



Robotics & Cobotics



Bionic Arm



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Introduction

- An innovative and functional bionic arm
- Natural movements of the human arm through the use of electromyography (EMG) signals



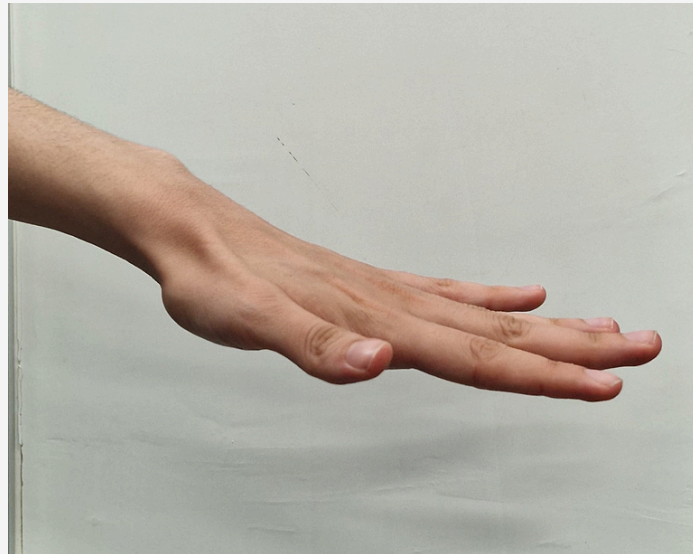
Data collection:

Question N	Questions	Possible Answers
1	What is your name?	String value
2	What is your gender?	<ul style="list-style-type: none">• Female• Male
3	What is your age?	Numeric value
4	Do you have any muscle disease?	<ul style="list-style-type: none">• Yes• No
5	Do you use any muscle related medication?	<ul style="list-style-type: none">• Yes• No
6	Have you used any stimulus in the last 24 h? (Alcohol etc.)	<ul style="list-style-type: none">• Yes• No
7	What is your dominant hand?	<ul style="list-style-type: none">• Right• Left• Both

Data collection



Data collection



Pronation



Like



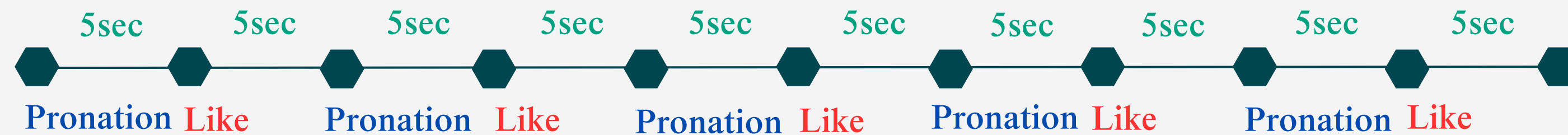
Handshake



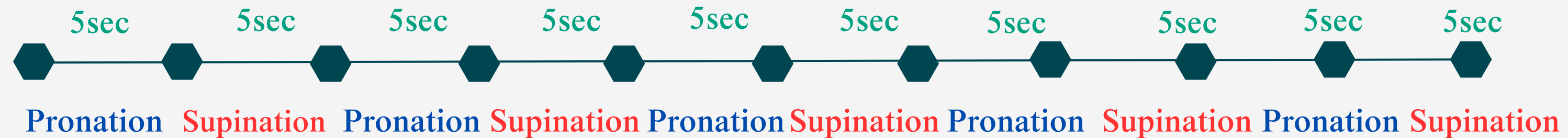
Supination

Data collection

Cycle 1:



Cycle 2:



Cycle 3:



Preprocessing



Fast Fourier Transform (FFT)

to determine cutoff frequencies for filtering.

