logica 2> Ingresso A	Logica	1 bit	C - W - -	boolean	Bassi
110	<Logica 2> Ingresso B	Logica	1 bit	C - W - -	boolean	Bassi
113	<Logica 3> Ingresso Sorveglianza	Ingresso Bit	1 bit	C - W - -	switch	Bassi
114	<Logica 3> Ingresso Stato	Ingresso Bit	1 bit	C - W - -	switch	Bassi
115	<Logica 3> Ingresso Reset	Off/On	1 bit	C - W - -	switch	Bassi
116	<Logica 3> Uscita Allarme	Off/On	1 bit	C R - T -	switch	Bassi

Figure 105 Logic group objects

7.13.3 Universal actuator parameters MaxinBox

In the project there are 6 different relay actuators, describing them all is useless as the basic functions are used for each of them, so the most modern is described below. The MaxinBox actuator is the actuator with more channels and less expensive on the market, it represents a basic and economical configuration in the case in which the fan coil is controlled by means of 3 speeds. The parameters are very simple to configure Figure 106, and are resolved in 24 triples of group objects consisting of the switching object, its feedback and the Figure 107, block object.

1.1.30 MAXinBOX 24 > Uscite > Configurazione

Generale

Uscite

Configurazione

Uscita 1

Configurazione

Uscita 2

Uscita 3

Uscita 4

Uscita 5

Uscita 6

Uscita 7

Uscita 8

Uscita 9

Blocco 1

Canale A

Uscita 1

Uscita 2

Canale B

Uscita 3

Uscita 4

Blocco 2

Canale C

Uscita 5

Uscita 6

Canale D

Uscita 7

Uscita 8

Uscite individuali / Canale tapparella

Uscite individuali

✓

✓

Uscite individuali

✓

✓

Uscite individuali / Canale tapparella

Uscite individuali

✓

✓

Uscite individuali

✓

✓

Figure 106 MaxinBox channel configuration

The on / off group objects and their respective states are linked to the transmission objects Figure 107, of the thermostat channel of the SPACE sensor

	Numero	Nome	Funzione Oggetto	De	Inc	Lunghe	C	R	W	T	U	Tipo Dato	Pric
	127	[O12] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	128	[O12] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	129	[O12] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi
	149	[O14] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	150	[O14] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	151	[O14] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi
	160	[O15] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	161	[O15] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	162	[O15] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi
	171	[O16] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	172	[O16] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	173	[O16] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi
	182	[O17] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	183	[O17] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	184	[O17] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi
	193	[O18] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	194	[O18] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	195	[O18] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi
	204	[O19] On/Off	N.A. (0=Apri relè; 1=Chiudi rel...	1 bit	C	-	W	-	-	-	-	binary value	Bassi
	205	[O19] On/Off (stato)	0=Uscita OFF; 1=Uscita ON	1 bit	C	R	-	T	-	-	-	binary value	Bassi
	206	[O19] Blocca	0=Sblocca; 1=Blocca	1 bit	C	-	W	-	-	-	-	enable	Bassi

Figure 107 Group Objects MaxinBox

7.13.4 Parameters shutter actuator

This device is a shutter actuator, it comes from reconditioned devices, it belongs to the EIB standard and therefore does not implement position control by means of the percentage. Furthermore, the lack of scene modules makes it necessary to use logic functions.

The setting parameters of the motors controlled by the Figure 108, channels do not show any configuration differences compared to normal actuators.

1.2.17 Jalousieaktor 2fach REG > Ausgang 1		
Ausgang 1	Priorität (1 = höchste Priorität)	<input type="radio"/> Stufe 7 <input checked="" type="radio"/> Stufe 8
Ausgang 2	Kurzzeitbetrieb Basis	10 ms
Sonnenschutzautomatik	Kurzzeitbetrieb Faktor (5...255)	40
Zentral 1	Langzeitbetrieb abwärts Basis	2,56 s
Zentral 2	Langzeitbetrieb abwärts Faktor (5...255)	47
Zentral 3	Langzeitbetrieb aufwärts Basis	2,56 s
Zentral 4	Langzeitbetrieb aufwärts Faktor (5...255)	47
Handbetätigung	Pause bei Richtungswechsel Basis	10 ms
	Pause bei Richtungswechsel Faktor (15...100)	50

Figure 108 Channel 1 motor property

In the central functions Figure 109, however, it is noted that the function is expressed in terms of time and not as a percentage.

The 1st parameter represents the priority of the function which is higher than the normal control function.

The 2nd parameter indicates the actuator the channel affected by the function

The 3rd and 4th parameters indicate the answer the value of the object created by Zentral or whether to go up or down

The last parameter allows you to determine the movement time. Obviously this parameter must be calibrated but the functions are clear the shutter is able to position itself with 4 different steps. This guarantees at least the existence of start and end steps.

1.2.17 Jalousieaktor 2fach REG > Zentral 1		
Ausgang 1	Priorität (1 = höchste Priorität)	Stufe 6
Ausgang 2	Zentralfunktion freigegeben für	Ausgang 1
Sonnenschutzautomatik	Betriebsart	Position anfahren
Zentral 1	Reaktion, wenn Objektwert ==> 0	aufwärts fahren
Zentral 2	Reaktion, wenn Objektwert ==> 1	<input type="radio"/> aufwärts fahren <input checked="" type="radio"/> abwärts fahren
Zentral 3	Fahrzeit aufwärts	15
Zentral 4	Kurzzeitbetrieb x Faktor (0...15)	
Handbetätigung		
Vorzug 1		
Vorzug 2		
Sicherheit Ausgang 1		

Figure 109 Properties of central function

The Sicherheit Ausgang channel Figure 110, allows the reception of alarm messages from wind or rain.

The 1st parameter indicates the priority which obviously for safety messages is 2 (this is taken for granted in new products) [74]

The 2nd parameter activates the function

The 3rd parameter disables the cyclic reception of the signal

The 4th parameter allows you to invert the incoming safety message

And the last 2 allow you to determine what happens when the message is received and once the alarm state is over. In this case, when the message is received, the shutter closes quickly in order to avoid damage and once the alarm status has ceased, the blind waits for a normal command.

1.2.17 Jalousieaktor 2fach REG > Sicherheit Ausgang 1		
Ausgang 1	Priorität (1 = höchste Priorität)	Stufe 2
Ausgang 2	Sicherheitsfunktion aktivieren ?	<input type="radio"/> NEIN <input checked="" type="radio"/> JA
Sonnenschutzautomatik	Sicherheitsmeldung zyklisch empfangen?	<input checked="" type="radio"/> NEIN <input type="radio"/> JA
Zentral 1	Sicherheitsobjekt negieren? (NEIN: Objekt = 1; JA: Objekt = 0)	<input checked="" type="radio"/> NEIN <input type="radio"/> JA
Zentral 2	Sicherheitsreaktion am Anfang	<input type="radio"/> aufwärts fahren <input checked="" type="radio"/> abwärts fahren
Zentral 3	Sicherheitsreaktion am Ende	warten auf nächsten Befehl
Zentral 4		
Handbetätigung		
Vorzug 1		
Vorzug 2		
Sicherheit Ausgang 1		
Sicherheit Ausgang 2		

Figure 110 Alarm channel property

The resulting group objects Figure 111 have two pairs, one for each channel, of step and stop control objects associated with the dimming control channel of the ABB button.

A safety object for each channel linked to the alarm objects for wind, precipitation, solar storm and Limit Temperature of the Weather Station. These connections are made by means of 5 distinct group addresses.

Four central functions, two of which, one for each channel, are connected to 4 (the actuator on the lower floor) and 3 (for the remaining actuators on the upper floor) byte-to-bit conversion logic modules that allow them to receive the scenes. The rest of the core functions have yet to find their purpose.

0	Ausgang 1	Sicherheit	W...3... 1 bit	C - W - U	Basso
1	Ausgang 2	Sicherheit	W...4... 1 bit	C - W - U	Basso
4	Zentral 1	Zentral 1	1 bit	C - W - U	Basso
5	Zentral 2	Zentral 2	1 bit	C - W - U	Basso
6	Zentral 3	Zentral 3	1 bit	C - W - U	Basso
7	Zentral 4	Zentral 4	1 bit	C - W - U	Basso
8	Ausgang 1	Langzeitbetrieb	M...4... 1 bit	C - W T U	Basso
9	Ausgang 1	Kurzzeitbetrieb	St...4... 1 bit	C - W T U	Basso
10	Ausgang 2	Langzeitbetrieb	M...3... 1 bit	C - W T U	Basso
11	Ausgang 2	Kurzzeitbetrieb	St...3... 1 bit	C - W T U	Basso

Figure 111 Group object of Jalousieaktor

It is important to note that thanks to the SPACE sensor it is not necessary for the moment to use the scenes except in the automatic opening and closing of the settings. In the future, these scenarios could also evolve by means of the Virtual Pocket function, but it is also possible that some specific scenarios for the application and requested by the customer disable the control of the SPACE sensor and allow a characteristic scene.

7.13.5 Dimmer 4 channels

There are two types of Dimmer actuators and both, since they are connected to the semiautomatic brightness control channels of the SPACE sensor, have the minimum of integrated functions. As previously said, even if possible, there is no reason for using the scenes, furthermore if elegant functions such as the switch on and the switch off behavior were activated they would conflict with those already present in the SPACE sensor and in the in the best of cases there would be sudden changes of luminosity. For this the best thing was to activate the standard channels. Activate the necessary feedbacks Figure 112, at thinka visualization interface, and connect only the group address containing the desired brightness value to the SPACE sensor. The rest of the parameters will be exploited by thinka.

1.2.13 1-10V Dimmer 4 Channels > Dimming channel 1 (E1) > E1 - General (Name) > E1 - Feedback telegrams

General
Times
Configuration of inputs / outp...
- Dimming channel 1 (E1)
- E1 - General (Name)
E1 - Enabled functions
E1 - Feedback telegrams
E1 - Supplementary functi...
E1 - Dimming characteristic
+ Dimming channel 2 (E2)
+ Dimming channel 3 (E3)
+ Dimming channel 4 (E4)

Feedback switching status?
feedback object is active signalling object

Updating the object value for switching status feedback
☐ after each update obj. "Switching" / "Central"
☒ only if the feedback value changes

Time delay for feedback telegram after bus voltage return?
☒ yes ☐ no

Cyclical transmission of the feedback?
☐ yes ☒ no

Feedback brightness value?
feedback object is active signalling object

Updating of the object value for brightness value feedback
☐ after each update obj. "Brightness value"
☒ only if the feedback value changes

Time delay for feedback telegram after bus voltage return?
☒ yes ☐ no

Cyclical transmission of the feedback?
☐ yes ☒ no

5	Dimming channel 1	Switching	C - W - - switch	Basso
6	Dimming channel 1	Switching feedback	C - - T - switch	Basso
8	Dimming channel 1	Dimming	C - W - - dimming control	Basso
9	Dimming channel 1	Brightness value	C - W T - percentage (0..100%)	Basso
10	Dimming channel 1	Feedback brightness value	C - - T - percentage (0..100%)	Basso

Figure 112 Parameters and objects of the first channel of the 4-channel dimmer

7.13.6 Weather station

The weather station has a marginal role in this project. The generator does not need the temperature and humidity information as it is a heat pump and therefore measures all necessary environmental parameters by itself. The shutters cannot be adjusted in the absolute position and therefore the dimming function is not necessary. Furthermore, the structure is built in a geographical place where there are no extreme weather events. For these reasons, considering the price of the weather station, it is probable that the project will continue without it. Finally, the eelectron weather station plus does [75] not maintain the calculation of the average weekly precipitation and therefore the possibility of saving irrigation water from a LEED perspective is also excluded. The only functions it performs are to monitor the weather alarms and the Twilight measurement function, useful only for the Hall on the first floor.

