Implementation of Stimulating Environment for Lateral External Disability and Autism Treatment by Using Hand Grippers

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Abstract— **The endeavor to satisfy both the physical and mental needs of the patient has always been a challenge for the medical profession. Recently, engineers are performing a key role in meeting this challenge. In order to provide a motivating treatment environment in a clinical setting and at home, a new computer input device and simulating games has been developed for this paper. The setup can be used with a range of custom-designed software and stimulating games. This paper presents the motivation behind the project and describes the prototype developed for a system that helps to alleviate the boredom associated with the treatment process using exercise machine 'Hand Gripper' which involves performing highly repetitive actions. A two-condition experimental study was conducted with suitable participants to test the feasibility and effectiveness of the developed system. The results of user feedback demonstrate the viability and usefulness of this system.**

Keywords— *Disability, Autism, Interfacing, Arduino, Virtual Reality.*

I. INTRODUCTION

The prospects of using computers to assist muscle function in the body are very promising. Feedback is an essential part of improving motor performance and learning. Computers may help to give better feedback during movement therapy. This system will give the opportunity to exercise with computer feedback for the autistic children and lateral external disable people.

Patients who have some lateral external physical disability, due to accidental injury, by born disability or paralysis can use the outcome of this paper. Here, lateral external physical disability means difficulties in mobility of the external posture of human body; such as hand, grip etc. People who have any kind of disabilities are prescribed to do exercises by the physician because this process is helpful for them to rehabilitate in the society and being fit for work [1]. Autism is a special kind of disability, which is actually a neural disorder that impacts on social interaction, verbal and non-verbal communication. Autistic children are of special attention for this paper because the number of autistic children is rising worldwide due to chromosome abnormality and environmental issue – pesticides, alcohol, smoking, illegal drugs, vaccines, prenatal stress etc. [2] Autism affects information processing in the brain by altering how nerve cells and their synapses connect and organize [3]. Generally, autistic children have normal, even above normal intelligence. The issues some autistic children have are their inability to function socially within the "normal" population [4]. There are some areas of behavioral improvement for those children, such as development of interaction, communication and posture, coping with transitions and improvising eye contact. In this paper a system is developed, by which autistic children can be motivated to interact and communicate with others and it helps them to improvise eye contact while communicating with others.

Stimulating environment of exercising is created by computer games for this paper. Video games in health care provide a generous example of innovative ways to use existing commercial games for health improvement or physical training [5] [6]. Exergaming or exer-gaming (a combination of "exercise" and "gaming") is a term used for video games that are also a form of exercise [7]. Exergaming relies on technology that tracks body movement or reaction. This genre has been recognized considering gaming as a sedentary activity and promoting an active healthy lifestyle [8]. The subject of Exercise Interfaces (and the integration of them in applications) forms a research area that is becoming more and more popular these days. Some games for the disabled person are implement which are usually overlay based game called Odyssey game [9]. Recently some research is made on game engine to utilize in network fitness works which is usually for physical module [10]. Another example of using games as stimulating environment for treatment is children with spastic cerebral palsy completed ankle selective motor control exercises using a virtual reality (VR) exercise system and conventional exercises [11]. A socially assistive robot (SAR) is a system that employs hands-off interaction, including the use of speech, facial expressions, and communicative gestures, to provide assistance in accordance with the particular healthcare context [12]. In this work, we present a stimulating environment for lateral external disability and autism treatment by using hand grippers. The details methodology of this work is explained in section II. In section III, the user feedback analysis is reported. Finally the paper is concluded in section IV.

