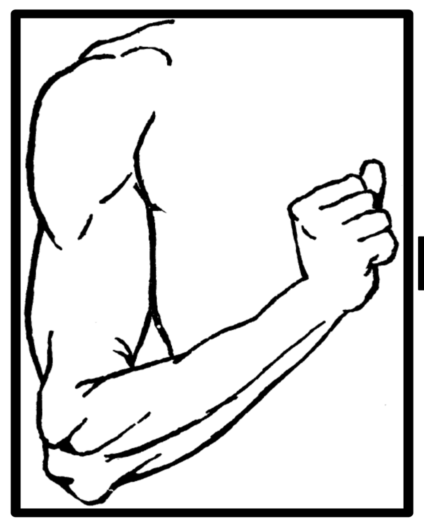
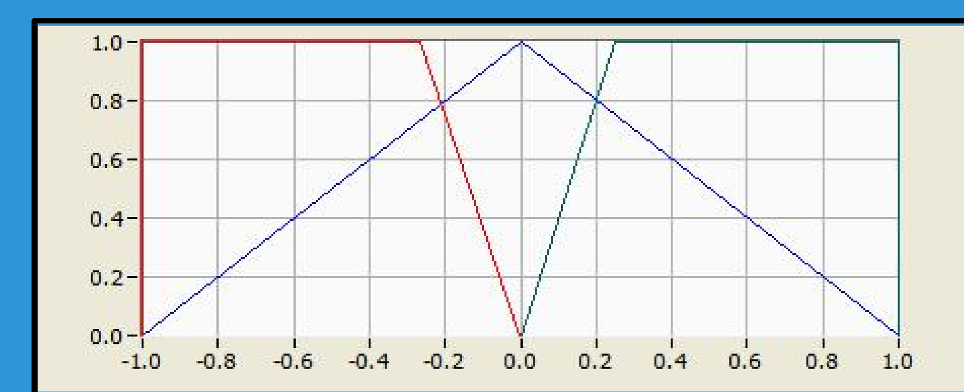
Preliminary Results of a Fuzzy-EMG Controller for a Rehabilitation Robot

Jayadevan Radhakrishnan, Glenn D. Snyder Jr., and Dr. Edward E. Brown Jr.
Biomechatronic Learning Laboratory
Department of Electrical Engineering, Rochester Institute of Technology



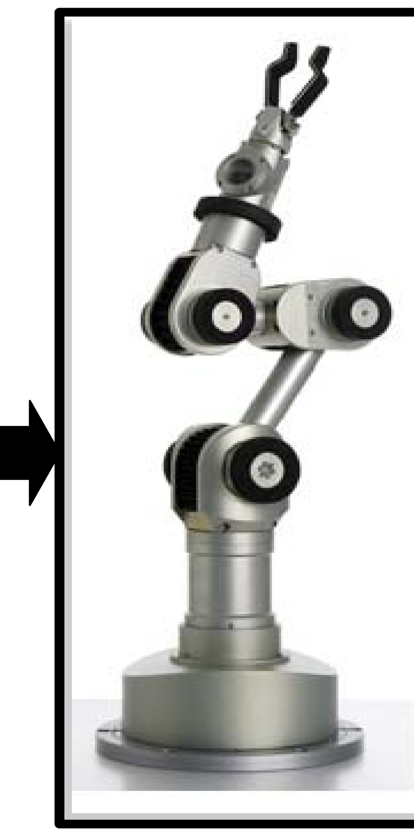
Raw EMG Signal

Fuzzy Controller



ENCODERS

JOINTS 1-6

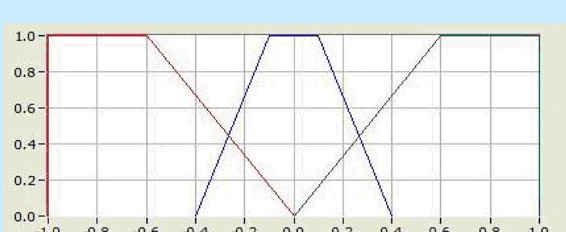


Introduction

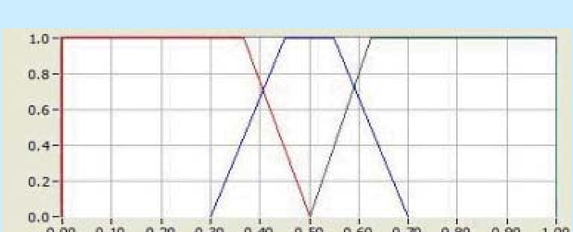
Rehabilitation robotics is a growing area of research in the biomedical engineering field, and is expected to contribute to improving the way of life for people with physical disabilities and various neuromuscular diseases. In this research project, our goal is to develop a fuzzy-EMG controller for rehabilitation robotic system to assist individuals having muscular atrophying diseases such as muscular dystrophy.