7.13.7 ABB pushbutton panel

The ABB pushbutton panel is one of the 2 available pushbutton panels. With the exception of the one in the lounge on the ground floor which has a copy of keys for the automatic closing of the shutters on the upper floor and the ECGs on the lower floor.

As you can see from the Figure 113, it is sufficient to select the channel you wish to configure and select the desired control from the drop-down menu of the 1st parameter. The leds of the buttons are already configured correctly. However, this configuration is good for the common areas while for the bedrooms it is necessary to turn them off in order to avoid the disturbance of the guest.

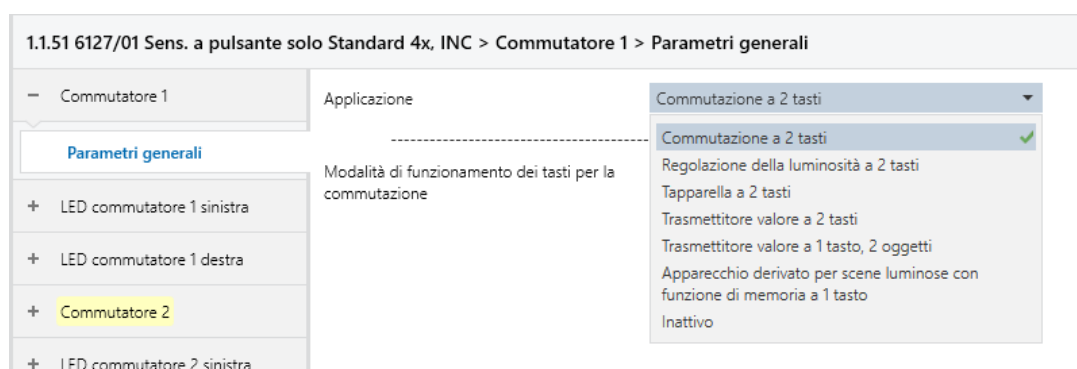


Figure 113 Parameter pushbutton

As you can see from the following Figure 114 it is possible to configure each channel as you wish: switching, blinds, dimming scenes and many other objects also available as a single button.

1	S1.1: Commutazione	Ingresso/Uscita	1 bit	C - W T U	switch	Basso
5	LED1.1: Stato	Ingresso	1 bit	C - W - U	switch	Basso
10	LED1.2: Stato	Ingresso	1 bit	C - W - U	switch	Basso
15	S2.1: Spostamento	Uscita	1 bit	C - - T -	up/down	Basso
16	S2.1: Regolazione	Uscita	1 bit	C - - T -	step	Basso
19	LED2.1: Stato	Ingresso	1 bit	C - W - U	switch	Basso
24	LED2.2: Stato	Ingresso	1 bit	C - W - U	switch	Basso
29	S3.1: Commutazione	Ingresso/Uscita	1 bit	C - W T U	switch	Basso
30	S3.1: regolazione luminosità relativa	Uscita	4 bit	C - - T -	dimming control	Basso
33	LED3.1: Stato	Ingresso	1 bit	C - W - U	switch	Basso
38	LED3.2: Stato	Ingresso	1 bit	C - W - U	switch	Basso
43	S4.1: Numero scena luminosa	Uscita	1 byte	C - - T -	scene control	Basso
47	LED4.1: Stato	Ingresso	1 bit	C - W - U	switch	Basso
52	LED4.2: Stato	Ingresso	1 bit	C - W - U	switch	Basso

Figure 114 Different type of objects for Configurable Pushbutton

7.14 COST ANALYSIS

To assess sustainability and verify the return to the ceiling, a cost and feasibility analysis is required. Unfortunately, this analysis for home automation can only be done after the choice of functions, but considering the two loans, we started from the beginning with a certain degree of security. The total price including VAT depends differently on whether or not you can take advantage of the eco-bonus on the services or products considered. It also depends on the rate applied. For example, if we consider a heat pump with heat recovery and demand-based control system, it can be classified according to 65% of home automation or with 110% [76] relating to the class of products in lower consumption band. For this reason, given that the devices of the heating system and the performances on the system are fully recovered, the feasibility analysis focuses on the appliances that fall within the 65% financing and on those that cannot be financed. Furthermore, it must be considered that the price of home automation devices is not known as it depends on the market and on bargaining. For this it is necessary to refer to an online catalog, out of habit Futurasmus was chosen [77]. Therefore, the costs of the devices were entered on an excel¹² sheet and, according to what was said in the funding chapter, whether or not to be included in the financing was taken into account. Then they were considered complementary components to the system such as the motor of the shutters; the servovalves of the radiators; the protective casings; the components of the developed device; the cost of the lots already purchased; the terminal blocks calculated on the basis of the number of outputs or inputs of the devices during the dimensioning of the home automation panels; the electric cables of the actuators calculated with the distance in standard 1 between the actuator (which is located in the electrical panel); and the device implemented and the BUS cable calculated by adding the length of the polyline segments by Autocad Figure 115. There is therefore a Total cost including VAT, that is the cost to be financed of € 27800 which is equivalent to 2 ceilings or exactly the number of ceilings that will certainly be obtained. In addition, there is a total funding of 40% and a cost to be incurred of € 15300. That for a system of this size almost, not considering the shutter actuators, the maximum potential is a ridiculous price.

¹² Attachment 5

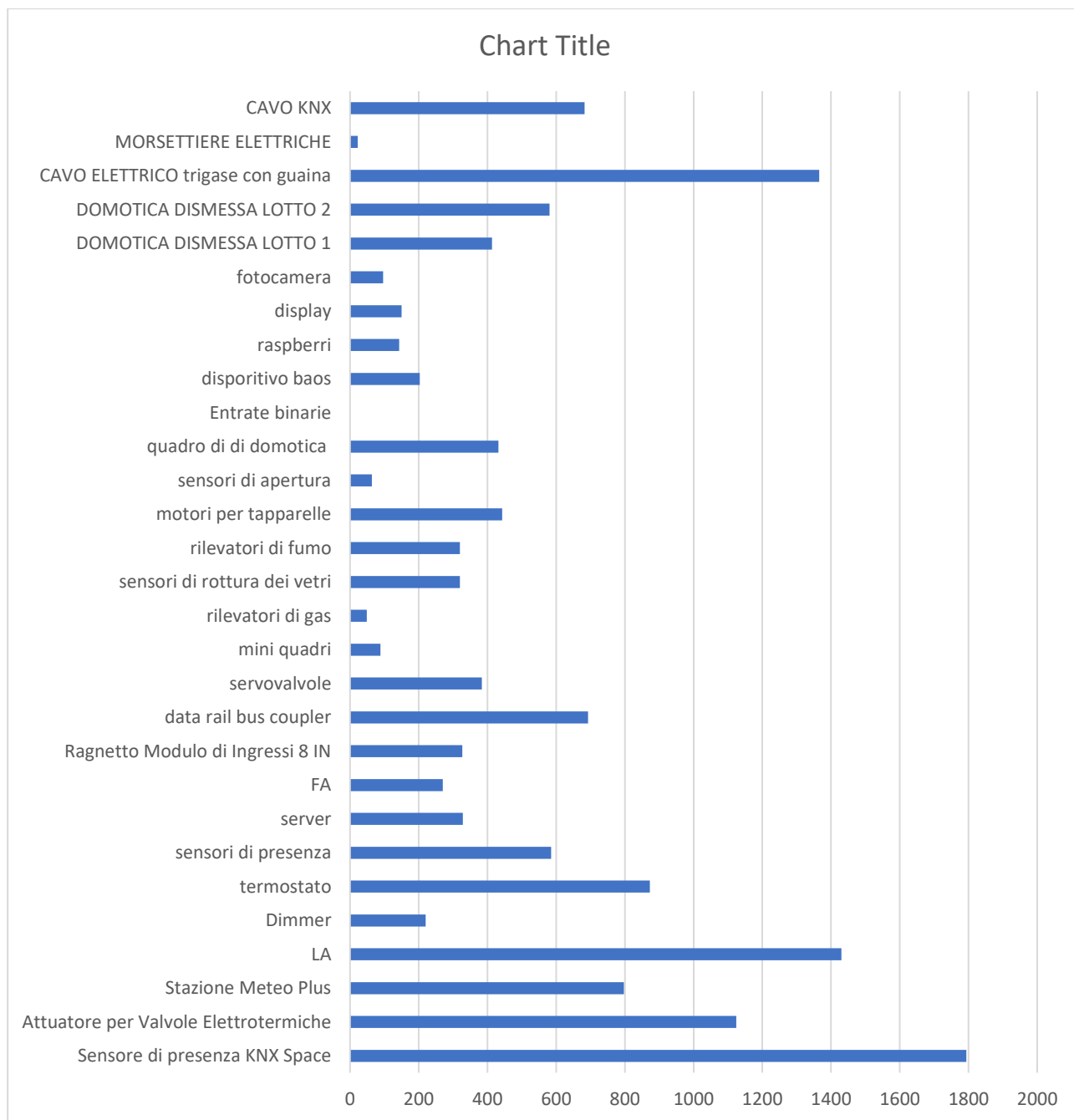


Figure 115 Cost for the type of device

8 RESULTS

The results of this project are of different nature and are disseminated in the project, in the people who are part of it and in the people who will benefit from it. you can evaluate different aspects:

ECONOMIC

The savings made through the refurbishment of the disused home automation which I estimated to be around € 10,000.

The potential reduction of 40% of the cost thanks to the eco-bonus, with reference to annex 5 an expense of € 15,300 financed against € 27,800 net of VAT is an excellent prospect.

Furthermore, if the Erasmus project is accepted, € 60,000 will be available to invest together with the Politecnico in the teaching and research aspect of the project.

INNOVATIVE

Innovation is conceived in relative terms. Realities such as that of this project are already present in socially and economically more developed areas, transferring and starting this project on a territory that has none, is innovation. In the regional panorama, this reality is interesting and has good prospects for success.

ECOLOGICAL

Due to its ecological aspect, the project positively faces the world panorama. Automation class A and LEED view point are relevant contributions in this aspect.

SOCIAL

Clearly the most important result lies in the social impact that the project will generate. Projects of this type are intended to improve comfort, while this project aims to improve the well-being of the most fragile subjects. The studies could give rise to easily replicable methodologies which could therefore have a positive impact on society.

TECHNICIANS PROGRESS

There are also excellent technical results:

- I tested the sending and receiving of messages using the BAOS module and I obtained 100% success in situations of optimal BUS charging better than the common devices.
- I designed a project in class A according to 15232 with a minimum cost (even if one if 2 functions out of 24 are in class B, at the time of sending this thesis).
- I got the best accuracy among those who published in kaggle (featured) on the same source database.

PERSONAL

I take this opportunity to get out of the 3rd person and make some personal considerations. I started this project with great enthusiasm, I personally contacted the people who participated in it and I trained independently. Personally I consider home automation among the different branches of automation engineering the one that comes closest to art since devices are chosen and programmed to arouse emotions. So, why not further automate it with the measurement and control of well-being and emotions?

