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Learning Example of a Biomedical Project from a Real Problem of Muscle Fatigue

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Abstract**—**This paper deals with a method of learning to solve a real problem in biomedical engineering from a technical study of muscle fatigue. Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles (viewpoint: anatomical and physiological). EMG is used as a diagnostics tool for identifying neuromuscular diseases, assessing low-back pain and muscle fatigue in general. In order to study the EMG signal for detecting fatigue in a muscle, we have taken a real problem which touches the tramway conductor the handle bar. For the study, we have used a typical autonomous platform in order to get signals at real time. In our case study, we were confronted with complex problem to do our experiments in a tram. This type of problem is recurring among students. To teach our students the method to solve this kind of problem, we built a similar system. Through this study, we realized a lot of objectives such as making the equipment for simulation, the study of detection of muscle fatigue and especially how to manage a study of biomedical looking.

Keywords**—**EMG, health platform, conductor's tram, muscle fatigue.

I. Introduction

BY using continuously the handlebar, the tramway conductor can get a pain (Fig. 2). The problem is how to detect this grief. This represents a real difficulty; we opt for obtaining the EMG signal from electrodes placed on the muscle. We have to know when really the tramway conductor must be replaced in his function due to the fatigue and the EMG signal gives us the answer to such issues (fatigue's detection). It is the suitable signal to describe muscle problem (including fatigue). For the scientists, the most important characteristics in an EMG signal is its intensity (amplitude) and its shape, this latter appears strange as a random noise [1]. We can see a typical EMG signal in Fig. 1.

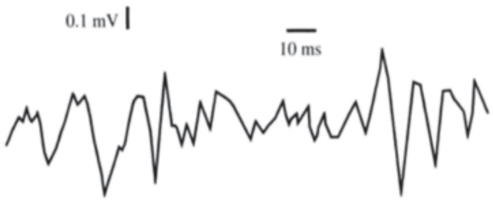

Fig. 1 A Normal EMG "recorded from surface electrodes" [1]

As a historical review, the first documented experiments dealing with EMG started with Francesco Redi's works in 1666. Redi discovered a highly specialized muscle of the electric ray fish generated electricity [2]. Galvani (1737–1789) showed that muscle contractions can be induced by electrical stimulation [3]. By evolution of science in the early 1980s, Cram and Steger introduced a clinical method for scanning a variety of muscles using an EMG sensing device [4]. Nowadays, we have electronic platforms which are highly developed and as small as our e-health platform used [5]. This latter is a typical autonomous platform which works with the famous Arduino device (exposed in Fig. 3). The electrodes used for detection are shown in Fig. 4.

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Fig. 2 A physical effort (handlebar) causing fatigue to the conductor's tram [6]

Fig. 3 Model of Arduino Mega 2560 R3 Front [7]

II. Methodology

The study is focused on the measure of raw data of EMG as a first step by doing a similar physical exercise done by a conductor's tram. To do this requested task for experiment and in order to approach the real situation of trams, we have used constructed equipment (Fig. 5).

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Fig. 4 EMG Electrodes

Fig. 5 The constructed equipment

The real difficulty was how to teach future learners the manner to solve the problem of detection of fatigue in the laboratory. We had two solutions, the first one is to keep only one position and do the same task for a whole day, which is a bit hard. The second was to find an ingenious solution that involves using the holes (orifices) in our equipment (Fig. 5) as a strain gauge. Indeed, we know that more muscle is stretched his hand more the driver is comfortable in these functions but if these muscles are contracted then the driver is tired. This situation can be simulated by replacing by holes (orifices), the upper hole is a fully outstretched hand while one that is close is a contracted hand. We have chosen the second solution.

III. Results and Discussion

Firstly we have selected a normal test -ordinary work without releasing or opening the hand-. The position was in the medium; we get Fig. 6).

