Fatigue load on the human body can cause several health issues and, in some cases, serious injuries. The concept of designing an engineering device to assist people under these types of loads in becoming more familiar in research topics. Exoskeletons can be used to assist labor in their daily job, moreover, they can be used to assist the elderly in maneuvering and standing up straight from other positions. This study is a follow up on several colleges' theses designing an active type exoskeleton to assist a person during bending and standing positions by supporting 30% of his load through dedicated modeling of the human himself and the designed exoskeleton model. Several control strategies will be implemented to accurately develop the best performance.

"Design of a control strategy for a pneumatically powered, active-type exoskeleton model on MATLAB and Simscape, implementing the control law on a dedicated microcontroller that interfaces the peripherals through a designed PCB and developing MIL, PIL and HIL testing through MATLAB, microcontroller and a designed testbench."

ALI Ahmed Hassan Aboubakr Shaaban, Prof. MAZZA Luigi, Politecnico Di Torino

The aim of the study is to implement the CAD models designed by former colleges and assemble all the parts and develop the selection procedure done before of the bearings and belts. Moreover, actuating the control law and have a working prototype of the exoskeleton ready for testing on the testbench.

After the assembly phase, the cornerstone of this thesis is how to implement the control law? Testing several control theories such as PID, LQR and MPC and simulating the best performance and least error. How to actuate the pneumatic air motors? Using a proportional value to vary the pressure on the device. How to interface this electronic valve? and which microprocessor to use? The application is not complicated and needs low processing power as an Arduino board can be used. Moreover, the valve can be interfaced with a designed PCB (printed circuit board) to actuate the valve at the correct rating. Several simulations of this PCB must be done first and must follow design guidelines. What type of sensor can be used to pick up data to be controlled? It can be a torque sensor to measure the torque required by the wearer and actuate the control law on this toque directly. On the other hand, an angular position sensor can be used to pick up the position of the wearer and the torque can be calculated. The first type of sensor is not suitable as the force generated by the wearer is distributed on the torso and not concentrated at a certain point, while the second sensor needs a rotating shaft to be mounted on or mounted very near, however, the model at hand has only rotating pulleys. However, there are several types of sensor that can be chosen as an accelerometer which can pick up the gravity vector in different axes and calculate a very precise position from the acceleration components in the gravity directions which then needs to be filtered as any movements from the wearer will introduce other acceleration components which are not needed and can introduce fault in the data acquired. Finally, some sensors are designed with integrated different sensor types, for instance, a 9-axis accelerometer, gyroscope, magnetometer can be used which can provide perfect gravity vectors and can provide angular velocity as well from the gyroscope.

The sensor selection procedure is followed by the sensor interfacing due to the high quantity of data sent from the sensor to the target hardware and this introduces the interfacing of the sensor using a dedicated bus as I^2C to handle these large bulks of data sent at a time.

After interfacing the sensor and actively reading data in real time, data acquisition from the sensor to the simulation tool is required to simulate the model with real time data while the test is not run in real time. Moreover, the acquired data can be used to visualize the movement of the device on simple models created by Python drawing libraries as vpython and on the actual CAD model imported from Solidworks into Simscape. Finally, Model in the Loop (MIL) testing should be performed and build up to Processor (PIL) and hardware (HIL) in the loop as well.

Following is the CAD model of the exoskeleton.

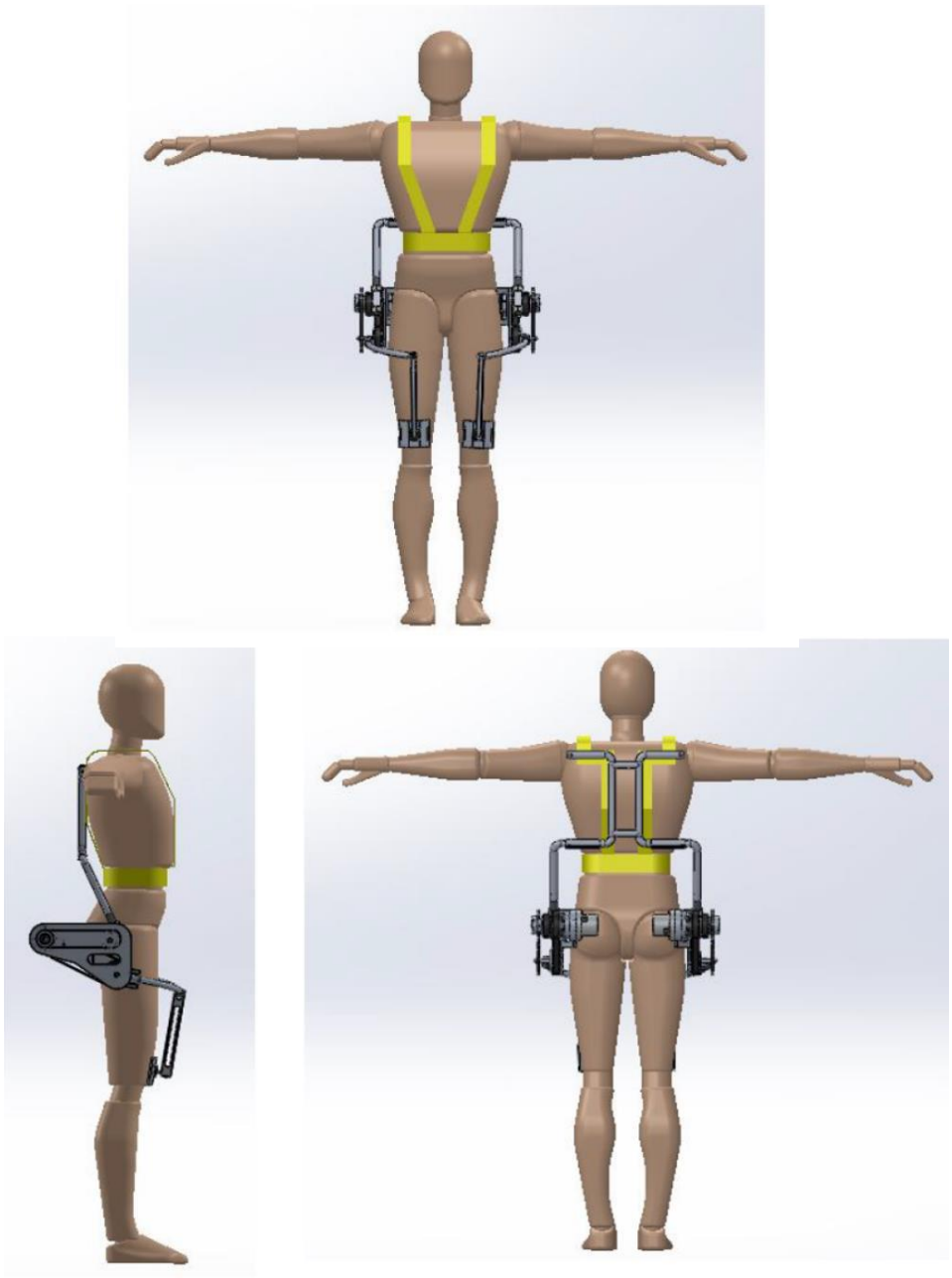

Figure: CAD model of the exoskeleton.