9 GREETINGS

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Pasquale D'Ippolito	Surveyor

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Paolo Masulli	Imotion
Maria Di Stradis	social designer
Francesco Taveri	labor Inspectorate
Francesca Semeraro	Psychology of Autism
Giuseppe Presicci	Eelectron seller
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12 ATTACHMENT 1 CMAKELIST PROGRAM

```

1  cmake_minimum_required(VERSION 3.16)
2
3  project(DOMIA6 C CXX)
4
5  find_package(PythonInterp REQUIRED)
6  find_package(PythonLibs ${PYTHON_VERSION_MAJOR}.${PYTHON_VERSION_MINOR} EXACT REQUIRED)
7  find_package(Python COMPONENTS Interpreter Development)
8  find_package(CMAKE_PREFIX_PATH OpenCV REQUIRED)#13/01/22
9
10 set(TENSORFLOW_SOURCE_DIR "${PROJECT_SOURCE_DIR}/external/tensorflow_src2"
11     CACHE PATH "Directory that contains the TensorFlow project" FORCE)
12
13 set(CMAKE_CXX_STANDARD 14)
14
15 add_executable(DOMIA6 main.cpp)
16
17 add_subdirectory(
18     external/baos
19     external/tensorflow_src2/tensorflow/lite/python/interpreter_wrapper
20 )
21
22 add_subdirectory(
23     external/pybind11
24 )
25 set(${pybind11_DIR} external/pybind11)
26
27 find_package(pybind11 CONFIG REQUIRED)
28
29
30 add_subdirectory(
31     "${TensorFlow_SOURCE_DIR}/tensorflow/lite"
32     "${TensorFlow_SOURCE_DIR}/tensorflow-lite"
33     EXCLUDE_FROM_ALL
34 )
35
36 target_include_directories(DOMIA6
37     PUBLIC external/baos/kdrive/include
38     PUBLIC external/tensorflow_src2/tensorflow/core/util
39     PUBLIC ${PYTHON_INCLUDE_DIRS}
40     PUBLIC external/tensorflow_src2/tensorflow/lite/python/interpreter_wrapper
41     PUBLIC ${pybind11_INCLUDE_DIR}
42     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates/gpu
43     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates
44     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates/coreml
45     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates/external
46     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates/hexagon
47     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates/nnapi
48     PUBLIC external/tensorflow_src2/tensorflow/lite/delegates/Utils
49 )
50
51 target_link_directories(DOMIA6
52     PRIVATE lib
53     PRIVATE src
54     PRIVATE xnnpack/src
55     PRIVATE pthreadpool-source/src
56     PRIVATE flatbuffers/src
57     PRIVATE flatbuffers-flatc/src
58     PRIVATE farmhash/src
59     PRIVATE cpuinfo-source/src
60
61     PRIVATE clog-source/src
62 )
63
64 set(LIBS ${KDRIVE_LIBRARY_NAME} Net Foundation ${SYSTEM_LIBS})
65
66
67 target_link_libraries(DOMIA6
68     PUBLIC
69     ${LIBS}
70     kdriveBAOS
71     tensorflow-lite
72     samplepcTest ${OpenCV_LIBS}#13/01/22
73 )

```

13 ATTACHMENT 2 MAIN PROGRAM FOR BAOS INTERFACE

```

1
2 #include <kdrive/connector/CallbackThread.h>
3 #include <kdrive/utility/LoggerFormatter.h>
4 #include <iostream>
5
6 #include <kdrive/baos/Baos.h>
7 #include <kdrive/utility/Logger.h>
8 #include <Poco/Thread.h>
9 #include <Poco/Exception.h>
10 #include <Poco/Logger.h>
11 #include <Poco/ConsoleChannel.h>
12 #include <Poco/Format.h>
13
14 #include <cstdio>
15 #include "tensorflow/lite/interpreter.h"
16 #include "tensorflow/lite/kernels/register.h"
17 #include "tensorflow/lite/model.h"
18 #include "tensorflow/lite/optional_debug_tools.h"
19
20 using namespace kdrive::baos;
21 using namespace kdrive::connector;
22 using namespace kdrive::utility;
23 using Poco::Thread;
24 using Poco::Exception;
25 using Poco::format;
26
27 CLASS_LOGGER("Domia")
28
29 namespace
30 {
31 {
32
33 struct BaosApp
34 {
35     enum CommunicationObjects { Ch1Request = 1 };
36     enum Parameters { Ch1Timeout = 1 };
37 };
38
39 void switchLight(BaosConnector::Ptr connector, bool enabled)
40 {
41     BaosDatapoint datapoint(connector, BaosApp::Ch1Request);
42
43     if (datapoint.getBoolean() != enabled)
44     {
45         const std::string status = enabled ? "on" : "off";
46         poco_information(LOGGER(), format("Switching DP number %d : %s", static_cast<int>(BaosApp::Ch1Request), status));
47         datapoint.setBoolean(enabled);
48     }
49 }
50
51 void waitTimeout(BaosConnector::Ptr connector)
52 {
53 {
54     const int timeout = readParameter(connector, BaosApp::Ch1Timeout);
55     poco_information(LOGGER(), format("Timeout is %d ms", timeout));
56     Thread::sleep(timeout);
57 }
58 }
59
60 int main(int argc, char* argv[])
61 {
62     // configure the logging channel
63     INIT_ROOT_CONSOLE_LOGGER();
64
65     try
66     {
67         // connects the BAOS FT 1.2 Module
68         FT12Connector::Ptr connector = std::make_shared<FT12Connector>();
69         connector->open("/dev/ttyAMA0");
70
71         // get the Serial Number
72         BaosServerItems baosServerItems(connector);
73         poco_information(LOGGER(), format("Serial Number: %s", LoggerFormatter::toHex(baosServerItems.getSerialNumber())));
74
75         // Reads the data point descriptions
76
77         BaosDatapointDescriptions baosDatapointDescriptions(connector);
78
79         baosDatapointDescriptions.readFromDevice();
80         const BaosDatapointDescriptions::Descriptions descriptions = baosDatapointDescriptions.getDescriptions();
81
82         const unsigned int count = descriptions.size();
83         poco_information(LOGGER(), format("%u items found", count));
84
85         for (const auto& item : descriptions)
86         {
87             const BaosDatapointDescription& d = item.second;
88             const int id = d.getId();
89             const int dpt = d.getDatapointType();
90             const int bits = d.getValueTypeSizeBits();
91             const int bytes = d.getValueTypeSizeBytes();
92             const std::string size = d.isBitType() ? format("%d Bits", bits) : format("%d Bytes", bytes);
93             poco_information(LOGGER(), format("Id: %d, Datapoint type %d, Size: %s", id, dpt, size));
94         }
95
96         switchLight(connector, true);
97         waitTimeout(connector);
98         switchLight(connector, false);
99     }
100     catch (Exception& exception)
101     {
102         LOGGER().log(exception);
103     }
104
105     return EXIT_SUCCESS;
106 }

```

14 ATTACHMENT 3 DIMENSIONING OF SMALL SWITCHBOARDS

POSIZIONE QUADRO

17,17	23,4	QUADRI PICCOLI PRIMO PIANO						
		QUADRO1						
		funzione	canali	numero dispositivi	spazio occupato		SPAZIO TOTALE	minore di 22
		RELE	6	0	4	0	14,68571429	TRUE
		RELE	8	1	4	4	8	
		RELE	4	0	4	0	0	
		PERSIANE	2	1	4	4	2	numero di dispositivi con 0 canali aggiungi
		CLIMA	8		4	0	0	1,828571429
		DIMMER	1	1	4	4	1	numero di canali che possono possedere
		TP-DIN		1	1,314285714	1,314285714	0	3
		CONNETTORI		4	0,342857143	1,371428571	0	
8,89	15,83	QUADRO2						
		funzione	canali	numero dispositivi	spazio occupato		SPAZIO TOTALE	minore di 22
		RELE	6	1	4	4	6	19,02857143
		RELE	8	0	4	0	0	
		RELE	4	1	4	4	4	
		PERSIANE	2	1	4	4	2	numero di dispositivi con 0 canali aggiungi
		CLIMA	8	0	4	0	0	0,742857143
		DIMMER	1	1	4	4	1	
		TP-DIN		1	1,314285714	1,314285714	0	
		CONNETTORI		5	0,342857143	1,714285714	0	
1,58	20,93	QUADRO3						
		funzione	canali	numero dispositivi	spazio occupato		SPAZIO TOTALE	minore di 22
		RELE	6	1	4	4	6	15,02857143
		RELE	8	0	4	0	0	
		RELE	4	0	4	0	0	
		PERSIANE	2	1	4	4	2	numero di dispositivi con 0 canali aggiungi
		CLIMA	8	1	4	4	8	1,742857143
		DIMMER	1		4	0	0	numero di canali che possono possedere
		TP-DIN		1	1,314285714	1,314285714	0	2
		CONNETTORI		5	0,342857143	1,714285714	0	
21,64	14,8	QUADRO4						
		funzione	canali	numero dispositivi	spazio occupato		SPAZIO TOTALE	minore di 22
		RELE	6	1	4	4	6	15,02857143
		RELE	8		4	0	0	
		RELE	4	0	4	0	0	
		PERSIANE	2	1	4	4	2	numero di dispositivi con 0 canali aggiungi
		CLIMA	8	1	4	4	8	1,742857143
		DIMMER	1		4	0	0	numero di canali che possono possedere
		TP-DIN		1	1,314285714	1,314285714	0	2
		CONNETTORI		5	0,342857143	1,714285714	0	
16,82	15,07	QUADRO5						
		funzione	canali	numero dispositivi	spazio occupato		SPAZIO TOTALE	minore di 22
		RELE	6	1	4	4	6	14,68571429
		RELE	8		4	0	0	
		RELE	4	1	4	4	4	
		PERSIANE	2	1	4	4	2	numero di dispositivi con 0 canali aggiungi
		CLIMA	8	0	4	0	0	1,828571429
		DIMMER	1	0	4	0	1	
		TP-DIN		1	1,314285714	1,314285714	0	
		CONNETTORI		4	0,342857143	1,371428571	0	
8,24	26,97	QUADRO6						
		RELE	6	0	4	0	0	1,028571429
		RELE	8					TRUE
		RELE	4	0	4	0	0	
		PERSIANE	2	0	4	0	0	numero di dispositivi con 0 canali aggiungi
		DIMMER	1	0	4	0	0	
		TP-DIN		0	1,314285714	0	0	
		CONNETTORI		3	0,342857143	1,028571429	0	