After releasing the hand, we took the EMG signal, we have seen Fig. 7. By analyzing this signal (Fig. 7), we can deduce that the variance of the signal had stabilized and its values turn abut a constant value. It seems normal because by doing physical effort one receives as tensing of muscles causing ascendance of the signal intensity. By doing data processing we can prove this remark (Figs. 8, 9).

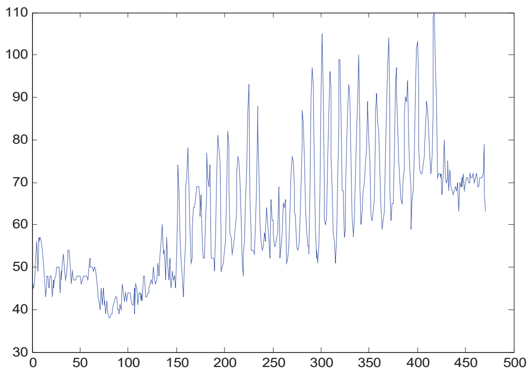

Fig. 6 Normal Works movement

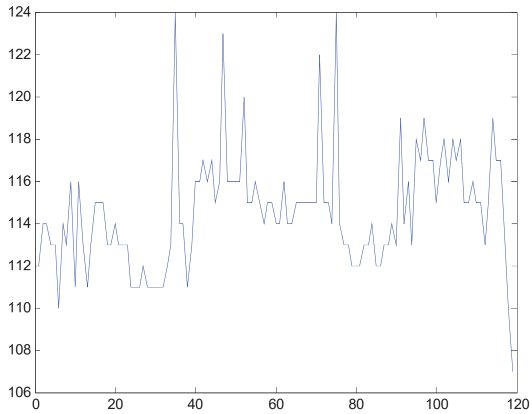

Fig. 7 Relax movement (State of rest)

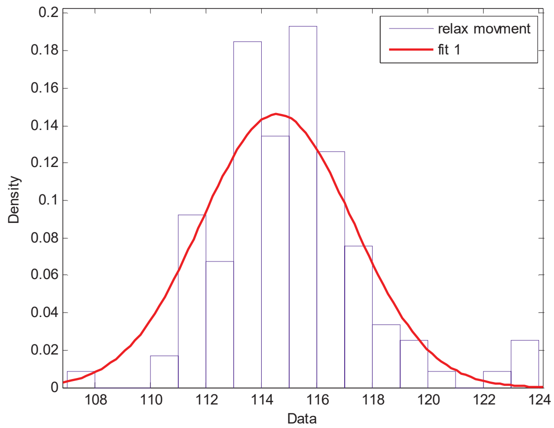

Fig. 8 Density of EMG signal (State of rest)

From Figs. 8, 9, it is seen that the signal energy is most concentrated and therefore more focused in the relax case than the case of work. Another finding, if one sees the density shows that the EMG intensity values were decreased by causing the effort.

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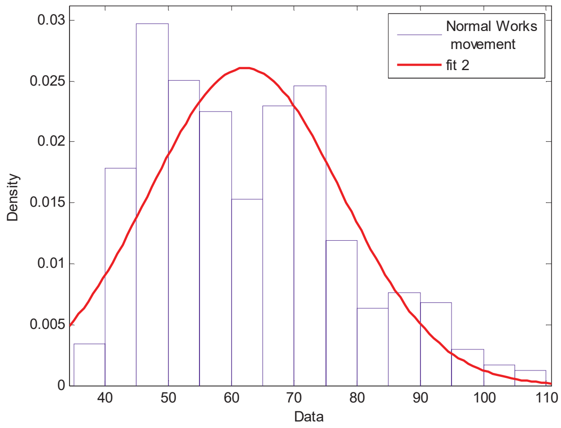

Fig. 9 Density of EMG signal (State of work-effort)

In the second step we changed our position of the hand (Fig.5) by following the mentioned distances (Table I).

TABLE I
NORMALIZED DISTANCES USED IN THE TASK

Number of the position	1	2	3	4	5	6
Distance from the board (cm)	09.5	11.0	13.5	16.0	18.5	21.0

The different distances explain also the length of the arm that is different from a conductor to another.