II. METHODOLOGY

The working principle of the implemented system can be analyzed using block diagram of Fig.1. A user will use specific equipment and the use of that equipment will be sensed by sensor based transmission module. This module will transmit data to the universal Micro HID module. This module is programmed to configure the game to play using that equipment and finally user will enjoy playing game in monitor. The operational method of the implemented system is based on three stages:

- Developing and Interfacing of Micro-HID Module
- Development of Transmission and Switching Module for Hand Gripper.
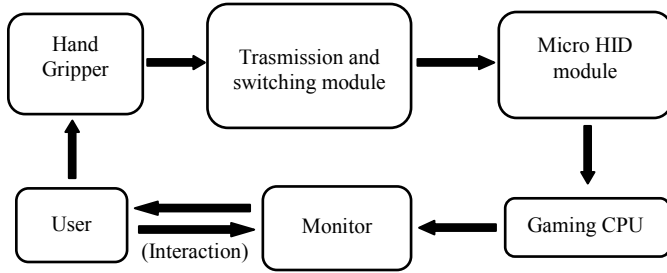- Designing Stimulating Environment i.e. Computer Games

Fig.1. Operational Method

A. Developing and Interfacing of Micro HID module

The prime concern of the implemented system to interface the virtual world (stimulating environment) with physical world, it was required to develop a suitable Human Interface Device (HID) module.
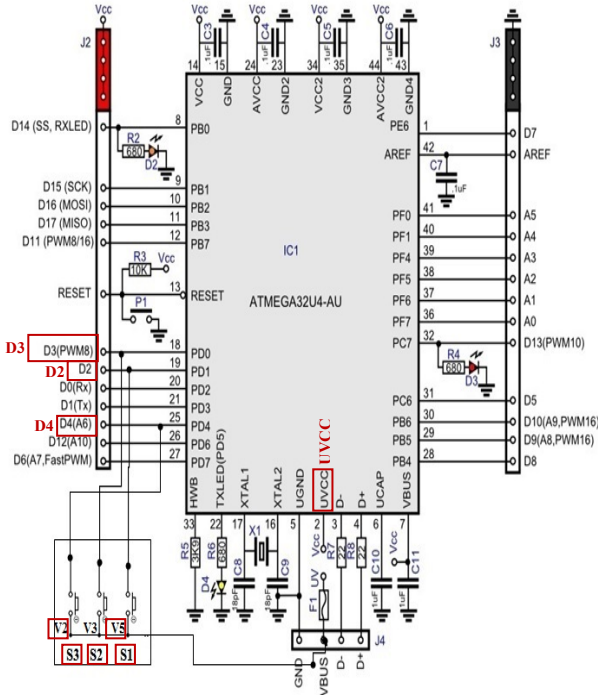

Fig.2. Circuit configuration for 'Micro HID module'

'Micro HID module' is a microcontroller based compact module, which is programmed, pin configured and specially developed for the purpose of regarding system. The main component of this unit is Arduino Leonardo Board. It is a microcontroller board based on the ATmega32u4. It is a tool for making computers that can sense and control more of the physical world than desktop computer.

In this work, Arduino Leonardo Board is programed to take inputs from a variety of switches and provide outputs by means of different ASCII values as like as a computer keyboard for different computer games. Basic circuit diagram of 'Micro HID module' with some sensor and switching arrangement is shown in Fig.2. The role of switching arrangement will be explained in the next section.