posiz	posiz	QUADRO GRANDE							
17,7	16,3	RESTO DELLA CASA							
		funzione	canali	numero di	spazio occupato			SPAZIO TO	Numero d
		RELE	6	1	4	4	6	51,814286	1
		RELE	4	1	4	4	4		
		RELE	16	1	4	4	16	numero di din	
		PERSIANE	2	2	4	8	4	12,953571	
		CLIMA	8	0	4	0	0		
		DIMMER	4	0	4	0	0		
		TP-DIN		1	1,314286	1,314286	0		
		CONNETTORI		33	0,5	16,5	0		
		THINKA	0	1	4	4	0		
		POWER SU	0	2	4	8	0		
		LINE ACCO	0	1	2	2	0		
		QUADRI GRANDI PRIMO PIANO							
8,72	13,6	QUADRO01							
		funzione	canali	numero di	spazio occupato			SPAZIO TO	minore di
		RELE	6	4	4	16	24	43,428571	TRUE
		RELE	8	1	4	4	8		
		RELE	4	2	4	8	8		
		PERSIANE	2	0	4	0	0	numero di dispositivi	
		CLIMA	8	0	4	0	0	3,1428571	
		DIMMER	1	1	4	4	1	numero di canali che	
		TP-DIN		1	1,314286	1,314286	0	8	
		CONNETTORI		12	0,342857	4,114286	0		
		POWER SU	0	1	4	4	0		
		LINE ACCO	0	1	2	2	0		
8,72	12,9	QUADRO02							
		funzione	canali	numero di	spazio occupato			SPAZIO TO	minore di
		RELE	6	0	4	0	0	46,057143	TRUE
		RELE	8	0	4	0	0		
		RELE	4	0	4	0	0		
		PERSIANE	2	5	4	20	10	numero di dispositivi	
		CLIMA	8	2	4	8	16	2,4857143	
		DIMMER	1	1	4	4	1	numero di canali che	
		TP-DIN		1	1,314286	1,314286	0	5	
		CONNETTORI		8	0,342857	2,742857	0		
		AIRZONE I	0	1	2	2	0		
		AIRZONE C	0	1	8	8	0		

	codice KNX	stima in € più IVA	ecobonus	piu ecobonus	numero		totale		finanziati	non fina	costo finanziabile	e' minore di 15000		costo da so
Sensore di presenza KNX Space	PDO0E03KNX	245	298,9	TRUE	15	1793,4	14196,17	TUTTI	4483,5	0	12541,70736	TRUE	14196,17	11073,015
Attuatore per Valvole Elettrotermid' ZIO-MB24	WS00A01KNX	576	702,72	TRUE	4	1124,352			2810,88	0	costo non finanziabile			percentual
Stazione Meteo Plus	LC00B01KNX	1633	1992,26	TRUE	1	796,904			1992,26	0	6056,332457			37,32%
LA	DL04A01KNX	390,82	476,8004	FALSE	3	1430,401			0	1430,401	costo totale al netto di iva			
Dimmer		225,6	275,232	TRUE	2	220,1856	5365,243	ELECTRON	550,464	0	18598,03982			
termostato	8269200	255,41	311,6002	TRUE	7	872,4806			2181,201	0	costo totale iva inclusa			
sensori di presenza		120	146,4	TRUE	10	585,6			1464	0	22689,60858			
server	068THX	672,13	819,9986	TRUE	1	327,9994			819,9986	0				
FA	PS,30,660,2	44,19	53,9118	FALSE	5	269,559			0	269,559				
Ragnetto Modulo di Ingressi 8 IN	EAE 48003	37,2	45,384	TRUE	18	326,7648	7950,387	DISPOSITIVI KNX	816,912	0				
data rail bus coupler		29,9	36,478	FALSE	19	693,082			693,082	0				
servovalvole		19,67	23,9974	TRUE	40	383,9584			959,896	0				
mini quadri		14,5	17,69	FALSE	5	88,45			0	88,45				
rilevatori di gas		20	24,4	FALSE	2	48,8			0	48,8				
sensori di rottura dei vetri		8,2	10,004	FALSE	32	320,128			0	320,128				
rilevatori di fumo		6,56	8,0032	FALSE	40	320,128			0	320,128				
motori per tapparelle		30,25	36,905	FALSE	12	442,86			0	442,86				
sensori di apertura		4	4,88	FALSE	13	63,44			0	63,44				
quadro di di domotica		353,9	431,758	FALSE	1	431,758	3486,926	PARTE ELETTRICA	0	431,758				
Entrate binarie														
dispositivo baos		55,39344	67,58	FALSE	3	202,74			0	202,74				
raspberri		39,16	47,7752	FALSE	3	143,3256			0	143,3256				
display		40,94	49,9468	FALSE	3	149,8404			0	149,8404				
fotocamera		26,22	31,9884	FALSE	3	95,9652	591,8712	DISPOSITIVO TESI	0	95,9652				
DOMOTICA DISMESSA LOTTO 1		338,6842	413,1947	FALSE	1	413,1947			0	413,1947				
CAVO ELETTRICO trifase con guaina		476	580,72	FALSE	1	580,72			0	580,72				
CAVO ELETTRICO trifase con guaina		1119,235	1365,466	FALSE	1	1365,466			0	1365,466				
MORSETTIERE ELETTRICHE		17,98143	21,93735	FALSE	1	21,93735			0	21,93735				
CAVO KNX		559,6173	682,7331	FALSE	1	682,7331			0	682,7331				

FUNCTION	CLASES				
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
1 Control de la calefacción					
1.1 Control de las unidades terminales					
La función de control se aplica a las unidades terminales de calefacción (radiadores, suelo radiante, ventilos-convectores, unidades interiores) al nivel del local; para el tipo uno una función puede controlarse varios locales					
0 Sin control automático	X				D
1 Control automático central	X				D
2 Control individual por local	X	X	X		B
3 Control individual por local con comunicación					
x	X	X	X	X	A
4 Control individual por local con detección de ocupación (no se aplica a ningún sistema de emisión de calor de reacción lenta, por ejemplo suelos radiantes)					
x	X	X	X	X	A
1.2 Control de unidades terminales para sistemas termoactivos (modo de calefacción)					
0 Sin control automático	X				D
1 Control automático central	X	X	X		B
2 Control automático central avanzado	X	X	X	X	A
3 Control automático central avanzado con operación por intermitencia y, o control de retroalimentación de temperatura interior					
x	X	X	X	X	A
1.3 Control de la temperatura del agua caliente de la red de distribución (ida o retorno)					
Se puede aplicar una función similar al control de las redes para la calefacción eléctrica directa					
0 Sin control automático	X				D
1 Control compensado en función de la temperatura exterior					
x	X	X			C
2 Control basado en las demandas	X	X	X	X	A
1.4 Control de las bombas de distribución en las redes					
Las bombas se pueden instalar en la red con distintos niveles de control					
0 Sin control automático	X				D
1 Control marcha/parada	X	X	X		B
2 Control multietapas	X	X	X	X	A
3 Control de las bombas de velocidad variable [estimaciones (internas) del grupo de bombas]					
x	X	X	X	X	A
4 Control de las bombas a velocidad variable	X	X	X	X	A
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
1.5 Control por intermitencia de la emisión y/o de la distribución					
Un único dispositivo de control puede controlar varios locales/zonas que tengan los mismos perfiles de ocupación					
0 Sin control automático	X				D
1 Control automático con programa horario fijo					
x	X	X			C
2 Control automático con optimización marcha/parada					
x	X	X	X	X	A
3 Control automático con evaluación de las demandas					
x	X	X	X	X	A
1.6 Control de los generadores de calor (combustión y calefacción urbana)					
0 Control de la temperatura constante	X				D
1 Control de la temperatura variable en función de la temperatura exterior					

x	X	X			C
2 Control de la temperatura variable en función de la carga					
x	X	X	X	X	A
1.7 Control de los generadores de calor (bomba de calor)					
0 Control de temperatura constante	X				D
1 Control de temperatura variable en función de la temperatura exterior					
x	X	X			C
2 Control de temperatura variable en función de la carga					
x	X	X	X	X	A
1.8 Control de los generadores de calor (unidad exterior)					
0 Control marcha/parada del generador de calor					
x x	X				D
1 Control multietapas del generador de calor	X	X	X	X	A
2 Control variable del generador de calor	X	X	X	X	A
1.9 Secuencia de los diferentes generadores de calor					
0 Prioridades basadas en una lista de prioridades fijadas					
x x	X				D
1 Prioridades basadas únicamente en las cargas					
x	X	X			C
2 Prioridades dinámicas basadas en las características y rendimiento del generador					
x	X	X	X	X	A
3 Prioridades basadas en las cargas previstas (varios parámetros)					
x	X	X	X	X	A
Definición de las clase Residencial No residencial					
D	D	C	B	A	
Control automático					
1.10 Control de la operación de la acumulación de energía térmica (TES)					
0 Operación continua de la acumulación	X				D
1 Control de la acumulación mediante 2 sensores					
x	X	X			C
2 Operación de la acumulación basada en la carga prevista					
x	X	X	X	X	A
2 Control del suministro en agua caliente sanitaria					
2.1 Control de la carga de la acumulación del agua caliente sanitaria con calefacción eléctrica integrada					
bomba de calor eléctrica					
0 Control automático marcha/parada	X				D
1 Control automático marcha/parada y programación de carga					
x	X	X			C
2 Control automático de marcha/parada y programación de carga y gestión de la acumulación con varios captadores					
x	X	X	X	X	A
2.2 Control de la carga de la acumulación de agua caliente sanitaria utilizando un generador de agua caliente					
0 Control automático de marcha/parada	X				D
1 Control automático de marcha/parada y programación de carga					
x	X	X			C
2 Control automático de marcha/parada y programación de carga y control de la temperatura de suministro según la demandas o gestión de acumulación con varios sensores					
x	X	X	X	X	A
2.3 Control de la carga de acumulación de agua caliente sanitaria con captación solar y generación de energía de apoyo					
0 Control manual	X				D

1 Control automático de la carga de acumulación de energía solar (Prioridad 1) y carga de acumulación de apoyo (Prioridad 2)					
x	X	X			C
2 Control automático de la carga de acumulación de energía solar (Prioridad 1) y carga de acumulación de apoyo (Prioridad 2) más control de la temperatura de suministro según las demandas o gestión de acumulación con varios sensores					
x	X	X	X	X	A
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
2.4 Control de la bomba de circulación de agua caliente sanitaria					
0 Sin control, operación continua	X				D
1 Con programación horaria	X	X	X	X	A
3 Control de refrigeración					
3.1 Control de las unidades terminales					
La función de control de aplica a las unidades terminales (panel refrigerante, ventilo-convector o u interior) al nivel del local; para el tipo uno una función puede controlar varios locales					
0 Sin control automático	X				D
1 Control automático central	X				D
2 Control individual por local	X	X	X		B
3 Control individual por local con comunicación					
x	X	X	X	X	A
4 Control individual por local con comunicación y detección de ocupación (no se aplica a ningún sistema de emisión de calor de reacción lenta, por ejemplo suelos refrigerantes)					
x	X	X	X	X	A
3.2 Control de unidades terminales para sistemas termoactivos (modo de refrigeración)					
0 Sin control automático	X				D
1 Control automático central	X	X	X		B
2 Control automático central avanzado	X	X	X	X	A
3 Control automático central avanzado con operación por intermitencia y, o control de retroalimentación de temperatura interior					
x	X	X	X	X	A
3.3 Control de la temperatura del agua enfriada de la red de distribución (ida o retorno)					
Se puede aplicar una función similar al control de la refrigeración eléctrica directa (por ejemplo, unidades de refrigeración compactas, unidades splits) para locales individuales					
0 Control de temperatura constante	X				D
1 Control compensado en función de la temperatura exterior					
x	X	X			C
2 Control basado en las demandas	X	X	X	X	A
3.4 Control de las bombas de distribución en las redes hidráulicas					
Las bombas se pueden instalar en la red con distintos niveles de control					
0 Sin control automático	X				D
1 Control marcha/parada	X	X	X		B
2 Control multietapas	X	X	X	X	A
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
3 Control de las bombas de velocidad variable (estimaciones (internas) del grupo de bombas)					
x	X	X	X	X	A
4 Control de las bombas de velocidad variable (señal de demanda externa)					
x	X	X	X	X	A
3.5 Control por intermitencia de la emisión y/o de la distribución					
Un único dispositivo de control puede controlar varios locales/zonas que tengan los mismos perfil					