Just we mention that for each distance, we do the requested ask which is moving the handlebar and after a moment we release the handlebar by opening our hand (as a produced fatigue) and as results we had the curves seen in Fig. 10.

As a first deduction, we can see plus the handlebar height increases, plus the intensity of the received EMG signal is greater. What looks to reality because if the driver of the tram becomes tired more his muscular signal intensity is low. We note also, when we release the handlebar, the EMG signal stabilizes. That is an indication of the fatigue driver.

Now, one can easily detect when the driver is tired. It is a kind of alarm.

Recall that muscular fatigue is due to physical effort but it can be a sign of disease reversible like cramp (temporary contraction of a muscle) and irreversible, which is a sign of illness.

IV. CONCLUSION

As a conclusion, we can say that to answer the problem of driver fatigue the electromyogram had done this function in success. However, if we want to complicate this problem, we should use another sensor to confirmation. Also we can give a numerical response to detection of fatigue by calculating the threshold, using data processing but the problem is that each conductor has his own and personal of fatigue's threshold. Note that the fatigue problem is not just detected electronically. Small signs whose daily lives can be useful for us such as the repetition of blinking eyes. The main goal of our study had been reached which is how to learn with pedagogical and logical the manner of solving problems related to a biomedical system.

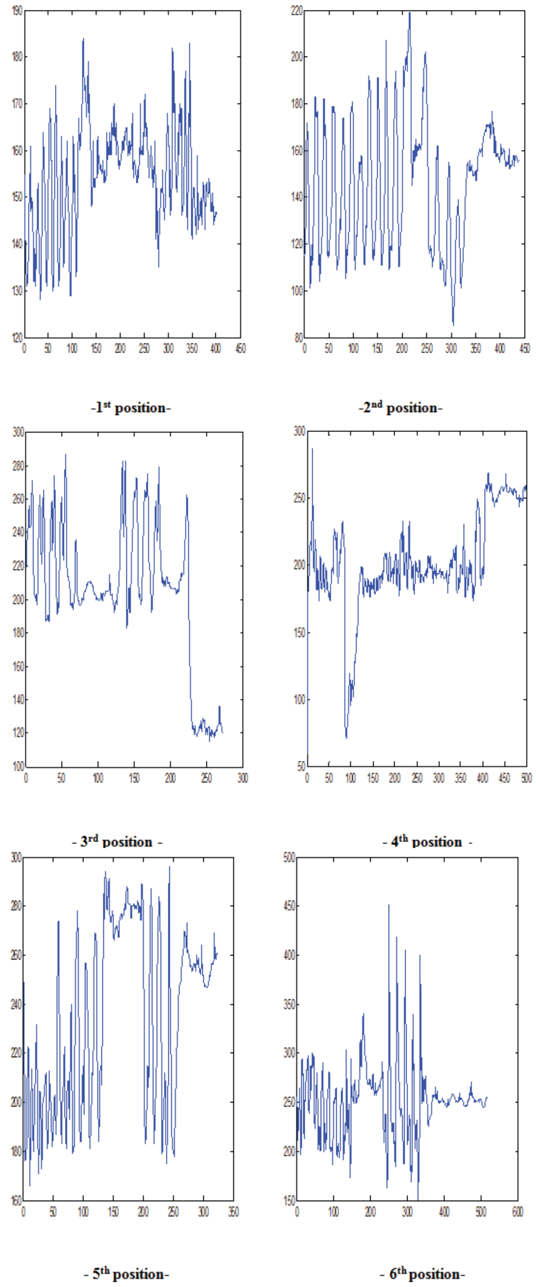

Fig. 10 EMG Signals of the main task for different distances, " EMG versus distance"

As a future work, we plan to continue this study by exploiting these results with data processing methods and construct a pedagogical simulator to the students working in biomedical field.

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