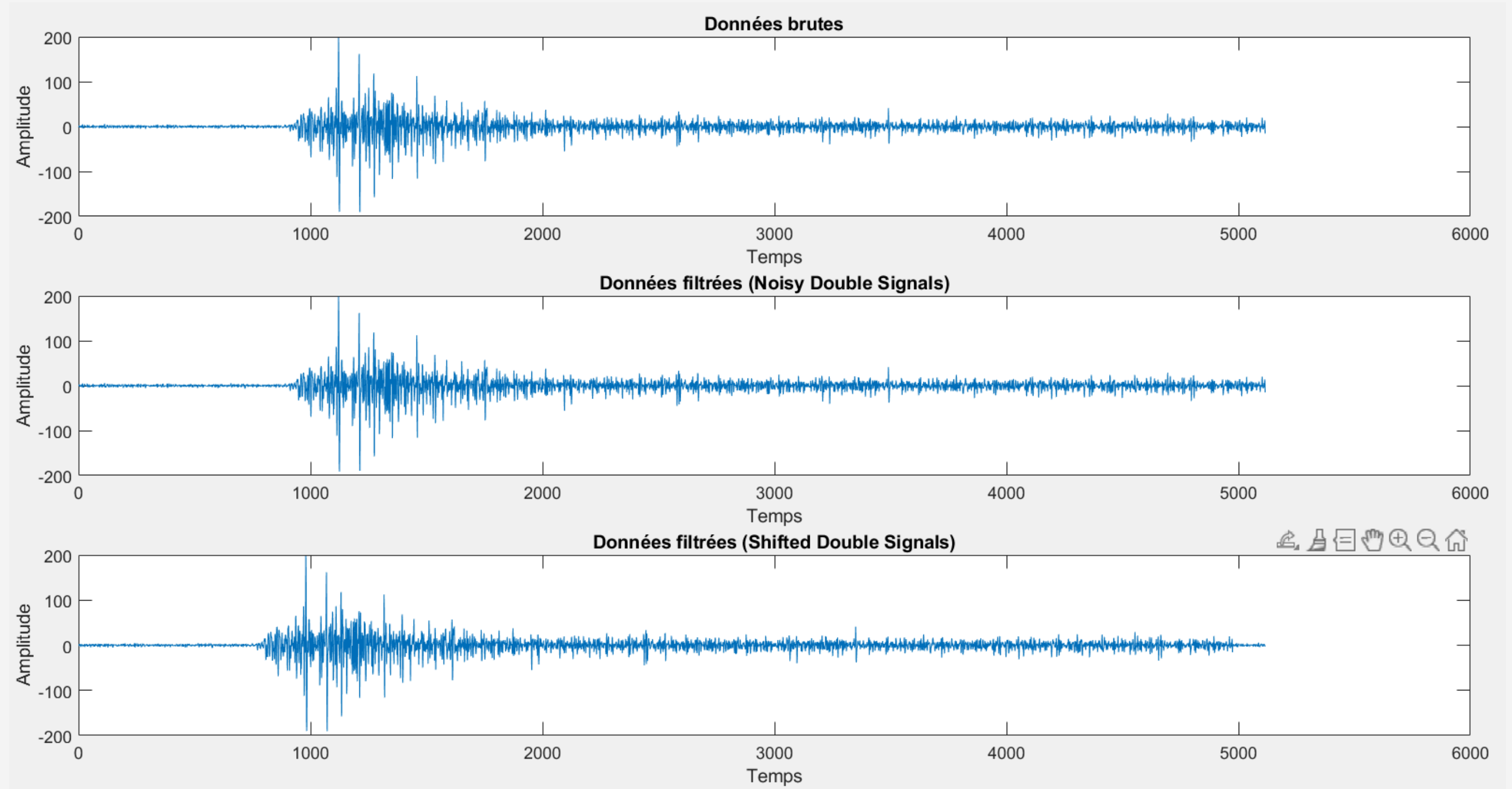
A bandpass Butterworth filter

is designed and applied to filter the EMG signal.

Data Augmentation

two data augmentation techniques - the Gaussian noise method and the time shifting technique.