ocupación					
0 Sin control automático	X				D
1 Control automático con programa horario					
fijo					
x	X	X			C
2 Control automático con optimización					
marcha/parada					
x	X	X	X	X	A
3 Control automático con evaluación de las					
demandas					
x	X	X	X	X	A
3.6 Enclavamiento entre el control de la calefacción y la refrigeración para la emisión y/o la distribución					
0 Sin enclavamiento	X				D
1 Enclavamiento parcial (en función del sistema HVAC)					
x	X	X	X		B
2 Enclavamiento total	X	X	X	X	A
3.7 Control del generador para enfriamiento					
El objetivo consiste generalmente en aumentar tanto como sea posible la temperatura del agua de enfriadoras					
0 Control de temperatura constante	X				D
1 Control de temperatura variable en función de la temperatura exterior					
x	X	X	X	X	A
2 Control de temperatura variable en función de la carga					
x	X	X	X	X	A
3.8 Secuencia de diferentes enfriadoras (generadores de agua enfriada)					
0 Prioridades basadas únicamente en el tiempo de funcionamiento					
x x	X				D
1 Prioridades basadas únicamente en las cargas					
x	X	X			C
2 Prioridades basadas en la eficiencia y las características de los generadores					
x	X	X	X	X	A
3 Secuencia basada en las cargas previstas	X	X	X	X	A
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
3.9 Control de la acumulación de la energía térmica (TES)					
0 Operación continua de la acumulación	X				D
1 Operación con programación horaria de la acumulación					
x	X	X			C
2 Operación de la acumulación basada en la carga prevista					
x	X	X	X	X	A
4 Control de la ventilación y del acondicionamiento de aire					
4.1 Control del aire de impulsión al nivel del local					
0 Sin control automático	X				D
1 Control programado	X	X	X	X	A
2 Control por detección de la ocupación	X	X	X	X	A
4.2 Control de la temperatura del aire interior (sistemas todo aire)					
0 Control de marcha/parada	X				D
1 Control variable	X	X	X		B
4 Control en función de las demandas	X	X	X	X	A
4.3 Control de la temperatura del aire interior (sistemas aire-agua combinados)					
0 Sin coordinación	X				D
1 Con coordinación	X	X	X	X	A
4.4 Control del caudal de aire exterior					
0 Relación de aire exterior/caudal de aire exterior fijada					
x	X				D
1 Relación de aire exterior/caudal de aire exterior escalonada (bajo/elevado): en función de un programador horario					
x	X	X	X		B

2 Relación de aire exterior/caudal de aire					
exterior escalonada (bajo/elevado) (en función de la ocupación)					
x	X	X	X	X	A
3 Control variable	X	X	X	X	A
4.5 Control del caudal de aire o de la presión al nivel de la central de tratamiento de aire					
0 Sin control automático	X				D
1 Marcha/parada por control horario	X	X	X		B
2 Control multietapas	X	X	X	X	A
3 Control automático del caudal o de la presión (sin reajuste)					
x	X	X	X	X	A
4 Control automático del caudal o de la presión (con reajuste)					
x	X	X	X	X	A
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
4.6 Control de recuperación de calor: protección contra heladas					
0 Sin protección contra heladas	X				D
1 Con protección contra heladas	X	X	X	X	A
4.7 Control de recuperación de calor: prevención de sobrecalentamientos					
0 Sin control de sobrecalentamiento	X				D
1 Con control de sobrecalentamiento	X	X	X	X	A
4.8 Enfriamiento gratuito					
0 Sin control automático	X				D
1 Enfriamiento nocturno	X	X	X		B
2 Enfriamiento gratuito	X	X	X	X	A
3 Control directo H,x	X	X	X	X	A
4.9 Control de la temperatura del aire de impulsión					
0 Sin control automático	X				D
1 Punto de consigna constante	X	X	X		B
2 Punto de consigna variable con compensación de la temperatura exterior					
x	X	X	X	X	A
3 Punto de consigna variable con compensación en función de la carga					
x	X	X	X	X	A
4.10 Control de la humedad					
0 Sin control automático	X				D
1 Control del punto de rocío	X	X	X		B
2 Control directo de la humedad	X	X	X	X	A
5 Control de la iluminación					
5.1 Control por ocupación					
0 Interruptor manual de encendido/apagado	X	X			C
1 Interruptor manual de encendido/apagado					
señal complementaria de apagado general					
x	X	X	X		B
2 Detección automática (encendido automático)					
x	X	X	X	X	A
3 Detección automática (encendido manual)	X	X	X	X	A
5.2 Control de la intensidad luminosa/luz natural					
0 Manual (centralizada)	X	X			C
1 Manual (por local/zona)	X	X	X		B
2 Conmutación automática	X	X	X	X	A
Definición de las clase					
Residencial No residencial					
D	D	C	B	A	
Control automático					
3 Modulación automática	X	X	X	X	A
6 Control de las persianas					
0 Operación manual	X				D
1 Operación motorizada con control manual	X	X			C
2 Operación motorizada con control automático					
x	X	X	X		B
3 Control combinado de la					

iluminación/persianas/HVAC					
x	X	X	X	X	A
7 Gestión técnica de viviendas y edificios					
7.1 Gestión de los puntos de consigna					
0 Reglaje manual individual de cada local	X	X			C
1 Adaptación únicamente a partir de locales repartidos/descentralizados					
x	X	X	X		B
2 Adaptación a partir de un local central	X	X	X	X	A
3 Adaptación a partir de un local central con retroalimentación frecuente de las entradas de los usuarios					
x	X	X	X	X	A
7.2 Gestión de los tiempos de operación					
0 Reglaje manual (activación de la instalación)					
x	X				D
1 Reglaje individual según un programa predefinido incluyendo fases de precondicionamiento fijas					
x	X	X	X		B
2 Reglaje individual según un programa predefinido; adaptación a partir de un local central; fases de precondicionamiento variables					
x	X	X	X	X	A
7.3 Detección de los fallos de los sistemas técnicos de los edificios y ayuda para el diagnóstico de detectados y de las alarmas					
0 Sin indicación centralizada de los fallos detectados y de las alarmas					
x	X				D
1 Con indicación centralizada de los fallos detectados y de las alarmas					
x	X	X	X		B
2 Con indicación centralizada de los fallos detectados y de las alarmas/funciones de diagnóstico					
x	X	X	X	X	A
7.4 Informe de los resultados acerca del consumo de energía y de las condiciones interiores					
0 Indicación de los valores reales únicamente (por ejemplo, temperaturas, valores medidos)					
x	X	X			C
Definición de las clases					
Residencial No residencial					
D	D	C	B	A	
Control automático					
1 Funciones de análisis de tendencias y determinación del consumo					
x	X	X	X	X	A
2 Análisis, evaluación de la eficiencia, comparación					
x	X	X	X	X	A
7.5 Producción de energía local y energías renovables					
0 Generación no controlada en función de la disponibilidad variable de las fuentes de energías renovables y/o del tiempo de producción de CHP; el exceso de producción se transferirá a la red					
x	X	X			C
1 Coordinación de las fuentes locales de energías renovables y de la producción de CHP en función del perfil de la demanda energética local, incluyendo la gestión de la acumulación de la energía; optimización del consumo individual					
x	X	X	X	X	A
7.6 Recuperación de calor y transferencia de calor					
0 Uso instantáneo del calor residual o de la transferencia de calor					
x x	X				D
1 Uso controlado del calor residual o de la transferencia de calor [incluida la carga/descarga de la energía térmica acumulada (TES)]					
x	X	X	X	X	A
7.7 Integración en una red inteligente					
0 Sin armonización entre la red y los sistemas energéticos del edificio; el edificio se opera independientemente de la carga de la red					
x	X	X			C
1 Los sistemas energéticos del edificio se gestionan y se operan en función de la carga de la red; se utiliza la gestión de la demanda para la transferencia de cargas					
x	X	X	X	X	A

TITOLO: INTERFACE

PROJECT DESCRIPTION

What are the concrete objectives you would like to achieve and outcomes or results you would like to realise? How are the objectives linked to the priorities you have selected

Le emozioni ed il comportamento sono due dimensioni strettamente collegate che si influenzano reciprocamente. Le emozioni sono elementi preziosi della vita quotidiana, in quanto ognuna trasmette delle informazioni precise sul significato che stiamo attribuendo ad una certa situazione.

Fanno parte della costruzione dell'Identità di un individuo, se non elaborate possono creare blocchi. Migliorano l'apprendimento, la cooperazione tra pari e permettono la crescita psicologica.

Le emozioni represses del disabile si trasformano in varie forme di: agitazione, ansia, preoccupazione, comportamenti impulsivi, disordini del comportamento, scoppi d'ira ingiustificati, incapacità di concentrazione, incontinenza, ecc.

Per gestire dunque in modo efficace le emozioni del disabile è necessario saperle rilevare e comprenderle per essere in grado di regolarle per evitare tra i disabili comportamenti a rischio. I comportamenti a rischio sono condotte che possono mettere in pericolo, sia nel breve che nel medio e lungo periodo, la salute fisica e il benessere psicosociale delle persone con disabilità.

Il progetto intende:

Sperimentare una tecnica di monitoraggio delle Emozioni del Disabile attraverso una tecnologia digitale e di domotica delle strutture sociali (come ad esempio le residenze sanitarie e/o centri diurni per disabili) tracciando le emozioni degli utenti (e del personale e staff) al fine di identificare e regolare eventi ed elementi negativi nella stabilità emotiva degli utenti delle strutture.

Nello specifico si intende sperimentare e testare questa tecnica digitale all'interno della struttura per disabili Minerva ed elaborare i dati raccolti, codificarli e creare un report sull'efficacia della sperimentazione.

Lo studio di Testing & Validation è fondamentale per diffondere sempre più la domotica nel settore sanitario allo scopo di garantire controllo e totale sicurezza degli utenti.

Please outline the target groups of your project

Il progetto identifica 2 principali gruppi target:

1. L'utenza delle strutture sanitarie e centri diurni (per disabili e anziani);
2. Lo staff delle strutture che impareranno a riconoscere le emozioni della loro utenza e intervenire di conseguenza.

Please describe the motivation for your project and explain why it should be funded

Il progetto nasce:

- dalla necessità di comprendere meglio i bisogni della nostra utenza (utenti disabili) e aiutare a gestire in maniera appropriata le loro emozioni. Ad esempio grazie alla rilevazione delle corrette emozioni Proporre una serie di attività da fare a casa o in classe, che possano aiutarlo a riconoscere meglio le sue emozioni e a gestirle in modo adeguato e aiutarli a gestirle in maniera funzionale;
- dalla necessità di portare innovazione all'interno delle strutture sanitarie attraverso processi di digitalizzazione e domotica rendendole più Smart ed efficaci;
- la necessità di rendere le strutture più Smart dopo la pandemia di covid che ha reso queste strutture più vulnerabili.

L'idea nasce dunque dalla necessità di mettere la domotica al servizio delle strutture di anziani e/o portatori di handicap.

How does the project address the needs and goals of the participating organizations and the identified needs of their target groups

Il progetto nasce dal bisogno:

- della nostra cooperativa di avviare un processo di domotica e digitalizzazione all'interno della nostra struttura;
- dall'esigenza del Dipartimento di Robotica dell'Università di Madrid di sperimentare e analizzare processi di domotica all'interno delle strutture sanitarie

Il progetto inoltre permette di efficientare i servizi rivolti all'utenza, e supporta allo stesso tempo staff ed educatori, per cui in tal senso il progetto incontra bisogni del target group e del consorzio.

