



MUSIC GLOVE FOR HAND MOTOR SKILLS REHABILITATION

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Abstract : People suffering with hand motor disability resulted from causes like ischemic stroke, ataxia, muscular sclerosis and hand injuries (accidents) are normally recommended to do most of the exercises by themselves devoid of any help. Intensive movement training can reduce hand motor impairment. Patients are quick to lose their will to practice their rehabilitation exercises, especially over prolonged periods of time, without any extrinsic motivation. This contributes to further decline in proper recovery of hand motor function in affected limb. The development of this glove is suggested as a technique to encourage and enable practising hand movements for those with hand motor impairments. It builds on existing technology. In order to direct hand exercises and quantitatively evaluate hand movement recovery, this device uses music as an engaging and motivational medium. It necessitates practise of practical movements such as finger-thumb opposition, pincer grasp, and key-pinch grip. With the songs performed by an interactive game, these movements are employed to play various musical notes. Using the glove, one can measure their hand dexterity (percent of notes hit). In a single training session, using music will greatly increase self-ratings of training motivation as well as objective measurements of hand motor performance.

Index Terms - Dexterity, motor disability, MusicGlove, Interactive Android game, Hand Motor skills rehabilitation.

I. INTRODUCTION

A fine motor disability is the inability or impairment of a person to do tasks that call for some manual dexterity. A number of conditions, including ataxia, muscular sclerosis, hand traumas, stroke, etc. can lead to a loss of fine hand motor skills. Stroke is quickly becoming a significant public health issue in India, as it is in all developing nations. A rising trend in India's incidence and prevalence of stroke is confirmed by population-based estimates. Generally speaking, stroke risk factors are the same over the world. According to epidemiological research conducted in India, the main risk factors for stroke include high blood pressure, diabetes, and smoking.

Up to 85% of stroke victims initially have hand motor impairment in the first few weeks after the stroke, and up to 75% do so six months after the initial examination. Intense movement training can help stroke survivors with their motor deficits. Unfortunately, inpatient rehabilitation institutions frequently only allow patients to stay for two weeks while receiving outpatient care. When the brain is most pliable, patients are expected to complete rigorous therapy at home with little direct supervision.[1]

A sensorized glove called Music Glove encourages the recovery of hand motor skills. The user of the motor impairment treatment must practise functional movements such as finger-thumb opposition, key-pinch grip, and pincher grip. The device is designed to target the medial and ulnar nerves primarily, while making the finger to thumb contacts, affecting the thenar and hypothenar eminence muscles of the hand and the music game which is developed using Unity3D, coded using Visual Studio is played using those required movements along the songs displayed by an interactive android game. The interactive game consists of a game object which will be destroyed when the force put by the user exceeds the preset value and threshold force. All the information - login Id, User Name, Level, Left/Right hand, Threshold, Time of the game, Max Score and the Score obtained by the user and the accuracy is stored in the Firebase database.

1.1. Role of Motivation in Rehabilitation

Extrinsic and intrinsic motivations are the two categories. The objective is distinct from the activity in extrinsic motivation. It refers to behaviour that is motivated by rewards from outside sources or it refers to behaviour that entails doing something because it has a separate outcome. These incentives may be material, like cash or grades, or immaterial, like acclaim or celebrity. Extrinsic motivation is solely focused on external rewards, in contrast to intrinsic motivation, which comes from within the person.

The act of performing something without any visible external incentives is known as intrinsic motivation. Instead of being motivated or under pressure from outside sources, like a deadline or reward, you do it because it's engaging and fun. Reading a

book because you enjoy it and are interested in the plot or subject, as opposed to reading it because you need to write a report on it to pass a class, is an example of intrinsic motivation.

According to this classification, extrinsic incentive might take the form of benefits like functional progress and praise from loved ones and medical professionals, while intrinsic motivation can take the form of enjoyment from rehabilitation. Extrinsic elements, such as the environment, a person's beliefs, and support from family and medical professionals, were found to have an impact on rehabilitation motivation in earlier studies [12–14]. We do not anticipate that intrinsic motivation plays a significant role in stroke patients' commitments to rehabilitation because the majority of stroke patients in the convalescent phase attend therapy to return to their pre-stroke-onset lives, a kind of extrinsic incentive.