B. Developmentof Transmission and Switching Module

Hand grippers are primarily used for testing and increasing the strength of the hands; this specific form of grip strength has been called crushing grip [13] which has been defined as meaning the prime movers are the four fingers, rather than the thumb [14]. People, who have some sort of muscle problems in the hand or have any gripping problem, are prescribed to do exercises using hand gripper.
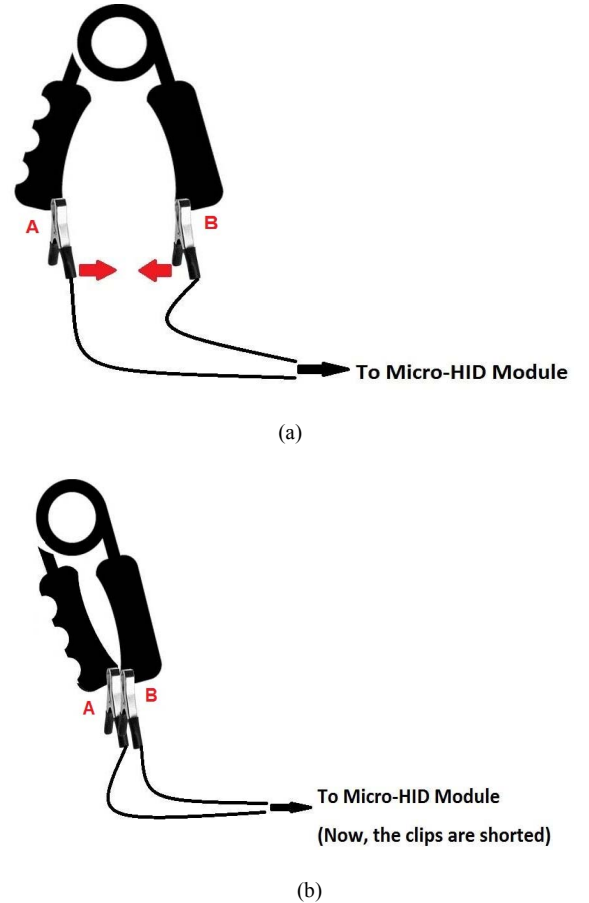

(a)

(b)

Fig.3. Handgripper is in (a) Opening state (b) Closing state

Short circuit switching method is used for hand gripper switching module. Each hand gripper is connected with

crocodile nose pin on each grip A and B, which is shown in Fig.3. When gripper is not in gripping state, no signal is passed to the Leonardo board as in Fig.3(a). When gripper is gripped, A and B get touched and shorted as illustrated in Fig.3(b), this operation is shown through push button S1 and S3 in Fig.2. This process sends digital signals on port D3 & D4, as shown in Fig.2, for both hand gripper through UVCC pin connected with V2, V5. The nose pin sensing module can be replaced by permanent ring type sensing material for commercial use. To START/STOP the function of equipment, D2 digital signal input pin is initialized according to program using external Switch S2.

Fig.4. Photographic view of practical setup of hand gripper

C. Designing Stimulating Environment i.e. Computer Games

As mentioned earlier, the motivating environment of exercising is created by computer games for this research. Under this research, various custom designed games have developed for the better user satisfaction. Game development is the process of creating a pc game. In other word, Game development is the software development process by which a computer game is produced [15]. Game can be developed in any programming language, but most are programmed in C++, C and Java. But the present day games are usually developed in a special tool called Game Engine. A game engine is a system designed for the creation and development of video games [16]. In this research, the games are developed with the GameMaker-Studio v1.1. GameMaker Studio is a game engine which is used to develop 2D games. It allows an entry point to game design through its integrated design tools. It is distinguished from earlier game creation systems by a comprehensive scripting language (referred to as Game Maker Language, or GML) that allows detailed modification of game elements well beyond its integrated tools. Using Drag-and-Drop (DnD) feature a game developer can import and create images and sounds to use in objects, and then instantly see the results of his actions. It should be noted here that, though GameMaker:Studio focuses on two-dimensional (2D) games but it can also be used to develop basic three-dimensional (3D) games.

Three games have developed for this research paper: i. CUET Rush, ii. Balloon Fight, iii. DX-Ball (CUET Edition)

1) CUET Rush

CUET Rush is a game which is developed for playing with only two buttons (left and right arrow). The objective of the game is avoiding collision with the incoming cars. When a collision is avoided, then the score in increased by two. If the score is 100, then the player wins. If there is a collision before reaching score of 100, then the game is over and asked to be restarted.
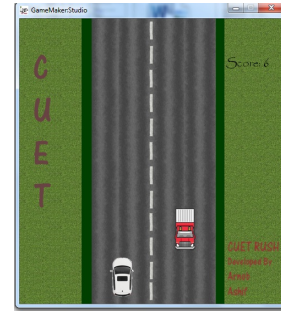

