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Controlled Robotic System by Using Facial Bio-potential Signal Pattern

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ABSTRACT

Some patients experience difficulty moving their facial muscles, making facial expressions, speech and eating difficulty after a stroke. Specific exercises can help regain control and strength in these muscles. To overcome the problem, an excitation agent is proposed for patient's motivator to perform the facial muscle therapy. The system will capture the raw bio-potential signal from the muscles excitation, then process it to become useful data. Arduino Uno starter kit is act as the converter the analog signal into the digital form before the data is transmitted wireless by using XBee module. The 8,425 gain factor and band pass filter of 50Hz to 500Hz frequency range is design in the Electromyography system.

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INTRODUCTION

Facial movement plays an important role in human computer interaction for rehabilitation of disabled people (Wei & Hu, 2009). Facial muscle therapy through regular exercise of the facial muscles has been proven to help in muscle recovery (May, M., & Schaitkin, 2000) for stroke patient. In order to motivate them to perform the rehabilitation activities, we have develop a system the that uses a small mobile robot as an excitation agent for the patient to have a light facial exercise. The system identifies a number of patterns in the electromyography (EMG) signals from the facial muscles, analyze the signal and command the small mobile robot to perform specific tasks.

The study on EMG involves the corresponding muscle function through analysis of electrical potential that emanates from the muscle itself and the work begun as early as 17th century (Norali, Som, & Kangar-arau, 2009). The effective frequency band of EMG signals is found to be within 1 Hz and 500 Hz[4]. Many researchers leverage the information from EMG signal to control some peripherals. The works on EMG signal focus on the arm muscles as reported in (Mohideen & Sidek, 2010)(Aso, Sasaki, Hashimoto, & Ishii, 2006) and (Chabot, DiCecco, & Ying, 2006) but in (Chin, 2008)(Wei & Hu, 2009) the author uses signal from forehead and other facial muscles to control the mouse movement and wheelchair.

2. EMG System Development:

In order to capture the EMG signal from facial muscles, a complete circuit to condition the EMG signal needs to be constructed. In this paper, the Argentum Chloride (AgCl) disposable surface ECG electrode is used. It is amongst the most popular used because of their characteristic and safe to experimental subject besides easy and quick handling.

The electrodes are attached to the selected muscles and connected to the EMG circuit. For every INA128P pre-amplifier, three units of AgCl surface electrode are used where two of them are to capture the different voltage generated by the muscles activities and the other one function as reference. The electrodes that capture the signal need to be placed as close as possible around one inch (25.4mm) in distance. The reason is to reduce any noise from the environment. The wire need also be twisted so to help the instrumentation amplifier suppress common mode signals(Mohideen & Sidek, 2010).

The EMG circuit consists of an instrumentation amplifier and four units of precision amplifiers. The Burr-Brown INA128P instrumentation amplifier is chosen as the front end amplifier due to its high CMRR at high gain (Instruments, 2005) ((i.e. 130dB at gain 1000 gain factor). As such is important to ensure the total CMRR of the circuit to be above 90dB for acceptable quality of signal for further analysis(Luca, 2002). The gain set at this stage is 50.

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The signal captures is then passed to bandpass filter of 50Hz to 500Hz. The high pass filter is having cutoff frequency of 50Hz with unity gain and the low pass filter has 500Hz cutoff frequency and with gain factor of 165. The filtered signal is then fed into full wave rectifier set the signal to positive values.

The analog signal after the rectification stage needs to be converted into digital form by using the ADC of ARDUINO UNO starter kit. The digital data is then transmitted to the microprocessor located on the small mobile robot by using transmitter and receiver module. The data is then used as input to the program to control the operation of mobile robot. Using the algorithm programmed, the wheels of the mobile robot rotate according to the movement of the appropriate muscles.

The muscles involve in the system development are:

a) Right Zygomaticus major muscle (RZM)
b) Left Zygomaticus major muscle (LRM),
c) Frontalis (FRT) muscle and
d) Sternocleido-mastoid muscle (SMM) as reference electrode.

