RESEARCH ARTICLE

Wearable Strike / Bend Receptor-Based Therapeutic Exercise for Children with Special Needs

Andrews Samraj[1], S. Prabhakaran [2], K. Rajendran[3]

[1]Department of Information Technology, Mahendra Engineering College (Autonomous), Mallasamudram - 637503, Tamil Nadu, India

[2]Mahendra Arts and Science College, Mahendra Arts and Science College (Autonomous), Namakkal, Tamilnadu, India

[3]Enability Foundation, IIT Research Park, Chennai, India

ABSTRACT: Therapeutic exercises given to special children are essential to keep their health steady and limbs active. Such exercises are repetitive, time consuming, monotonous, and tiresome for both the child and the therapist. In this work a new method is suggested by means of wearable technology to make the process fun and interesting. The caregivers and medical personnel to gain a lot of expertise through the innovations involved in such treatment methodology. The system proposed by this work was developed successfully with a set of handmade varying pressure gauges with color codes that enables the users to interrelate color and the pressure associated with a help of, location and the amount of pressure required. Four different exercises were completed by four different subjects in two sessions and the feedback system was generated from every single trial performance via a visual display in a smart phone. The accuracy of the system's output depends on the striking force applied to the appropriate sensors marked with colour codes. This experiment is to represent the novel practice of giving a feedback on therapy for motor movements rather working on the hardware more in detail. The system is connected with an android app via Bluetooth to give feedback of every strike and to guide the strikes in an expected way for the therapy to retain the deteriorating health of children with CP due to jerks, seizures etc. The proposed system calculates the pressure of data that arrives from the Bluetooth file electrodes periodically, thus preserving the performance of the subject and giving feedback in both directions of the App created.

Index Terms – Assistive Technology, Bionics, Data Glove, Gesture Computing, Wearable Computing.

I.INTRODUCTION

Physiotherapy in special children is a must-do practice to retain the health, especially children with cerebral palsy for neuromuscular recovery like muscle power, sensational, and fine motor movement. It helps as a clinical practice to retain the motor movement health of children to avoid stiffness in limbs and regulate limb movements. [2] The problem often reported is that the children are unwilling to repeat the same and boring exercises and trying to develop ways to avoid it. The need for modifying the monotonous exercises is felt essential now a days and many started working towards such modification, including computer aided exercises by introducing fun and enjoyment. It becomes easy to compel children to do more repetitions than the conventional exercise methods, and the range of motion and hold time in the stretched position were better if aided with computer games, etc. This proposed system is also based on a model of exercise to bring forth and guide pressure exercises which will improve motor response and enhance motor skills and their effectiveness. [3] The physical activity of this kind of children is necessary to develop coordination, build strength in their body, improve their balance, to maintain flexibility, optimize physical functioning levels and especially maximize their independence. [4,8] The exercise is designed and tested for the efficacy of activity-based strategies in subjects with cerebral palsy. A few sets of homemade pressure sensors with various resistances were developed to serve this purpose. These sensors were deployed with multiple colors and tags and used for numerous bi-directional paradigms of exercises. The picture of a sample sensor is shown in figure 1. The resistance range of these homemade pressure sensors depends a lot of the initial pressure. Normally above 2M ohm resistance can be achieved between both contact points when the sensor is lying flat. The resistance could be modified, by the way the sensor is sewn and how big the overlap of the adjacent conductive surfaces is. The sensors are created with conductive fabrics and diagonally stitched conductive threads inside as directed in http://www.instructables.com. The slightest touch of the finger on this sensor will generally bring the resistance down to a few Kilo ohm and, when completely pressured, it reduces up to 200 ohms and the sensor detects a difference. The range is non-linear and gets lesser as the resistance diminishes.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \quad (1)$$

In this kind of Pressure sensors the expected output is a voltage which is utilized for the proposed system. [1] In addition to the voltage, this pressure sensor outputs a conditioned 0-5V signal. This small signal is considered as the desired output and many signal preprocessing and

**Corresponding Author:* *andrewsmalacca@gmail.com*

Received: 20.05.2016 **Accepted:** 02.07.2016 **Published on**: 22.07.2016

conditioning were applied before we quantified it. Signals are measured using the circuitry in Multi-function Data Acquisition (DAQ) hardware with rest as a reference signal. Necessary modifications were done in stitches inside the sensors to adjust the readings. The pressure sensor based physiotherapy exercises involve, a Bluetooth device for exchanging data and an appropriate App is developed to do a Bi-directional paradigm system. This system works in short distances between the fixed pressure sensor equipment and the mobile devices, and building a personal area network (PANs). The range is approximately 10 Meters (30 feet). Arduino Bluetooth Control App from playstore can be modified and used for this purpose.