What will be the benefits of cooperating with transnational partners to achieve the project objectives ?

Nonostante in Europa il mercato della domotica sia in espansione, il 71 per cento degli europei non utilizza alcun dispositivo domotico, il dato peggiora se si va a vedere il basso livello di domotizzazione delle strutture sanitarie.

In particolare dopo la crisi sanitaria è importante cooperare per la creazione di strumenti sempre più innovativi basate sulla domotica e digitalizzazione soprattutto quando parliamo di strutture sanitarie.

I benefici della cooperazione transnazionale derivano dal fatto che gli obiettivi prefissati possono essere meglio conseguito a livello dell'UE che non a livello nazionale, regionale o locale per i seguenti motivi: -Il progetto può raggiungere un Impatto più ampio di medio-lungo periodo; -Permette di fare uno studio su ampio e comparare problematiche tra paesi e soluzioni, per cui si favorisce un meccanismo di trasferibilità da parte dei paesi più virtuosi rispetto a quelli più in difficoltà; -rafforza l'identità europea e avvicina realtà e persone apparentemente diverse e lontane tra di loro; -favorisce il miglioramento delle attività; - promuove un rapporto basato sulla cooperazione e sulla fiducia reciproca genera risultati superiori rispetto a quelli che i partner singolarmente a livello locale potrebbero conseguire; -stimola innovazioni e scambio di idee; -aiuta a condividere e confrontare esperienze e idee.

COOPERATION ARRANGEMENTS

How was the partnership formed? What are the strengths that each partner will bring to the project

Il Progetto è composto da 2 organizzazioni desiderose di collaborare in sinergia per incoraggiare un processo innovativo di digitalizzazione e domotica per le strutture sanitarie che lavorano con disabili e anziani.

Il partenariato è strategico e promuove competenze ed expertise complementari per il raggiungimento degli obiettivi.

- L'Università di Madrid parteciperà infatti partecipa con il Dipartimento di Robotica e Domotica pertanto potrà assistere MINERVA nella fase di realizzazione della sperimentazione e testing e si occuperà dell'elaborazione e codifica dei dati.
- La cooperativa MINERVA gestisce un centro per disabili (in particolare con disabilità Intellettiva) e hanno grandissima esperienza nella gestione di questo tipo di target.

La collaborazione tra Minerva e l'Università nasce qualche anno fa, grazie ad un rapporto di collaborazione tra lo staff e l'Università attraverso l'ospitalità di alcuni tirocinanti (staff di Minerva, In particolare nella persona di Francesco de Luca si occupa di digitalizzazione all'interno di MINERVA e che ha avuto la possibilità di partecipare alle attività di Ricerca del Dipartimento.

How will you ensure sound management of the project and good cooperation and communication between partners during project implementation?

Attività di progetto implementate per garantire un buon management:

- Preparazione degli accordi interni; - Preparazione del Project management plan PMP; - Preparazione dei piani dettagliati e degli strumenti di comunicazione del progetto, controllo della qualità, monitoraggio e diffusione; - aspetti amministrativi; - sviluppo di modelli per il reporting interno; - traduzioni dei contenuti del sito Web; - realizzazione template vari; - preparazione rapporti finanziario; - kit di lavoro per i TPM; - coordinamento del progetto; - coordinare le attività di disseminazione e diffusione

Per garantire la corretta attuazione del progetto si utilizzerà un approccio su misura, fluido e il più semplice possibile, per garantire che tutte le attività siano adeguatamente attuate, tutti i partecipanti coinvolti e risorse non sprecate. I compiti saranno distribuiti equamente tra i partner, ma tenendo conto dell'area di competenza e pertinenza di ciascuna organizzazione. All'interno del PMP saranno stabiliti metodi di lavoro e documenti specifici del progetto per la fase di gestione di progetto. L'attività di Project management comprende le operazioni di quotidiana gestione, come monitoraggio dei costi, generale coordinamento interno da parte di ciascun partner, comunicazioni e conference call, raccolta e archiviazione di documenti interni, disseminazione ecc. (Durata: mese 1-24).

La Comunicazione sarà fluida e costante attraverso TPM in presenza e online.

La cooperazione e l'organizzazione del lavoro sarà chiaramente definita e strutturata in modo da raggiungere obiettivi e risultati prefissati. All'avvio del progetto, un Accordo di Partenariato interno sarà concordato e firmato da tutti i partner per garantire da parte loro impegno totale e senso di appartenenza all'azione. Esso formalizzerà inoltre obblighi ed aspettative e definirà i meccanismi interni di cooperazione e comunicazione tra i partner.

Have you used or do you plan to use Erasmus + platform for preparation, implementation, or follow up of your project? If yes please describe how

L'utilizzo delle piattaforme Erasmus plus sarà fondamentale nell'attività di follow up del progetto per diffondere i risultati e le tecnologie utilizzate. In particolare si farà riferimento a EPALE e la piattaforma dei risultati Erasmus plus.

Please describe the tasks and responsibilities of each partner organization in the project

Ruolo del coordinatore: la Cooperativa Minerva ha la capacità tecnica e operativa per un adeguato coordinamento dei partner e il coinvolgimento degli stakeholder. Ha nel proprio interno una chiara struttura per garantire la corretta gestione del progetto: il ruolo guida di MINERVA garantisce l'impegno pro attivo dei partner.

Nello Specifico MINERVA Coordina e monitora il progetto ed è responsabile dell'Attività 1, ovvero la sperimentazione e testing con l'utenza disabile e ne raccoglie i dati.

L'Università supporta Minerva nelle attività di PM, disseminazione e monitoraggio ed è responsabile dell'Attività 2 ovvero la codifica dei risultati della sperimentazione.

ACTIVITIES

A1

Describe the content of the proposed activity

Questa attività consiste nel definire, progettare e installare il sistema composto di telecamere e calcolatori e gestire le risorse del sistema stesso prevedendo una elaborazione più o meno centralizzata. In particolare l'attività prevede la scelta, montaggio e programmazione delle telecamere e la loro connessione al sistema di comunicazione che può essere Wi-Fi, Ethernet, TP o una combinazione di essi, suddividere le capacità di calcolo all'interno del sistema, implementare gli algoritmi di riconoscimento facciale e "machine learning" necessari alla applicazione.

Inoltre sarà programmata un'applicazione in grado di associare i risultati ottenuti da queste due tecniche e memorizzarle in un file informativo anonimo contenente:

- l'identificativo per ciascun utente, lo spettro emotivo associato,
- la data dell'acquisizione
- la camera dalla quale sono state acquisite le informazioni.

Con l'ausilio di Psicologi, educatori e staff viene verificata la corretta acquisizione delle emozioni, questa parte può essere svolta a margine per ridurre l'invasività degli ospiti. Infine, l'intero apparato viene testato nelle varie situazioni verificabili per 2 giorni al fine di rilevare eventuali errori.

A Coordinare questa attività sarà l'Ing Francesco De Luca. che fornirà anche supporto informatico per integrare la fase 1 (A1) con la fase 2 (A2) attraverso ad esempio un'interfaccia utente.

L'Attività consiste anche nel formare educatori, psicologi e staff a riconoscere le emozioni con questa tecnologia innovativa.

Describe the target group for this activity. Who is going to take part and who is going to benefit from the results?

E' possibile rilevare 2 gruppi target per questa attività:

- L'Utenza che sarà sottoposta alla sperimentazione per la rilevazione delle emozioni;
- Educatori, psicologi e staff che avranno uno strumento scientifico ed efficace per comprendere meglio le emozioni della loro utenza

Explain how is this activity going to help to reach the project objectives

Questa attività è direttamente collegata all'obiettivo del progetto, in quanto implementa concretamente la sperimentazione della tecnica del monitoraggio delle Emozioni del Disabile e ne raccoglie dati rilevanti per valutarne l'efficacia e l'impatto.

describe the expected results of the activity

Risultati attesi dall'attività:

- identificare le emozioni;
- formati gli educatori e lo staff a riconoscere le emozioni dell'utente e utilizzarle in maniera funzionale nel guidare e assistere l'utenza disabile e/anziانا;
- avviato un processo di digitalizzazione della struttura;

Please explain how you determine the grant amount allocated top this activity

Come è intuibile dalla descrizione dell'attività questa attività è molto onerosa e complessa, richiede attrezzature, tempo e specializzazione. Pertanto giustifica perfettamente la quantità di budget allocata.

40.000

A2

Describe the content of the proposed activity

La seconda attività del progetto riguarda la sperimentazione e validazione. I dati verranno acquisiti e analizzati utilizzando l'intelligenza artificiale in modo tale da identificare bisogni e problemi, verrà attuata un'azione correttiva, sotto la consulenza dello psicologo e i risultati saranno valutati utilizzando lo stesso sistema.

In questa fase gli educatori/operatori impareranno ad utilizzare gli output del sistema digitale per migliorare il proprio lavoro e la user experience.

Verrà definita una strategia da attuare e un piano d'azione, distinguendo tra disagi dovuti ad eventi o situazioni eliminabili con un'unica azione e tra disagi dovuti a caratteristiche individuali e quindi non eliminabili con un'unica azione. Nel secondo caso gli operatori dovranno mettere in atto un comportamento personalizzato verso le particolari esigenze di specifici pazienti.

I dati verranno codificati dall'Università che si occuperà di stilare un report accademico sull'efficacia della metodologia e sperimentazione. Report che sarà diffuso attraverso un'attività di disseminazione allo scopo di creare un effetto moltiplicatore e diffondere a livello UE e nazionale le potenzialità della domotica e digitalizzazione .

Describe the target group for this activity. Who is going to take part and who is going to benefit from the results?

Questa attività prevede i seguenti gruppi target:

- educatori e operatori che acquisiscono nuove competenze chiave;
- altre strutture, e stakeholder che possono beneficiare dei risultati della sperimentazione e delle tecnologie condivise e diffuse.

Explain how is this activity going to help to reach the project objectives

Questa attività è perfettamente legata all'obiettivo di progetto, in quanto codifica i dati della sperimentazione e dunque testa l'efficacia di questa tecnica digitale all'interno della struttura per disabili, ne valuta dunque l'impatto e le potenzialità.

describe the expected results of the activity

Risultati attesi dall'attività:

- valutata l'efficacia del processo di domotica;
- contribuito a dare rilevanza accademica e scientifica al tema;
- creato report sull'attività di sperimentazione;
- diffusa la sperimentazione tra gli stakeholder.

Please explain how you determine the grant amount allocated to this activity

Questa attività, sebbene, soprattutto di ricerca, prevede un lavoro molto impegnativo di codifica dei dati e diffusione dei risultati che giustifica perfettamente il budget allocato.

20.000

IMPACT AND FOLLOW UP

How will you know if the project has achieved its objectives? What tool or methods will you use?

Il progetto intende sperimentare una tecnica di monitoraggio delle Emozioni del Disabile attraverso una tecnologia digitale e di domotica delle strutture sociali tracciando le emozioni degli utenti (e del personale e staff) al fine di identificare e regolare eventi ed elementi negativi nella stabilità emotiva degli utenti delle strutture.

Per il raggiungimento dell'obiettivo le 2 attività descritte sopra sono collegate.