Fig.5. Screen shot while playing CUET Rush

2) Balloon Fight

Balloon Fight is a game which is developed for playing with only two buttons (left and right arrow). The objective of the game is to make collision with the incoming Balloons and movable arrows. When a collision is made, then the score in increased by five. If the score is 100, then the player wins.
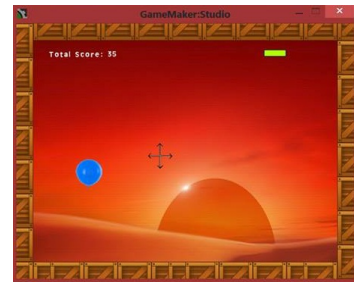

Fig.6. Screen shot while playing Balloon Fight

3) DX-Ball (CUET Edition)

DX-Ball (CUET Edition) is a game which is developed for playing with only two buttons (left and right arrow). The objective of the game is breaking the bricks with the moving ball. When a brick is broke, then the score in increased by two. When all the bricks are broke, then the player wins. There are three life, each is lost if the ball is failed to land on the bat. The bat is controlled by the gamer with the left and right arrow key. If three lives are lost before destroying all the bricks, then the game is over and asked to be restarted.

Fig.7. Screen shot while playing DX-Ball (CUET Edition)

Using different game engines, many games can be developed for the specific user demand. Suitable games will motivate the potential user in the treatment process.

III. User Feedback analysis

An intrinsic user feedback study to investigate the role of computer games interfacing with specialized indoor exercise equipment is designed and conducted for this research. This section discusses the study methods employed, the subjective and objective measures that were evaluated, and the outcomes of the study and system evaluation with various participants.

A. Study Design

The study consisted of two conditions, using our implemented system tool and without using it, to explore the effects of communicative relationship-building techniques on a user's intrinsic motivation to engage in the exercise task with the specialized exercise equipment. The study design was within subject; participants saw both conditions, one after the other, and the order of appearance of the conditions was counterbalanced among the participants. Surveys are administered during both sessions to capture participant perceptions of each study condition independently.

B. Participant Statistics

User from different age group participated in this research study. Seven participants responded and successfully completed the study. The sample population consisted of 3 female participants (42.9%) and 3 male participant (57.1%). This research data is collected from two user groups- Users who are prescribed by physician for exercising and Users who are not prescribed by physician for exercising. Non-Prescribed Users' data is considered from the people who are physically fit and do regular exercise for keeping themselves physically appropriate and healthy. Prescribed Users' data is collected from the users who are prescribed by physiotherapist or consultant doctors to take regular exercise as a mandatory. Two types of prescribed users are studied for this research- physically injured/paralyzed and physically/mentally disable. A special type of disability is Autism. Autistic children are of special attention for this study because various kinds of exercises are needed for them to overcome their difficulties. Statistics data from autistic children is collected from- *Nishpap*, a School for Autistic Children, Chittagong, Bangladesh.

C. User Feedback for Hand Gripper

Data is collected from seven participants who have used Hand Gripper with and without stimulating environment created by our implemented system tools. Three of participants (Subject 2, Subject 3 and Subject 4) of this study are suffered from injury or paralysis and prescribed to do several exercise including Hand Gripper exercise. Two (Subject 1 and Subject 5) of the participants are non-prescribed user. Two autistic children participated in this research study (Subject 6 and Subject 7). It should be noted that, different hand grippers are used for the children (which are soft and suitable for their physical strength). Gripping number (Grip No.) is selected as the parameter for the study because it indicates the efficiency of stimulating environment created by our system tools. Among seven participants six users have remarked the stimulating environment as enjoyable and one of them mentioned it as satisfying. In the discussion, participants are mentioned as 'Subjects' for analytical purpose. Several facts about this study are listed in table:

TABLE I.   HAND GRIPPER USER FEEDBACK

User	Sex	Age (yrs)	Without Virtual Environment (Games)		With Virtual Environment (Games)	
			Right Hand (Grip No.)	*Left Hand (Grip No.)*	*Right Hand (Grip No.)*	*Left Hand (Grip No.)*
Subject 1	F	50	45	33	54	42
Subject 2	M	58	40	15	53	24
Subject 3	M	23	62	18	79	33
Subject 4	M	24	43	3	71	7
Subject 5	F	23	42	46	91	95
Subject 6	M	11	34	31	44	40
Subject 7	F	12	32	28	39	37
Average	-	29	43	25	62	40

The following graphs represent user response as mentioned above.
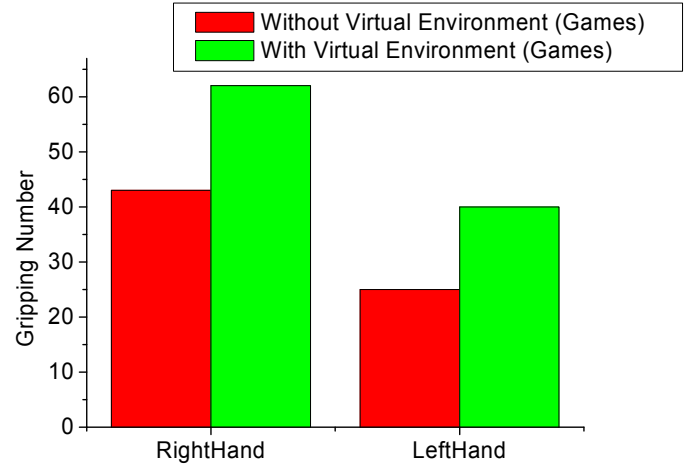

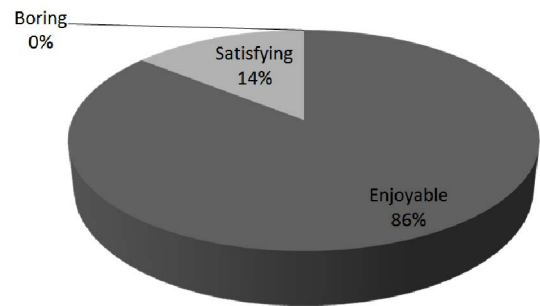Fig.8. Gripping Number (Average)

Fig.9. User remark about Stimulating Environment for Hand Gripper

D. Outcome of Analysis

The results of the study show a strong user preference for the stimulating environment created by the system tools over ordinary system and demonstrating the positive effects of exer-gaming. From Fig.8 it is evident that, with the help of motivating environment (computer games), average gripping number for right hand has increased from 43 to 62 and left hand has levitated from 25 to 40. The griping number is slightly greater for right hand than that of left hand, because most of the participants of this experiment are right handed. No participant has claimed this virtual motivating environment as a boring one; rather they enjoyed the whole experimental procedure which is illustrated in Fig.9. After the preceding analysis, it is decided that stimulating environment is very effective for hand gripper exercise. One important thing should be mentioned here, during the experiments under stimulating environment, autistic children were very attracted to the whole set up. Their participation indicates that, this type of virtual motivating environment increases their interaction and communication ability. Their capability of improvising appropriate eye contact also improves during the experiments under gaming environment.

IV. CONCLUSION AND FUTURE WORK

This paper concludes with definite results and user response, which verifies that this implemented system is build up an useful impact on user mind and gives them more enjoyable way to complete their daily prescribed routine. There are some sectors that may be improved for better output considering recent advancement of technology worldwide. Our implemented system is wire based; that could be replaced and improvised by adding wireless technology. Recently image processing based game designing is much familiar. This feature could be added with stimulating environment. Instant user behavior response feature can be added using HTML database plotting system and can be added with server for online analysis by the physician. The efficiency of stimulating environment to improve health behaviors suggests that the strengths of motivating environment should be seriously considered when designing facilities in health care. The work outlined in this paper proofs that games can have direct clinical implications which can help improving treatment process. The future work of this research would be developing an industrial scale prototype of such interfacing system that could be used for large scale manufacturing and production at a reasonable low cost.

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