II.SIGNAL ACQUISITION AND TRAINING

A. Pressure sensors

A few colors of materials for sensors were chosen and are used in producing different resistance pressure sensors. These sensors are fixed on a solid board against which the subjects are going to apply their pressure. Few cartoon characters are drawn around the sensors as the whole sensor to be a part of the cartoon so that the children feel that they are pressing the body of those cartoons. The pressure sensors produce diverse signals for every level of pressure applied to it. The signals produced from these sensors depend on the level of pressure, the area of contact and the pace of the activity etc. This makes the system is highly customized which is a desirable quality in clinical physiotherapy treatments. Each subject was asked to press all the sensors one by one, press them, modify their pressure, according to the name of the character, etc..like a game.

B. Signal capturing and pre-processing

The pressure sensors produce various levels of data acquired during this pressure gaming at the sampling rate of minimum 75Hz [7].

In the preliminary stage, a few sample pressure trials were recorded to decide the ideal way of doing the exercise suitable for the subject. The alignment to the exercise and the pressing game is achieved first by modifying the story/game one by one with the assistance of the therapist. It is very difficult to do this synchronization to make an exercise gesture perfectly into a game in a single attempt even with all the help. Once the most perfect activity or paradigm is identified, it is recorded, for the repetitions later. The important thing is to justify the game by the physiotherapist is by its activities involved. This pressure exercise is to get approved by counting the activity involved and is appropriate for the particular subject doing the particular exercise. This *perfect* game paradigm is registered and kept as the approved game sample for further and repeated playing. Comparison with the conventional pressure and hold exercises is necessary to validate the game and its benefit at any point of time. The acceptable precision of the game repetition for the App we created is set to any deviation of + or – 5% from the *perfect* game paradigm as we do in our previous experiments too. [5,6].

The signals were acquired during the pressure applied on the sensors and each is then converted to a series of files. The files are then transmitted to the mobile device through the app developed. The Pressure signals were collected during the gaming-exercise of a subject with the help of the physiotherapist after getting necessary ethical permissions. The entire activities and its corresponding impact on motor sensitivity and benefits thus approved by the physiotherapist were linked to the paradigm. The App algorithm computed the percentage of exactness from the pressure signals by calculating the mean value of the transmitted file during the operations by comparing the threshold fixed for color display. '*t*' is the total time taken to complete one pressure activity. *t* determines the name and sequence of the file to be transmitted.

C. Pressure experiments

The Pressure experiments were done on different Scenario or paradigms. The homemade pressure sensors are designed in such a way that the conductive surface is reduced to minimum by stitching very few stitches on either side of the colored material with the conductive thread.

"Figure 1. Sample Pressure exercise"

This is done to create a good range of fingertip pressure. The Pressure sensors are designed with an initial resistance range to have a uniform or varying response according to the requirement. It is desirable to have 2 Mega ohm resistances between both contacts when the sensor is kept free and lying flat. As mentioned earlier, the value is achieved by trial and error stitching to make the contact overlaps of surfaces as required. The sewing is done diagonally for this purpose by the conductive thread so that the overlap of conductive surface is minimal. When the subject slightly touches this pressure sensor by the finger, then the resistance value of rest stage goes down to a few Kilo ohms and when it is fully pressured, it goes down to about 200 ohms. The pressure experiments carried out by the subjects for this pilot work are classified into four categories. The app created will also aligned to display four different colors. Consistent and precise repetition of such pressure exercises improve the coordination function of limbs in course of the prescribed time. Pressure, P, is defined as force, F, per unit area, A

$$P = F/A \qquad (2)$$

and a pressure sensor may be modeled as:

$$V_{OUT} = k_0 + k_1 P \qquad (3)$$

Where:

k_0 = offset

k_1 = pressure sensitivity in V/pressure unit

The signals captured from the pressure files of subjects were initiated with a baseline measurement. The baseline is the static movement, (rest) without any action and without touching the pressure sensor pad. Then the pressure game exercises were started one by one with repetitions. As an example game, the task of the subject to apply different levels of pressure on sensor pads to match makes the same colour to appear on the mobile device display.

D. Separation and mean calculation

The pressure signals were collected by the core circuit [3]. The selected pressure sensor data file is then processed by the app we created and the mean value of the signals was created. The app displays the corresponding Color Patch on the display screen. Then the display was cleared after 3 seconds and the app is ready to receive the next file from the pressure sensor pad.