1.2. Muscles and Nerves of the Hand

The thenar eminence (near the base of the thumb) and the hypothenar eminence are two sets of stronger hand muscles (control the movement of little finger). The thenar muscles allow the and tips of the four fingers and the thumb to touch each other among other things (opposable thumb). The thumb is pulled toward the palm using a different muscle called the adductor pollicis. The muscles that cover the hypothenar eminence are mostly employed for pushing out the little finger, bringing it back in, and tightening the skin that covers it.

The three nerve groups that control the movement of muscles and nerves of hand are:

- Radial nerve or *nervus radialis* – It is responsible for the extension of the hand by activating finger extensors in the wrist.
- Median nerve or *nervus medianus* – Controls the movements of thenar eminence muscles and most of the other lumbricals.
- Ulnar nerve or *nervus ulnaris* – It is responsible for the movement of two lumbrical muscles between fingers and pulling of the thumb towards the palm by affecting the adductor pollicis muscle. It also affects the hypothenar eminence muscles and the muscles between the metacarpus bones.

II. METHODOLOGY

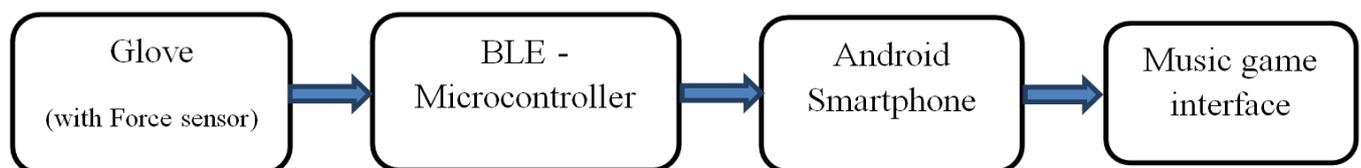


Fig 1:Block Diagram

In order to practise functional motions such as pincer grip, key-pinch grip, and finger-thumb opposition, the user of the motor impairment treatment must play along with songs that are displayed by an interactive computer game.

Glove Design and Working: The glove will have five force sensors—four on the thumb and one on the proximal interphalangeal joint on the side of the index finger—on its four fingertips. In case of the Force sensors, when the force applied by the thumb on any of the 5 force sensors exceeds certain pre-set threshold, an event is registered and the android device is notified of the event.

Game Description: The Music game is controlled with the five inputs given by the glove. In the game, a particular game object such as beads or balls move down 5 lanes, coming closer and closer to the screen. At the end of each lane, images are placed, depicting the functional grip that has to be made which is unique to a particular lane. As they approach the user, the beads or balls enter a region where they are in sync with the music being played in the background. After then, the user has a certain window of time in which to touch the thumb to the particular force sensor on a particular finger that is connected to that note, i.e., the amount of time that the balls stay on the image at the conclusion of each lane. To provide the impression that the song is being played with a glove, each note is timed to a certain song. By the conclusion of the level, you want to correctly hit as many notes as you can. The level of difficulty for each session can also be changed. Additionally, the game can be altered such that both the user and the therapist can obtain a quantitative evaluation of motor function at the conclusion of each song, such as the overall number of correct notes hit as well as the number of correct notes hit on each fret.

Thus, the game primarily tests the user on two parameters:

- Trigger Actuation Force
- Trigger Pull Speed or Reflex Action

BLE (Bluetooth Low Energy)-Controller: A Bluetooth integrated micro-controller (ESP-32) interfaces the glove with the Smartphone. The microcontroller sends the voltage data generated by the sensors to the android game corresponding to the force applied on each of them. If the force applied on any of the sensors exceeds a threshold that is set in the game, the balls in the lanes can be destroyed, when actuated within the right time window.