L'attività 2 infatti consiste nella codifica dei dati raccolti nell'attività 1 per cui funge da indicatore dell'efficacia della sperimentazione

Nello specifico per misurare il grado di raggiungimento degli obiettivi si farà affidamento ai seguenti indicatori:

- Numero delle rilevazioni effettuate con la tecnologia descritta in A1;
- Diario dove vengono annotati i feedback dell'attività di misurazione;
- interviste con lo staff e gli educatori;
- attività di codifica dei dati (che sarà fatta in A2);
- N° Attività di disseminazione dello studio effettuato per far conoscere la fattibilità e l'impatto del processo di digitalizzazione all'interno delle strutture sanitarie.
- misurare attraverso interviste allo staff ed educatori l'efficacia della metodologia per aiutare gli utenti a riorientare le loro emozioni e guidarli verso uno stato di benessere psico-fisico;
- monitoraggio dei cambiamenti degli utenti.

How will the participation in this project contribute to the development of the involved organizations in the long term? Do you have plans to continue to implement some of the activities after the project's end?

Il progetto rappresenta solo il primo step di digitalizzazione della nostra struttura. L'obiettivo di lungo periodo è quello di creare una struttura domotica adattando la struttura alle nuove tecnologie in maniera da offrire un'offerta sempre più attenta ai reali bisogni degli utenti e beneficiari dei nostri servizi. Un processo che non è circoscritto alla nostra struttura ma che attraverso il seguente progetto intende diffondere le potenzialità della domotica e digitalizzazione delle strutture sanitarie. Lo studio in A2 infatti ha questo scopo principale, quello di diffondere i risultati e dunque l'efficacia di un processo di questo tipo, contribuendo a portare innovazione all'interno delle strutture in Europa.

Nello specifico il progetto permette alle organizzazioni di:

- Avviare e proseguire il processo di Domotica delle strutture;
- innovare l'offerta per l'utenza disabile;
- Studiare meglio l'impatto e l'efficacia della domotica;

Ma anche di:

- Avviare un processo di Dimensione Europea della nostra struttura;
- sviluppare sempre più relazioni e sinergie transnazionali e multi-settore.

Please describe your plans for sharing and use of project results:

How will you make the results of your project Known within your partnership, in your local communities and in the wider public? Who are the main target groups you would like to share your results with?

Are there other groups or organizations that will benefit from your project? Please explain how

Il progetto prevede una capillare attività di disseminazione.

Gli obiettivi specifici delle attività di disseminazioni sono i seguenti:

- La promozione del progetto;
- La disseminazione dei risultati del progetto;
- L'aumento della diffusione e della consapevolezza dell'importanza della domotica per le strutture sanitarie;

Attività di disseminazione:

- Seminari/conferenze;
- promozione del progetto tra le reti della Cooperativa Minerva e l'Università;
- Eventi moltiplicatori;
- diffusione dei risultati del progetto attraverso un'efficace comunicazione online;
- Articoli sulla stampa/blog e siti rilevanti;

TARGET AUDIENCE: - Istituzioni pubbliche (quali asl, ambiti territoriali, Università) , istituti sanitari, Educatori, staff delle strutture,utenza, Cittadini tutti, Comunità locale, e stakeholder; Interlocutori e in generale tutte quelle organizzazioni e persone coinvolte e attente al settore sanitario e della formazione.

Anche altre organizzazioni del settore potranno beneficiare della nostra sperimentazione e del nostro studio che avrà una buona rilevanza scientifica in quanto curato dall'Università e dunque con un profilo accademico. Il progetto sarà loro di stimolo per avviare processi di digitalizzazione e domotica nelle proprie strutture.

19 ATTACHMENT 8 CV IMPLEMENTATION FOR EMOTION RECOGNITION INTERFACE

```

1 import cv2
2 import numpy as np
3 import matplotlib.pyplot as plt
4 import tensorflow as tf
5
6 path = "haarcascade_frontalface_default.xml"
7 font_scale = 1.5
8 font = cv2.FONT_HERSHEY_PLAIN
9
10 # set background white
11 rectangle_bgr = (225,225,225)
12 # set blank image
13 img = np.zeros((500,500))
14 # set some text
15 text = "text in the box"
16 # get the width and height of the text box
17 (text_width,text_height) = cv2.getTextSize(text, font, fontScale=font_scale, thickness=1)[0]
18 # set the text start position
19 text_offset_x = 10
20 text_offset_y = img.shape[0] - 25
21 # make the coords of the box with a small padding of tow pixels
22 box_coors=((text_offset_x, text_offset_y), (text_offset_x + text_width +2, text_offset_y - text_height -2))
23 cv2.rectangle(img, box_coors[0],box_coors[1],rectangle_bgr,cv2.FILLED)
24 cv2.putText(img, text, (text_offset_x, text_offset_y), font, fontScale=font_scale, color=(0,0,0), thickness=1)
25
26
27 model_loaded = tf.keras.models.load_model('emotion_recognition_vallacc_6990_input_48_48_1_without_transfer.h5')
28 model_loaded.summary()
29
30
31 cap = cv2.VideoCapture(1)
32 #Check if the webcam is opened correctly
33 if not cap.isOpened():
34     cap = cv2.VideoCapture(0)
35 if not cap.isOpened():
36     raise IOError("Cannot open webcam")
37
38
39 while True:
40     ret,frame = cap.read()
41     faceCascade = cv2.CascadeClassifier(cv2.data.haarcascades + 'haarcascade_frontalface_default.xml')
42     gray = cv2.cvtColor(frame,cv2.COLOR_RGB2GRAY)
43     faces = faceCascade.detectMultiScale(gray,1.1,4)
44     for x,y,w,h in faces:
45
46         roi_gray = gray[y:y+h, x:x+w]
47         roi_color = frame[y:y+h, x:x+w]
48         cv2.rectangle(frame, (x,y), (x+w,y+h), (0,0,225), 2)
49         faces = faceCascade.detectMultiScale(roi_gray)
50         if len(faces) == 0:
51             print("Face not detected")
52         else:
53             for (ex,ey,ew,eh) in faces:
54                 face_gray = roi_gray[ey: ey+eh, ex:ex+ew]
55
56                 final_images = cv2.resize(face_gray,(48,48))
57                 final_images = np.expand_dims(final_images,axis = 0)
58                 final_images = np.expand_dims(final_images,axis = 3)
59                 final_images =final_images/255.0
60
61                 Prediction = model_loaded.predict(final_images)
62
63                 x1,y1,w1,h1 = x,y,w,-int(h/3)
64                 # Add text
65                 if(np.argmax(Prediction) == 0):
66                     status = "Angry"
67                 elif(np.argmax(Prediction) == 1):
68                     status = "Disgusted"
69                 elif(np.argmax(Prediction) == 2):
70                     status = "Fear"
71                 elif(np.argmax(Prediction) == 3):
72                     status = "Happy"
73                 elif(np.argmax(Prediction) == 4):
74                     status = "Sad"
75                 elif(np.argmax(Prediction) == 5):
76                     status = "Surprise"
77                 else:
78                     status = "Neutral"
79
80                 cv2.putText(frame, status, (x1, y1), cv2.FONT_HERSHEY_SIMPLEX, 0.7, (0,0,255), 2)
81                 cv2.rectangle(frame, (x,y), (x+w,y+h), (0,0,225))
82
83     cv2.imshow('Face Emotion Recognition', frame)
84     cv2.waitKey(2)
85     cap.release()
86     cv2.destroyAllWindows()
87     cap.release()
88     cv2.destroyAllWindows()

```


Importing and Data generation

```
import numpy as np
import pandas as pd
import os
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.preprocessing import image
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPool2D, Flatten, Dense, Dropout, BatchNormalization
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import cv2
from tensorflow.keras.applications import VGG16, InceptionResNetV2
from tensorflow.keras import regularizers
from tensorflow.keras.optimizers import Adam, RMSprop, SGD, Adamax
train_dir = r'C:\Users\UTENTE\Desktop\TensorFlow_projects\emotion_recognition\Dataset\train'
test_dir = r'C:\Users\UTENTE\Desktop\TensorFlow_projects\emotion_recognition\Dataset\test'
img_size = 48 #original size of the image

train_datagen = ImageDataGenerator(
    rotation_range = 15,
    width_shift_range = 0.1,
    height_shift_range = 0.1,
    horizontal_flip = True,
    rescale = 1./255,
    #zoom_range = 0.2,
    validation_split = 0.2
)

validation_datagen = ImageDataGenerator(rescale = 1./255,
                                       validation_split = 0.2)

train_generator = train_datagen.flow_from_directory(directory = train_dir,
                                                    target_size = (img_size,img_size),
                                                    batch_size = 64,
                                                    color_mode = "grayscale",
                                                    class_mode = "categorical",
                                                    subset = "training"
                                                    )

validation_generator = validation_datagen.flow_from_directory( directory = test_dir,
                                                             target_size = (img_size,img_size),
                                                             batch_size = 64,
                                                             color_mode = "grayscale",
                                                             class_mode = "categorical",
                                                             subset = "validation"
```

Model construction

```
model= tf.keras.models.Sequential()
model.add(Conv2D(32, kernel_size=(3, 3), padding='same', activation='relu', input_shape=(48, 48,1)))
model.add(Conv2D(64,(3,3), padding='same', activation='relu' ))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(128,(5,5), padding='same', activation='relu'))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(512,(3,3), padding='same', activation='relu', kernel_regularizer=regularizers.l2(0.01)))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(512,(3,3), padding='same', activation='relu', kernel_regularizer=regularizers.l2(0.01)))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Flatten())
model.add(Dense(256,activation = 'relu'))
model.add(BatchNormalization())
model.add(Dropout(0.25))

model.add(Dense(512,activation = 'relu'))
model.add(BatchNormalization())
model.add(Dropout(0.25))

model.add(Dense(7, activation='softmax'))

model.summary()
```

Training

```
model.compile(
    optimizer = Adam(learning_rate=0.000001),
    loss='categorical_crossentropy',
    metrics=['accuracy']
)
epochs = 100
batch_size = 64
history = model.fit(train_generator,epochs = epochs,validation_data = validation_generator)
```



```

import tensorflow as tf
import keras_preprocessing
from keras_preprocessing import image
from keras_preprocessing.image import ImageDataGenerator
import cv2
import os
import matplotlib.pyplot as plt
import numpy as np
from os import path, getcwd, chdir
import random
from tensorflow.keras.optimizers import RMSprop

training_directory = r'C:\Users\UTENTE\Desktop\TensorFlow_projects\emotion_recognition\Dataset\train'
validation_directory = r'C:\Users\UTENTE\Desktop\TensorFlow_projects\emotion_recognition\Dataset\test'
classes = ["0", "1", "2", "3", "4", "5", "6",]
img_size = 224
newarray = cv2.resize(img_array, (img_size, img_size))
plt.imshow(newarray)
newarray.shape

```

Data generation

```

training_datagen = ImageDataGenerator(
    width_shift_range = 0.1,
    height_shift_range = 0.1,
    horizontal_flip = True,
    rescale = 1./255,
    zoom_range = 0.2,
    validation_split = 0.2
)

validation_datagen = ImageDataGenerator(rescale=1./255,
                                       validation_split = 0.2)
train_generator=train_datagen.flow_from_directory(
    directory = training_directory,
    target_size = (img_size,img_size),
    batch_size = 64,
    class_mode = "categorical",
    subset = "training"
)
validation_generator=train_datagen.flow_from_directory(
    directory = validation_directory,
    target_size = (img_size,img_size),
    batch_size = 64,
    class_mode = "categorical",
    subset = "validation"
)