Fuzzy-EMG Controller

Signal Slope



Controller Output



EMG Signal

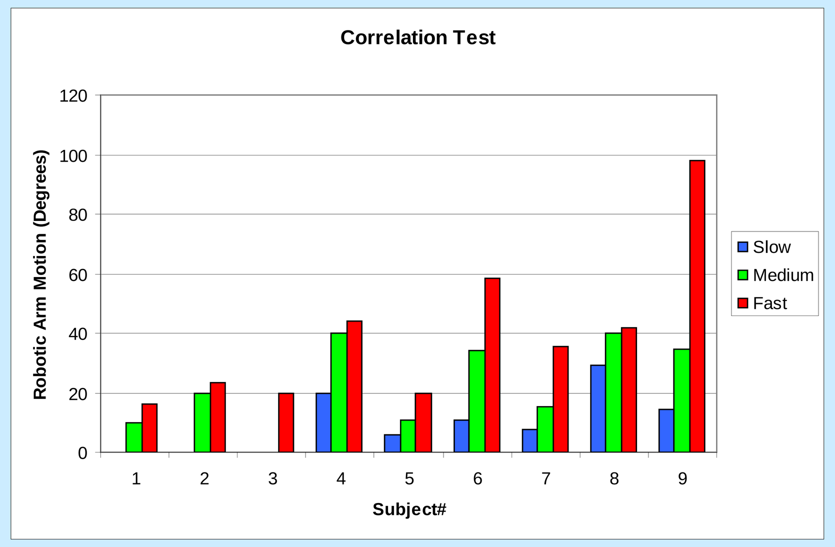
		EMG Signal Amplitude		
		Neg	Zero	Pos
EMG Signal Slope	Neg	Zero	Neg	Neg
	Zero	Neg	Zero	Pos
	Pos	N/A	Pos	Pos

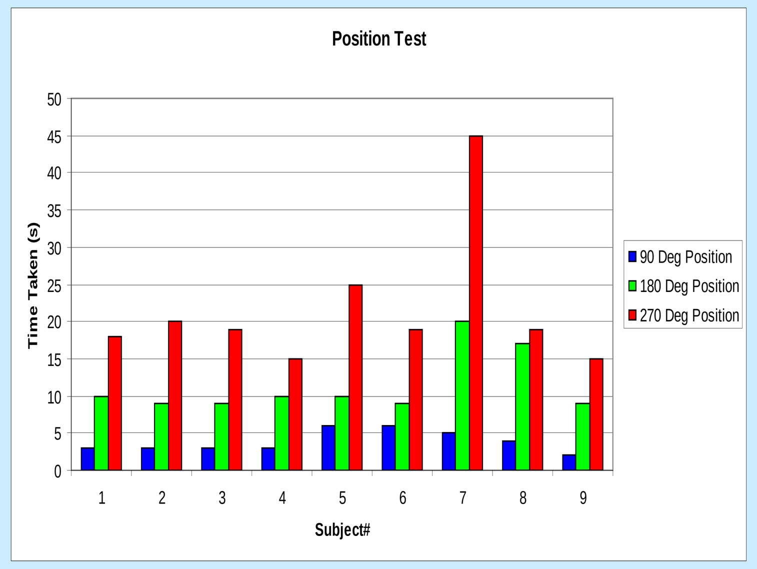
Fuzzy Rule Base

Results

Subject#	Gender	Height (in)	Weight (lbs)	BMI
1	Female	69	124	18.3096
2	Female	63	100	17.71227
3	Female	65	123	20.46604
4	Female	66	153	24.69215
5	Male	70	165	23.67245
6	Male	72	215	29.15606
7	Male	72	165	22.37558
8	Male	68	250	38.00822
9	Male	69	178	26.28313

** Note BMI - Body Mass Index*





Correlation Test: Each subject was asked to flex their biceps in three different paces slow, medium and fast. The starting point was from rest at 0 degrees to the completely flexed position of approximately 150 degrees. The corresponding robotic arm movement was recorded and tabulated.

Position Test: Users were asked to move the robotic arm to three different positions at 90, 180 and 270 degrees. The ease with which each user was able move the robotic arm with biceps contractions is reflected on the time it took them to move to the designated positions.

The fuzzy controller accepts the sEMG signal amplitude and its slope as inputs to the fuzzy controller. The primary focus here is to develop a simple and robust interface for a rehabilitation robotic system in LabVIEW that uses sEMG signals as the inputs. These inputs are obtained from the surface of the skin to develop a robust and simple system that can be used by various users with different Body Mass Indices. The major scope of the work is done in real-time, therefore, the design is kept simple; any algorithms developed in the future can be tested on the controller developed here.

Experimental Methodology

As the user flexes his muscles, a sEMG excitation is produced and captured by the Bio-Radio. This signal and its slope are used as control inputs for the Katana Harmonic Arm. When the user curls his arm, a corresponding motion is produced by the robotic arm. The interface was developed to give the user fine control over the arm's joint position. The interface, developed in LabVIEW was empirically modified to be robust for subjects with different BMI.

Conclusion

The interface provides the framework to use raw sEMG signals from bicep contraction. The fuzzy controller assists in mapping the EMG signal from the muscle to a control input for the elbow joint for the Katana Harmonic arm. The system worked reliably well on 9 subjects both male and female with different BMI.

Acknowledgments

This project is supported by a grant from the Semiconductor Industry Association and by the National Science Foundation CISE division under Award No. IIS-0705130 and Award No. IIS-0748418.

R·I·T