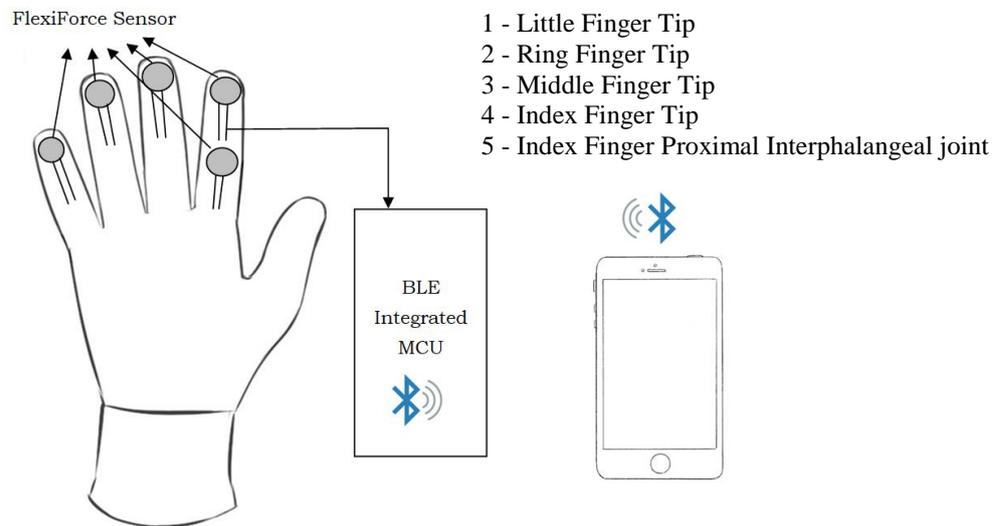


Fig 2: Prototype Design of the Glove-Game Interface

Firestore API and Data Storage: The data generated by each session that is played by the user is sent to the Firebase Realtime Database. Here the data such as the difficulty level, threshold, hand information, accuracy, etc is stored in the format of a JSON tree. This data can be displayed in the game again, in the reports section, by downloading from the database.

III. RESULTS AND DISCUSSION

The FSR sensor and the ESP32 were connected through a voltage divider circuit on a compact circuit board. This circuit board was then attached to a strap that would go around the user's wrist. The sensors were held in place inside finger caps and connected to the MCU on the circuit board through jumper cables as shown in Fig 3.



Fig 3: Glove Setup

The device is designed to target the medial and ulnar nerves primarily, while making the finger to thumb contacts, affecting the thenar and hypothenar eminence muscles of the hand.

- The Improvements in FMS due to the hand motions exercised by the Music glove device is to be measured and compared against conventional methods to determine its effectiveness.
- The extent of motivation induced by this device in comparison to other rehabilitation exercises.