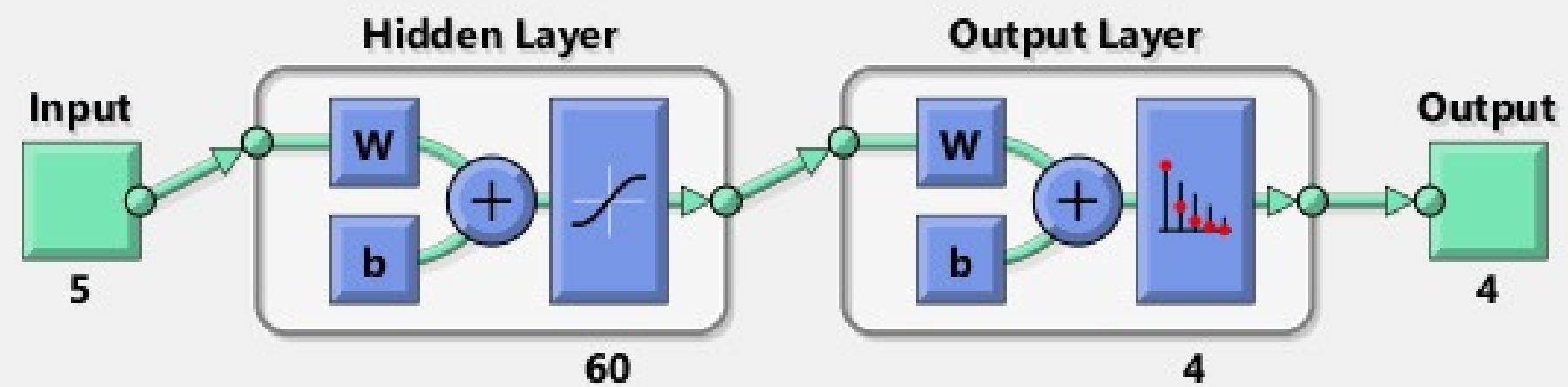
Data Augmentation



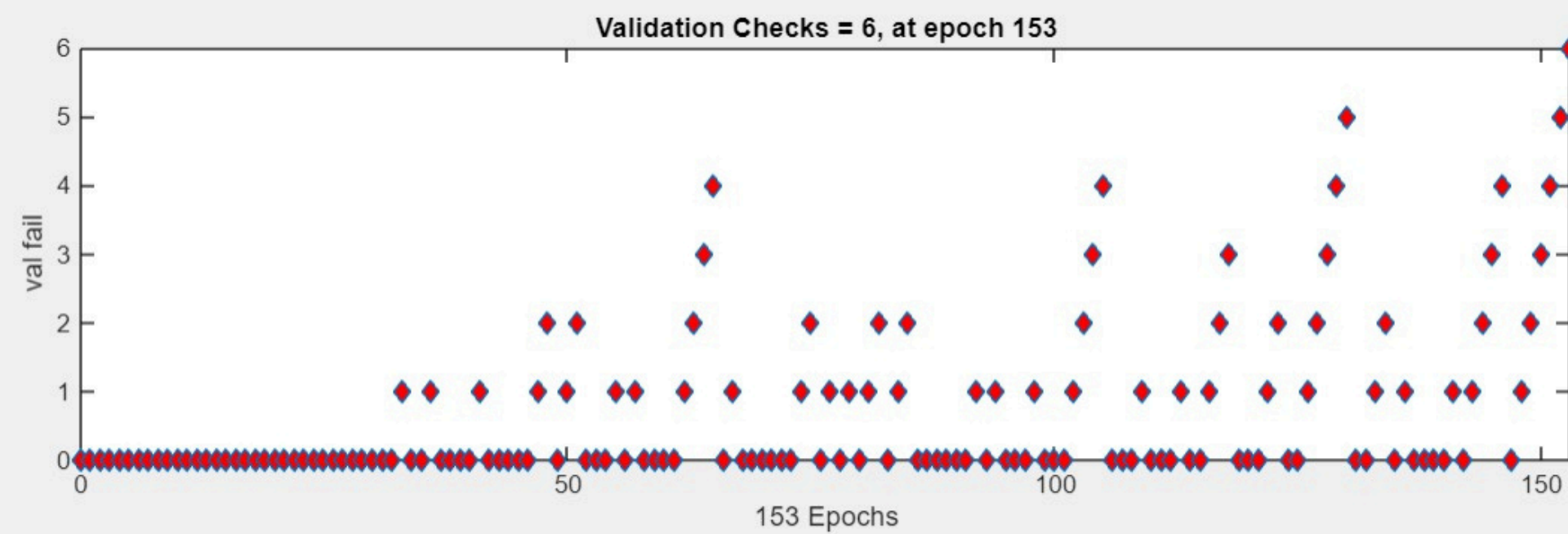