The algorithm to relate the facial muscle activation (Marieb & Hoehn, 2010) and the movement of the mobile robot is developed and programmed into the Arduino Uno controller of the mobile robot The relationship is shown in Table 1.

Table 1: Relationship between muscle contraction and small mobile robot movement.

Muscle contractions	Mobile robot motor movement	Robot locus movement
RZM	Both motors will run. Motor 1 will rotate wheel 1 clockwise and motor 2 will rotate wheel 2 anticlockwise. Therefore, the mobile robot will turn in radial locus to right.	Turn right
LZM	Both motors will run. Motor 2 will rotate wheel 1 anticlockwise and motor 2 will rotate wheel 2 clockwise. Therefore, the mobile robot will turn in radial locus to left.	Turn left
RZM LZM	Both motors will run and rotate both wheels clockwise. Therefore, the mobile robot will move forward.	Forward
FRT	Both motors will run and rotate both wheels anticlockwise. Therefore, the mobile robot will move backward.	Backward
RZM , LZM , FRT	Both motors will not run and both wheels will not rotate. Therefore, the mobile robot will not move (stop).	Stop
No muscle active	Both motors will not run and both wheels will not rotate. Therefore, the mobile robot will not move (stop).	Stop

Two DC motor used to actuate the mobile robot are commanded accordingly to move the robot. The purpose of the classification algorithm is to specify the activation of a signal or a group of facial muscle signals and to map the information to specific movements of the mobile robot.

RESULT AND DISCUSSION

A series of experiments is performed to investigate the characteristic of facial muscle activities. Five healthy college student ages from 20 to 30 years old participate in the experiment. The EMG electrodes are placed on the respected facial muscles of the subjects. The subjects are then asked to activate the EMG signals by pulling up the left cheek, right cheek or squeezing forehead muscle. The experiments involve the RZM. LRM, FRT muscles with SMM muscles functions as reference electrode.

It can be summarized that the output voltages of the muscle contraction depend on the strength of the individual's muscle. Right Zygomaticus major muscle consumes higher voltage output than the Left Zygomaticus major muscle because that muscle is stronger than the other. The value also can be fluctuated if the muscle is weak when it flexes.

Some sharp signals have been captured and from the observation, it normally happens at the beginning of the muscle flex. It shows that the muscle displays strong contraction at the beginning and slowly becomes weak or maintains a regular contraction depends to someone's individual muscle.

Thus, from the signal captured and muscle selection, the average value shown at the LCD of the EMG system has been taken. The digital data that is used as a benchmark of the algorithm development are shown below:

Table 2: Benchmarking data for algorithm development.

Muscle	System Channel	Benchmarking Digital value
Right Zygomaticus major muscle	Channel 1	15
Left Zygomaticus major muscle	Channel 2	20
Frontalis muscle	Channel 3	20

The activation of respected muscles creates movement of mobile robot as shown in Fig. 1-4. There are four locus movements that have been program in the Arduino based on the information in Table 1 relationship.

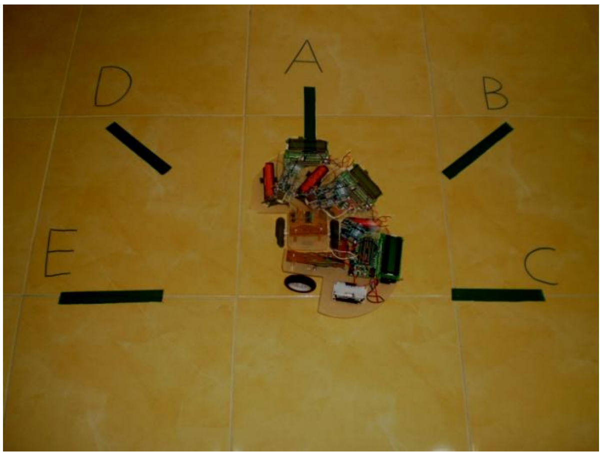

Fig. 1: Mobile robot locus to right side.
Description: The right cheek pulled up.
Result: The mobile robot turns right from A to C