3.1. Game Screens



Fig 3.1: Login Screen

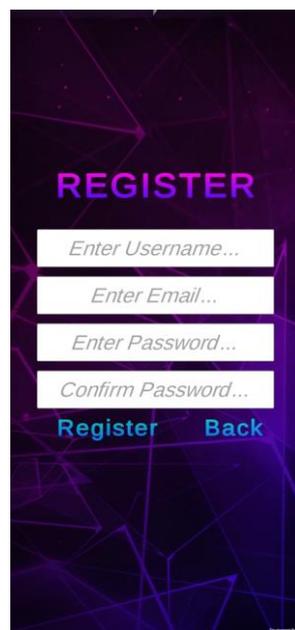


Fig 3.2: Register Screen



Fig 3.3: Main Menu

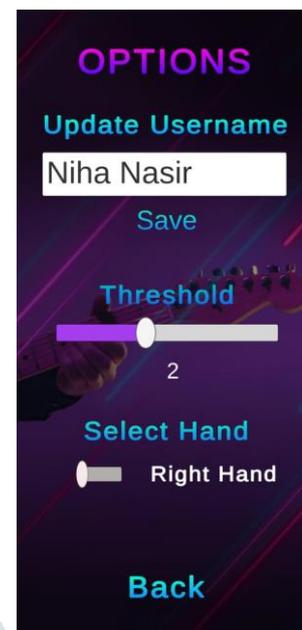


Fig 3.4: Options Screen



Fig 3.5: Levels Screen

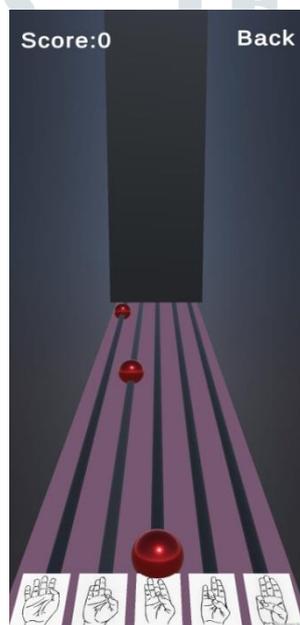


Fig 3.6: Game Screen

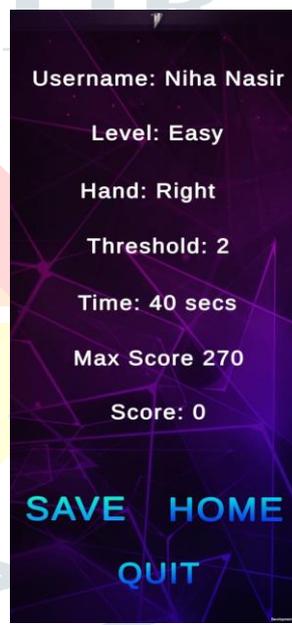


Fig 3.7: End Screen

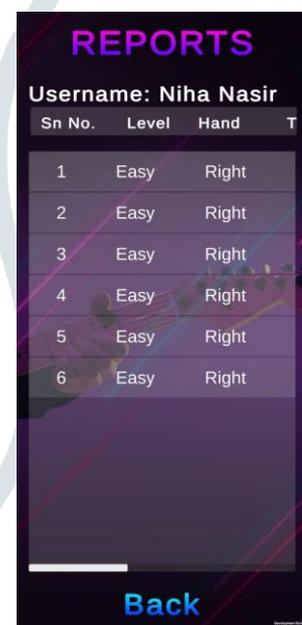


Fig 3.8: Reports Screen

Login Page – This page serves as the authentication page, where the user can login to their account using their E-mail Id and password which was created at the time of their account creation.

Register Page – The user can make a new account, if playing the game for the first time, after clicking on the Register button in the login page. The user will have to enter a Username, E-mail Id and a new password.

Main Menu Screen – This is the Home page, where the user can start a new session, or go to options screen to change some user settings, or go to reports page.

Options Screen – In this screen, the user can change their username, threshold force for destroying the balls, or change the hand setting to either left or right after shifting the glove to that hand.

Levels Screen – In this page, the user can select between 3 different levels i.e. Easy, Medium, and Difficult.

These levels determine the frequency of spawning of the balls and are preset. Easy – 7-6secs, Medium – 5-4secs, Difficult – 3-2secs.

Game Screen - After selecting an appropriate level, the user can now play the game, where they can destroy the balls, by applying a force above the set threshold force on the respective sensor corresponding to its lane in the screen.

End Screen - After the game session played by the user ends, next screen that appears is the end screen, where the data generated by that particular session is displayed. It includes username, level, hand, threshold, time duration of the session, max score and player score

Reports Screen – The user can see the data generated by all his previous sessions in the reports screen, which is accessed through the main menu screen. It includes username, level, hand, threshold, time duration of the session, max score, player score and accuracy.

IV. CONCLUSION

Remote health monitoring is becoming more popular, especially in light of the recent pandemic of the new coronavirus. However rehabilitation patients are not very motivated to continue their repetitive rehabilitation regimen in these conditions. This is what gamification in rehabilitation attempts to fix in our project.

- The project's low-cost Music Glove device detects when users perform functional grips, such as the pincer grip, key squeeze, and thumb-finger opposition, and tracks their FMS therapy regimen.
- In comparison to traditional forms of motor therapy and tabletop exercises, the inclusion of music to hand movement practise in the MusicGlove Device is anticipated to greatly increase both objective measurements of hand motor performance and self-ratings of motivation.
- Proprioceptive input's effect in promoting hand motor recovery will also be investigated with the use of the Music Glove.
- The population that can participate in its training paradigm with little help can utilise it at home.

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