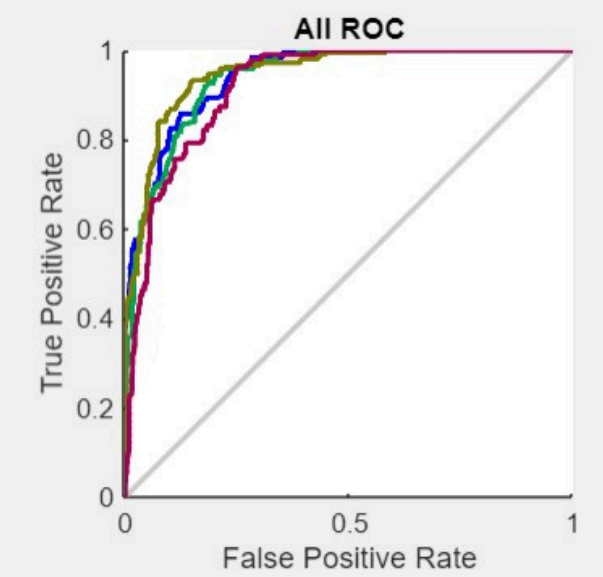
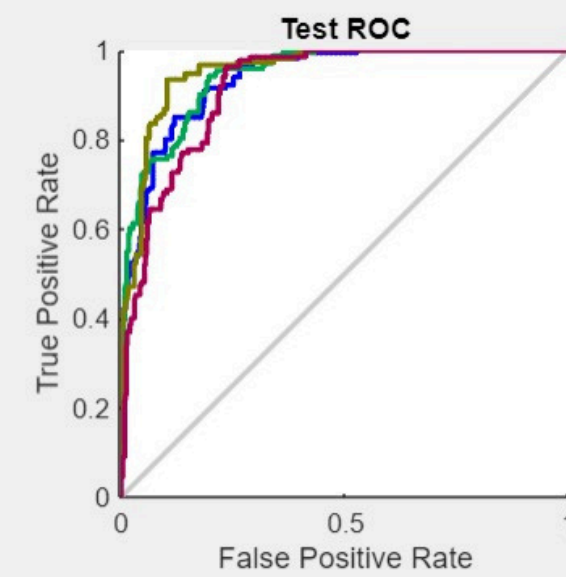
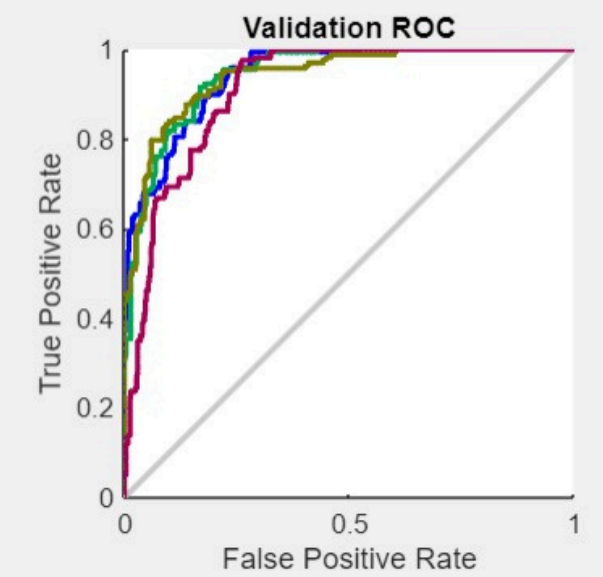