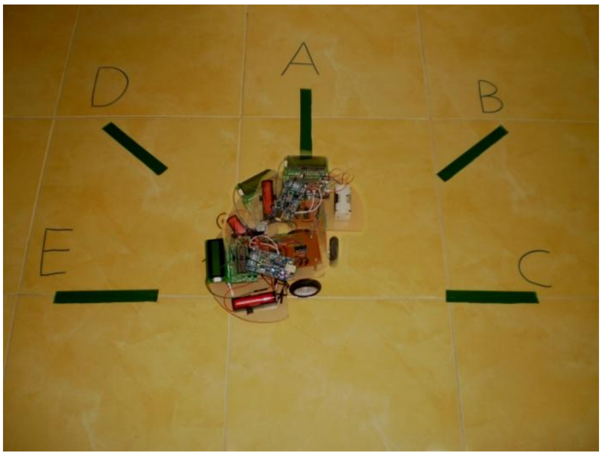

Fig. 2: Mobile robot locus to left side.
Description: The left cheek pulled up.
Result: The mobile robot turns right from A to E

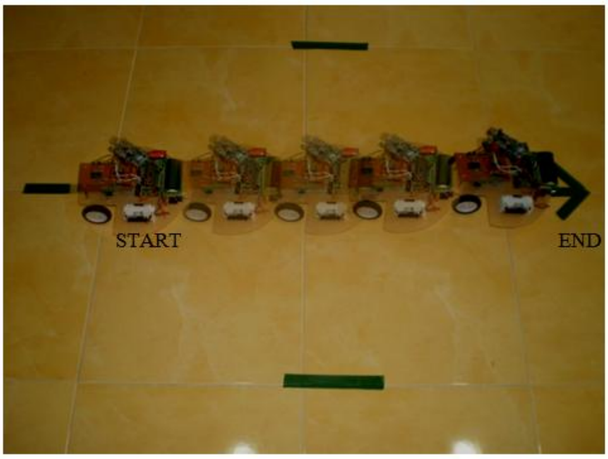

Fig. 3: Mobile robot locus from left to right side.
Description: Both cheeks pulled up.
Result: The mobile robot moves forward.

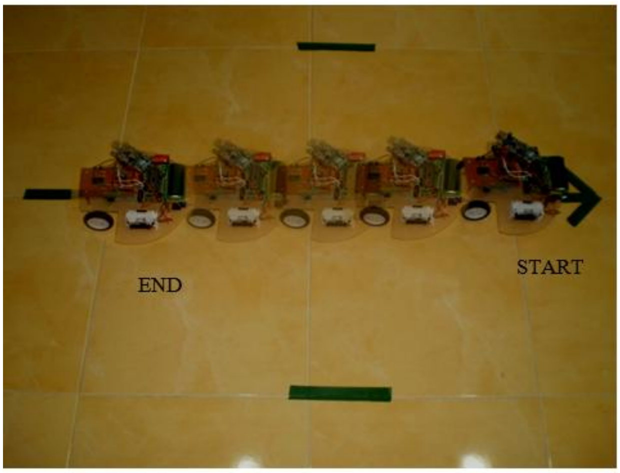

Fig. 4: Mobile locus from left to right side.
Description: Forehead pulled up.
Result: The mobile robot moves backward.

Conclusion:

The objective of the work is to produce a motivator agent to the facial stoke is achieved. Arduino has been used to replace the microprocessor that has been used before. The Arduino program is more simple and easy to handle but its depend to the user technical knowledge of the programming. The response of the mobile robot movement is much better than using PIC programming.The system developed is interactive in features and exciting enough to promote intense exercise amongst stroke patients that have their facial muscle affected.

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