The breadboard fitted with a Photon or a Core which are the same and essentially serve the same purpose except the difference in version. The difference between the Core and photon is that the Core is the first generation and the Photon is from the 2nd as well as the latest version. [7]

E. Pressure sensing Algorithm

The algorithm developed for the feature selections from the signals of selected core is as follows:

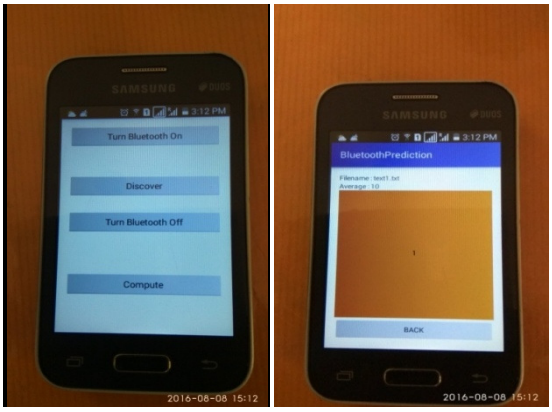
```
Initialize
<p>const int butPin = 0;<br>
const int ledPin =  7;
int butSt = 0;

void setup() {
pinMode(ledPin, OP);
pinMode(butPin, IP);
}
void loop(){
butSt = digitalRead(butPin);
if (butSt == HIGH) {
digitalWrite(ledPin, HIGH);
}
else {
digitalWrite(ledPin, LOW);
}
}</p>
```

F. Pressure sensing App

Figure 3 shows the App created and the sample colour display according to the signal received by Bluetooth from the Pressure sensors. The improved way of representing feedback for the user subjects is seen from the innovative idea and usage of the system.

In this paper, we describe an easy and entertaining system by creating an App in response to the Pressure signals during the Therapeutic activity by special users. This proposed work is an extension of our rehabilitation activities we created with the Data glove [5,6] and to replace the manual guidance and monitoring as well as boring conventional methods. The ideal method of every gaming paradigm taught by the physiotherapist is recorded in terms of proposed signal values into the exercise lexicon of the particular patient and is considered as training methods.



"Figure 3: the App developed to show exercise result"

III.RESULTS & DISCUSSIONS

The Pressure signals captured from subjects were tested with the system developed for all pressure levels and the responses of the App created. All modules worked as intended and various colors displayed according to the Pressure signal inputs. Figure 4 shows one of the outputs in response to the input from the Pressure sensors via Bluetooth. Colors can be replaced with sounds or vibrations according to the requirements.

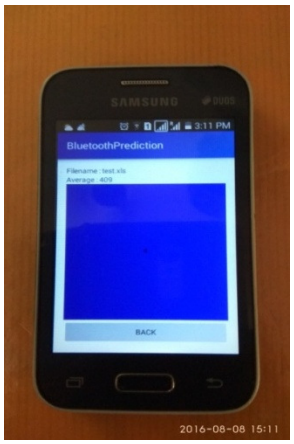


Figure 4: Change in output colour based on the pressure value

IV.CONCLUSION

The App created to display colors responded well for the pressure signal input. This App can be modified to sound, vibration and all combinations to conduct the exercises to various levels and can be converted into a good learning system for the children with special needs. Simple mathematical calculations involved in this App which reduces the computational complexity and time.

V.ACKNOWLEDEMENTS

The authors wish to thank Dr. Md. Shohel Sayeed, of Faculty of Information Science and Technology, Multimedia University for providing facilities to conduct the experiments.

VI.REFERENCES

1. Johnson, Curtis D. Pressure Principles, *Process Control Instrumentation Technology*, Prentice Hall PTB.
2. Bert Steenbergen, Celine craje, Dawn M Nilsen, Andrew M. Gordon, Motor imagery training in hemiplegic cerebral palsy: a potentially useful therapeutic tool for rehabilitation, *Developmental ZMedicine & Child Neurology*, Volume51, Issue 9, September 2009, Pages 690–696.
3. Simone, L.K., Kamper, D.G., Design considerations for a wearable monitor to measure finger posture", *Journal Neuro Eng Rehabil,* Vol 2 page, 5, 2005.
4. http://www.cerebralpalsy.org/about-cerebral-palsy/treatment/therapy/physical-therapy on 1/7/2016
5. Kalvina, R., Samraj, A., Maheswari, R., 2013. Emergency gesture communication by patients, elderly and differently abled with care takers using wearable data gloves, *Journal of Signal and Information Processing, 4, 1-9,.*
6. Kalvina, R., Andrews Samraj, Daffala, Z.I., 2016. Electrode reduction for Biometric Glove Based Communication Using Simplified SVD: A Pilot Study accepted-unpublished, International Journal of Cognitive Biometrics.
7. https://learn.sparkfun.com/tutorials/force-sensitive-resistor-hookup-guide
8. www.physiotherapynotes.com assessed on 15/5/2016