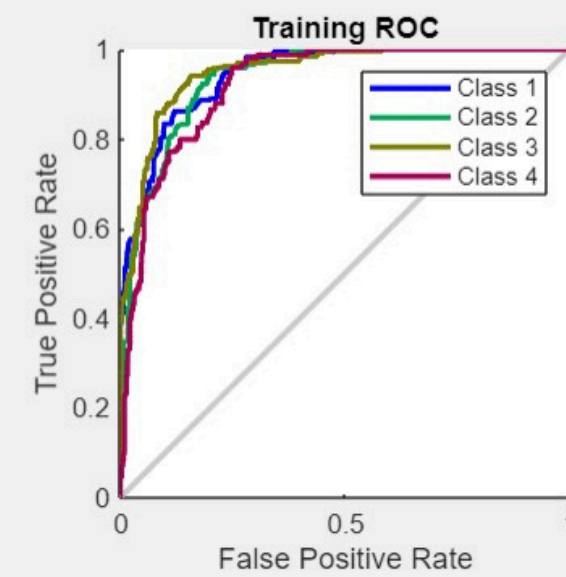
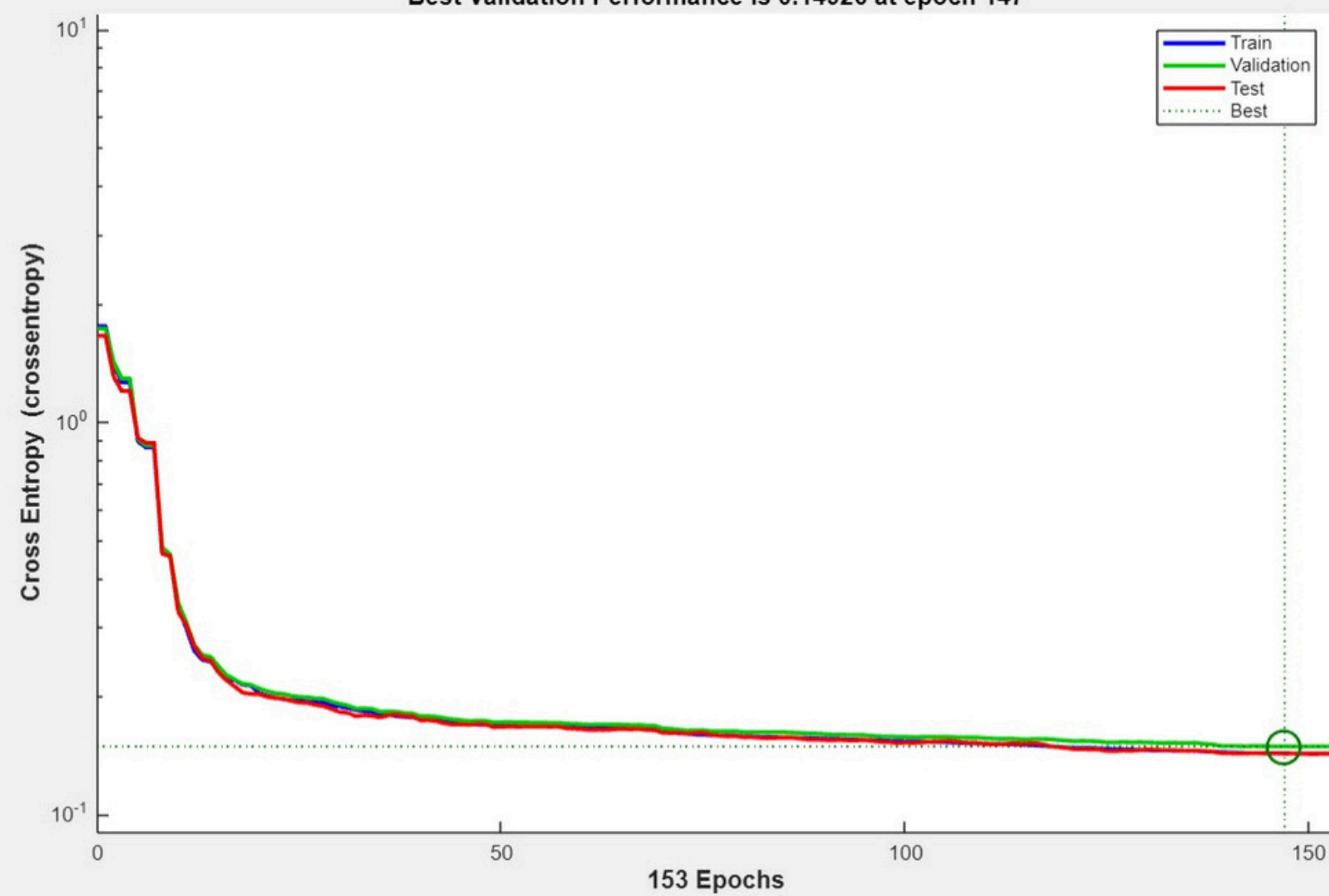
Feature extraction:

