Development of Dynamic Arm Support for Children with Duchenne Muscular Dystrophy

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Introduction

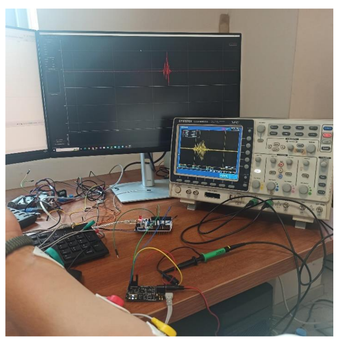
- Duchenne Muscular Dystrophy (DMD) is the most common neuromuscular disease in childhood with a live male birth rate of 1/3500.
- Due to the nature of the proximal muscle weakness of the disease, it loses its function of lifting the arm at an average age of 13-15 years.
- The purpose of this study is to develop a dynamic arm support and show feasibility of this exoskeleton for children with Duchenne Muscular Dystrophy.

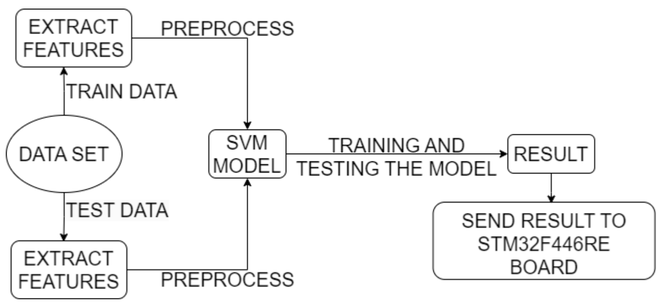
Specifications and Design Requirements

- MaM Sense EMG sensors - obtaining EMG signals that help us estimate which movement sequence the patient is attempting to complete with a pre-developed AI using MATLAB
- MPU6050 6 degrees of freedom gyroscope/accelometer sensors – obtaining angle values that help us calculate the exact position of the elbow and the shoulder of the patient
- RP-C18.3-ST Force sensor - measuring the force exerted by the patient towards the inner parts of the exoskeleton to determine if the patient is successful in completing his/her desired movement
- Using all of these data to estimate the location of the arm in real time and to figure out if the patient is struggling. If the motion has not been completed, motor control circuitry will assist the patient

Solution Methodology

- EMG: MaM Sense acquires EMG data with a built-in ADC. We used the UART protocol to send the data to the computer. We predicted the movement with the help of the received data and artificial intelligence created from MATLAB.





- Gyroscope: MPU6050's main purpose is to provide the necessary data that will be used to determine the location of the exoskeleton at any given time. Since the sensor supports I2C, its configuration with the STM32 Nucleo board was completed with ease.

Expression	Type	Value
Axx	float	-0.120361328
Ayy	float	0.913818359
Azz	float	0.258789062
Gxx	float	-1.67175567
Gyy	float	-6.77099228
Gzz	float	2.69465637
mpu1.Ax	float	-0.161132812
mpu1.Ay	float	-0.261230469
mpu1.Az	float	0.884277344
mpu2.Ax	float	-0.120361328
mpu2.Ay	float	0.913818359
mpu2.Az	float	0.221923828
result	float	88.9776917

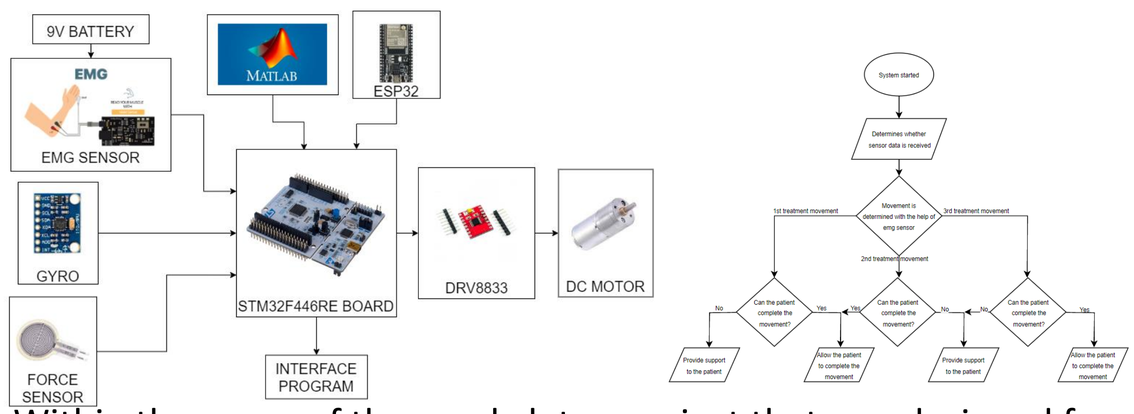
- Force Sensor: RP-C18.3-ST's main purpose is to provide the data that will be required to see if the patient is exerting force on the inner surface of the exoskeleton. This information is crucial in the calculation of the success of the patient.

Expression	Type	Value
SystemCoreClock	uint32_t	168000000
voltage	volatile float	2.65689874
adcValue	uint32_t	2168
Add new expression		

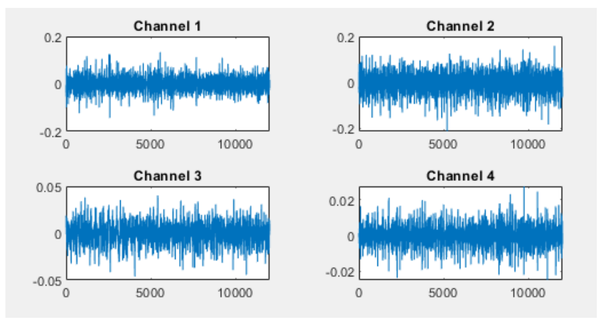
Application Areas

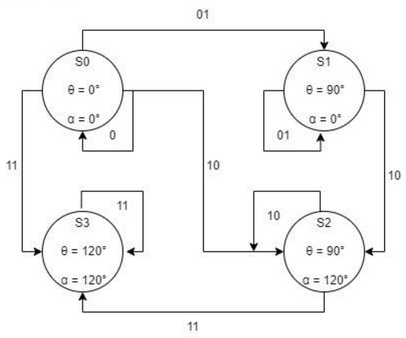
- A prototype of the exoskeleton has been designed and assembled. We used a 3D printer for some crucial parts of the design.

Results and Discussion



- ❖ Within the scope of the exoskeleton project that was designed for children with DMD and MS, we contribute to the rehabilitation process by predicting the desired physical movement by taking data from EMG, gyroscope and force sensors.
- ❖ Artificial intelligence developed through MATLAB analyzes the data received, predicts the movement the patient wants to make, and supports the patient when necessary, with the help of DC motors.
- ❖ Two main points that could be improved are sensor models and the mechanical components of the exoskeleton.





References

1) RP-C18.3-ST Thin Film Pressure Sensor SKU:SEN0294. (n.d.). Available at: https://media.digikey.com/pdf/Data%20Sheets/DFRobot%20PDFs/SEN0294_Web.pdf [Accessed 2 Jan. 2024].
2) Anon, (n.d.). Mam Sense – MaM High Tech. [online] Available at: https://www.mamhightech.com/portfolio/mam-sense-eog-emg-ecg-sensor/.
3) InvenSense Inc. (2013). MPU-6000 and MPU-6050 Product Specification Revision 3.4 MPU-6000/MPU-6050 Product Specification. [online] Available at: https://invensense.tdk.com/wp-content/uploads/2015/02/MPU-6000-Datasheet1.pdf.

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