```

Data augmentation

```

data_augmentation = tf.keras.Sequential([
    tf.keras.layers.experimental.preprocessing.RandomFlip('horizontal'),
    tf.keras.layers.experimental.preprocessing.RandomRotation(0.3)
])

```

Pre-existing net importing

```

base_model = tf.keras.applications.MobileNetV2()
base_model.trainable= False
base_model.summary()

```

Cancel layer with wrong dimension and add new layers

```

inputs = base_model.layers[0].input
x = base_model.layers[-2].output
#x = tf.keras.layers.GlobalAveragePooling2D()(x)
x = tf.keras.layers.Dense(1280/2)(x)
x = tf.keras.layers.Dropout(0.25)(x)
x = tf.keras.layers.Dense(1280/4)(x)
x = tf.keras.layers.Dropout(0.2)(x)
final_output = tf.keras.layers.Dense(7,activation='softmax')(x)
new_model=tf.keras.Model(inputs=inputs,outputs=final_output)
new_model.summary()

```

Training only the last layers

```

new_model.compile(
    loss='categorical_crossentropy',
    optimizer=tf.keras.optimizers.Adam( learning_rate=0.0001),
    metrics=['accuracy']
)
history = new_model.fit(
    train_generator,
    validation_data = validation_generator,
    epochs = 60,
)

```










Fisrt Line devices

Inc	Stanza	Descrizione	Programma Applicativo *	Adr	Prg	Par	Grp	Cfg	Costruttore	Numero	Prodotto
	Stanza Letto Est		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Soggiorno		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Sud-O...		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Sud-Est		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Isolata		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Nord-...		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Nord		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Intern...		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Stanza Letto Nord-...		6127_01_TP_ApplicationProgram2.mtxml	-	-	-	-	-	ABB	6127/01-500	6127/01 Sens. a pulsante solo Standard 4x, INC
	Quadro Primo Pian...	Dimmen 300D01		-	-	-	-	-	GIRA Giersiepen	633 00	Dimmaktor 500VA mit Nebenstelle REG
	Quadro Primo Pian...	Dimmen 300D01		-	-	-	-	-	GIRA Giersiepen	633 00	Dimmaktor 500VA mit Nebenstelle REG
	Quadro Primo Pian...	InnoFlexaKNX one2one		-	-	-	-	-	AIRZONE - ALTRA	AZ01-GWL...	KNX-AIRZONE INTEGRATION GATEWAY
	Quadro Primo Pian...	Jalousie 204001		-	-	-	-	-	GIRA Giersiepen	548 00	Jalousieaktor 2fach REG
	Quadro Primo Pian...	Jalousie 204001		-	-	-	-	-	GIRA Giersiepen	548 00	Jalousieaktor 2fach REG
	Quadro Primo Pian...	Jalousie 204001		-	-	-	-	-	GIRA Giersiepen	548 00	Jalousieaktor 2fach REG
	Quadro Primo Pian...	Jalousie 204001		-	-	-	-	-	GIRA Giersiepen	548 00	Jalousieaktor 2fach REG
	Quadro Primo Pian...	Jalousie 204001		-	-	-	-	-	GIRA Giersiepen	548 00	Jalousieaktor 2fach REG
	Soggiorno	KNX BAOS 83x		-	-	-	-	-	Weinzierl Engineering GmbH	KNX BAOS...	KNX BAOS 830
	Quadro Primo Pian...	LC00B01KNX Line Coupler		-	-	-	-	-	Eelectron	LC00B01K...	LC00B01KNX Line Coupler
	Quadro Piano Terra	MAXinBOX 24 1.4		-	-	-	-	-	Zennio	ZIO-MB24	MAXinBOX 24
	Quadro Primo Pian...	MAXinBOX 24 1.4		-	-	-	-	-	Zennio	ZIO-MB24	MAXinBOX 24
	Quadro Primo Pian...	MAXinBOX 24 1.4		-	-	-	-	-	Zennio	ZIO-MB24	MAXinBOX 24
	Disimpegno letto s...	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Disimpegno letto e...	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Soggiorno	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Sud-O...	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Sud-Est	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Nord-...	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Nord-...	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Nord	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Est	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Stanza Letto Intern...	PD00E03KNX Sensore di Presenza SPACE		-	-	-	-	-	Eelectron	PD00E03K...	Sensore di Presenza SPACE E03
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	WC soggiorno	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Disimpegno Ascens...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Disimpegno entrat...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Disimpegno letto e...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Disimpegno letto n...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Disimpegno letto s...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Bagno stanza letto...	PIR comfort A00802		-	-	-	-	-	GIRA Giersiepen	1304 xx	Pannello interruttore automatico Comfort 1,1...
	Quadro Primo Pian...	PS.30.640.2 KNX Power Supply 640mA		-	-	-	-	-	CONTROLtronic	PS.30.640.2	PS.30.640.2 KNX Power Supply 640mA
	Stanza Letto Nord	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Letto Nord-...	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Letto Nord-...	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Letto Sud-Est	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Letto Sud-O...	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Soggiorno	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Disimpegno letto n...	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Disimpegno letto s...	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Letto Isolata	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Cucina	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Soggiorno	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza COVID	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Laboratori	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Zone Pranzo	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Disimpegno letto e...	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Stanza Letto Est	RH07A01KNX		-	-	-	-	-	Eelectron	RH07A01K...	9025 KNX Termostato Capacitivo/Umidostat...
	Quadro Primo Pian...	Schalten 203501		-	-	-	-	-	GIRA Giersiepen	987 00	Schaltaktor 6fach 6A REG
	Quadro Primo Pian...	Schalten 203501		-	-	-	-	-	GIRA Giersiepen	987 00	Schaltaktor 6fach 6A REG
	Quadro Primo Pian...	Schalten 203501		-	-	-	-	-	GIRA Giersiepen	987 00	Schaltaktor 6fach 6A REG
	Quadro Primo Pian...	Schalten 203501		-	-	-	-	-	GIRA Giersiepen	987 00	Schaltaktor 6fach 6A REG
	Quadro Primo Pian...	Schalten 203A01		-	-	-	-	-	GIRA Giersiepen	883 00	Schaltaktor 4fach 16A REG
	Quadro Primo Pian...	Schalten 203A01		-	-	-	-	-	GIRA Giersiepen	883 00	Schaltaktor 4fach 16A REG
	Quadro Primo Pian...	Schalten RM, VK, ZF 206001		-	-	-	-	-	GIRA Giersiepen	1009 00	Schaltaktor 8fach REG

Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Disimpegno letto s...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Disimpegno letto n...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Disimpegno letto e...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
WC soggiorno	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Disimpegno Ascens...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Disimpegno entrat...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld
Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx	Tastsensor 2fach mit Beschriftungsfeld

Second Line devices

1.... Stanza COVID	6127_01_TP_ApplicationProgram2.mbxml	- - - - -	ABB	6127/01-500 6127/01 Sens. a pulsante solo Standard 4x INC
1.... Zona Pranzo	6127_01_TP_ApplicationProgram2.mbxml	- - - - -	ABB	6127/01-500 6127/01 Sens. a pulsante solo Standard 4x INC
1.... Soggiorno	6127_01_TP_ApplicationProgram2.mbxml	- - - - -	ABB	6127/01-500 6127/01 Sens. a pulsante solo Standard 4x INC
1.... Stanza Laboratori	6127_01_TP_ApplicationProgram2.mbxml	- - - - -	ABB	6127/01-500 6127/01 Sens. a pulsante solo Standard 4x INC
1.... Quadro Piano Terra	Dimmer C018	- - - - -	Eelectron	DM04D01... 1-10V Dimmer 4 Channels
1.... Quadro Piano Terra	Dimmer C018	- - - - -	Eelectron	DM04D01... 1-10V Dimmer 4 Channels
1.... Quadro Piano Terra	Jalousie 204001	- - - - -	GIRA Giersiepen	548 00 Jalousieaktor 2fach REG
1.... Soggiorno	KNX BAOS 83x	- - - - -	Weinzierl Engineering GmbH	KNX BAOS... KNX BAOS 830
1.... Stanza Laboratori	KNX BAOS 83x	- - - - -	Weinzierl Engineering GmbH	KNX BAOS... KNX BAOS 830
1.... Quadro Piano Terra	LC00B01KNX Line Coupler	- - - - -	Eelectron	LC00B01K... LC00B01KNX Line Coupler
1.... Stanza COVID	PD00E03KNX Sensore di Presenza SPACE	- - - - -	Eelectron	PD00E03K... Sensore di Presenza SPACE E03
1.... Soggiorno	PD00E03KNX Sensore di Presenza SPACE	- - - - -	Eelectron	PD00E03K... Sensore di Presenza SPACE E03
1.... Stanza Laboratori	PD00E03KNX Sensore di Presenza SPACE	- - - - -	Eelectron	PD00E03K... Sensore di Presenza SPACE E03
1.... Disimpegno stanza...	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Disimpegno soggio...	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Bagno stanza COVID	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Bagno Disabili	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Bagno stanza letto...	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Disimpegno zona p...	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Quadro Piano Terra	PS 30.640.2 KNX Power Supply 640mA	- - - - -	CONTROLtronic	PS 30.640.2 PS 30.640.2 KNX Power Supply 640mA
1.... Scala Interna	Regolatore esterno PIR A00301	- - - - -	GIRA Giersiepen	880 xx Pannello interruttore automatico Standard 1,1...
1.... Scala Interna	Regolatore esterno PIR A00301	- - - - -	GIRA Giersiepen	880 xx Pannello interruttore automatico Standard 1,1...
1.... Quadro Piano Terra	Schalten 203A01	- - - - -	GIRA Giersiepen	883 00 Schaltaktor 4fach 16A REG
1.... Quadro Piano Terra	Schalten VK_ZF 200212	- - - - -	GIRA Giersiepen	612 00 Schaltaktor 2fach 6A REG
1.... Quadro Piano Terra	Schalten ZF / Jalousie 802602	- - - - -	GIRA Giersiepen	1029 00 Schaltaktor 16fach / Jalousieaktor 8fach REG
1.... Entrata via Giusepp...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx Tastsensor 2fach mit Beschriftungsfeld
1.... Bagno stanza COVID	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx Tastsensor 2fach mit Beschriftungsfeld
1.... Bagno Disabili	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx Tastsensor 2fach mit Beschriftungsfeld
1.... Bagno stanza letto...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx Tastsensor 2fach mit Beschriftungsfeld

Third line devices

1.... Quadro Piano Terra	LC00B01KNX Line Coupler	- - - - -	Eelectron	LC00B01K... LC00B01KNX Line Coupler
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... terrazza Est	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... terrazza Sud	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... terrazza Sud	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... terrazza Sud-Est	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Terrazza Nord stan...	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Giardino	PIR comfort A00802	- - - - -	GIRA Giersiepen	1304 xx Pannello interruttore automatico Comfort 1,1...
1.... Quadro Piano Terra	PS 30.640.2 KNX Power Supply 640mA	- - - - -	CONTROLtronic	PS 30.640.2 PS 30.640.2 KNX Power Supply 640mA
1.... Lavanderia terrazza...	Schalten/Tasten 103402	- - - - -	GIRA Giersiepen	882 xx Tastsensor 2fach mit Beschriftungsfeld
1.... terrazza Sud-Est	Stazione Meteo Plus KNX C01810	- - - - -	Eelectron	WS00A01K... Stazione Meteo Plus KNX