No.	Name of the <u>feature</u>	Equation
1	<u>Mean absolute value</u> (MAV)	$\text{MAV} = \frac{1}{N} \sum_{i=1}^N x_i $
2	<u>Root mean square</u> (RMS)	$\text{RMS} = \sqrt{\frac{1}{N} \sum_{i=1}^N x_i^2}$
3	Standard <u>Deviation</u> (STD)	$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$
4	<u>Variance</u> (VAR)	$\text{VAR} = \frac{1}{N - 1} \sum_{i=1}^N x_i^2$
5	<u>Waveform length</u> (WL)	$\text{WL} = \sum_{i=1}^{N-1} x_{i+1} - x_i $

Classification:



Best Validation Performance is 0.14926 at epoch 147



Classification:

Training Confusion Matrix

Output Class \ Target Class	1	2	3	4	
1	560 19.1%	144 4.9%	5 0.2%	26 0.9%	76.2% 23.8%
2	123 4.2%	475 16.2%	3 0.1%	9 0.3%	77.9% 22.1%
3	0 0.0%	17 0.6%	564 19.3%	146 5.0%	77.6% 22.4%
4	47 1.6%	81 2.8%	157 5.4%	569 19.4%	66.6% 33.4%
	76.7% 23.3%	66.2% 33.8%	77.4% 22.6%	75.9% 24.1%	74.1% 25.9%

Validation Confusion Matrix

Output Class \ Target Class	1	2	3	4	
1	114 18.2%	36 5.7%	4 0.6%	8 1.3%	70.4% 29.6%
2	23 3.7%	100 15.9%	1 0.2%	0 0.0%	80.6% 19.4%
3	0 0.0%	3 0.5%	118 18.8%	28 4.5%	79.2% 20.8%
4	12 1.9%	16 2.6%	40 6.4%	124 19.8%	64.6% 35.4%
	76.5% 23.5%	64.5% 35.5%	72.4% 27.6%	77.5% 22.5%	72.7% 27.3%

Test Confusion Matrix

Output Class \ Target Class	1	2	3	4	
1	124 19.8%	29 4.6%	1 0.2%	5 0.8%	78.0% 22.0%
2	32 5.1%	127 20.3%	1 0.2%	2 0.3%	78.4% 21.6%
3	0 0.0%	2 0.3%	112 17.9%	25 4.0%	80.6% 19.4%
4	10 1.6%	15 2.4%	39 6.2%	103 16.4%	61.7% 38.3%
	74.7% 25.3%	73.4% 26.6%	73.2% 26.8%	76.3% 23.7%	74.3% 25.7%

All Confusion Matrix

Output Class \ Target Class	1	2	3	4	
1	798 19.1%	209 5.0%	10 0.2%	39 0.9%	75.6% 24.4%
2	178 4.3%	702 16.8%	5 0.1%	11 0.3%	78.3% 21.7%
3	0 0.0%	22 0.5%	794 19.0%	199 4.8%	78.2% 21.8%
4	69 1.7%	112 2.7%	236 5.6%	796 19.0%	65.6% 34.4%
	76.4% 23.6%	67.2% 32.8%	76.0% 24.0%	76.2% 23.8%	73.9% 26.1%