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Fingers Exergames to Improve Fine Motor Skill in Autistic Children

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***Abstract*—**Autism is a lifelong developmental disability that affects how people perceive the world and interact with others. Most of these children have difficulty with fine motor skills which typically struggle with handwriting and fine activities in their routine life such as getting dressed and controlled use of the everyday tool. Because fine motor activities encompass so many routine functions, a fine motor delay can have a measurable negative impact on a person's ability to handle daily practical tasks. This project proposed a simple fine motor exercise aid plus the game (exergame) for autistic children who discover from fine motor difficulties. The proposed exergame will be blinking randomly and user needs to bend their finger accordingly. It will notify the user, whether they bend the right finger or not. The system is realized using Arduino, which is programmed to control all the operated circuit. The feasibility studies with six autistic children were conducted and found the child interested in using exergame and could quickly get used to it. This study provides important guidance for future investigations of the exergame potential for accessing and improving fine motor skill among autistic children.

***Keywords*—**Autism children, Arduino project, fine motor skill, finger exergame.

I. Introduction

AUTISM Spectrum Disorder (ASD) refers to a variety of situations characterized by social skills problems, repetitive behaviours, speech and nonverbal communication, and unique strengths and differences. Lots of autistic children perform poorly in complex fine motor skills [1]-[3]. These fine motor skills involve the use of the smaller muscle of the hands, such as when doing up buttons, opening lunch boxes, using pencils and scissors. The efficiency of fine motor skill can influence quality and speed to finish up those activities. Autistic children often have difficulty developing motor skills that lead to hand-eye coordination, visual discrimination, and eventually reading and writing. Excitement and preference for movement and other sensory experiences often affect the child's ability to sit and learn basic skills. Children with autism have shown significant benefits for rigorous physical activity, but it is often difficult to motivate these children to exercise because of their usual sedentary lifestyle [4]. Therefore, this research attempts to combine interactive technology in therapeutic aid tools to help children with autism to improve their fine motor skills using exergame. With this exergame, children will bend their finger according to finger model that made from LED. If the children bend the right or wrong finger, the exergame will give feedback to the user in term of sound and lighting indicator. Each finger exercise is equipped with spring that has different load that can be adjust according to a normal finger capability.

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II. Fine Motor Skill Intervention

The significant motor delays that are experienced by young children with ASD justify the need to create early motor skill interventions in order to minimize motor delays and promote optimal overall development [5]-[7]. A study demonstrated that fine and gross motor skills were a significant predictor of calibrated autism severity at age 14-33 months that mean children with better motor skills demonstrated fewer core symptoms of autism [7]. There are numerous intervention activities for children with ASD with fine motor skill deficiency; among them are using conventional playing activities such as play dough, colouring, drawing, cutting paper, lacing beads and use finger play songs and rhymes. Nevertheless, the actual improvement of the motor skills development is not measured accurately. Besides that, the products in the market are not designed specifically for autistics as a user but more to rehabilitation purposes.

Recent study shows that games have been increasingly used in many educational environments, and these not exclude children with ASD [4], [6], [8]. These studies found that children with ASD, who interact with games, were more likely to show attention rather than interact with the only therapist. Reference [9] shows that gesture-based games give positive effect as an intervention to help ASD improve their performance regarding fine motor skills and recognition object. Another study shows that leap motion-based matching games improved fine motor skill and cognitive skill in children with autism [10]. Similarly, [11] reported that autistic children give significant response while using robotic kit in communicating the acquaintance with orientation, hand-eye coordination and palmar grasp. Therefore, the objective of this work is to develop an exercise tools plus game for finger bend with different strengths to attract the ASD children to do exercise. It combines the use of the small muscles in the hands, in accordance with what the children's eyes see and is very helpful in strengthening the finger muscles of autistic children. This exergame employs a simple game that can interact with ASD children. The interactive concept for this exercise tool is implemented using LED indicator light and voice system to attract and gain attention from the autistic

children. At the same time, finger instruction features are designed to stimulate the children's brain, therefore, the children must follow the instruction to complete a task for one cycle of the game. The exergame is controlled by Arduino Mega as a main controller to control the overall circuit system.

III. Development of Finger Exergame

Since there are different hand sizes according to age, this study focusses on autistic children aged between 7-12 years old. 20 sample hand size is collected among children at one autism centre. Each finger size is sketched is one A4 paper, and then it is scanned and the average size of the finger is found using overlapping the sketched finger in Photoshop Software. Then, the finger exercise module is designed, and printed in 3D.

Fig. 1 shows the design of the finger exergame. It is consisting of one of hand indicators that will be blinking in according to the program cycle. There are two indicators of light, one with smiley faces and another one is with sad faces. There are five rings made from ABS plastic and it is designed based on average size finger of the children ages 7 to 9 years old. Attached from the rings is individual spring that can be adjusted the strength according to the user's suitability.

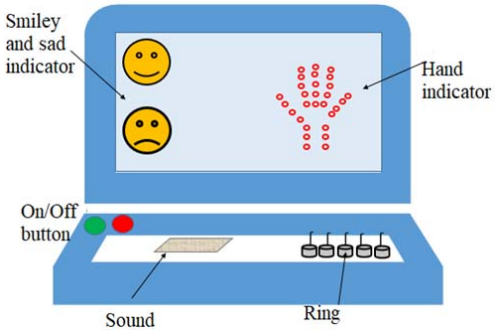

Fig. 1 Design of the finger exergame

TABLE I
Operation of the Exergame

Programmed	Operation
Random	• User bends their hand according to light on LED finger displayed randomly • If user is bending the correct finger with specific strength, smiley faces and MP3 will generate 'good' voice • If user is bending the incorrect finger with specific strength, sad faces and MP3 will generate 'wrong' voice • If the cycle is complete, the applause sounds will be heard.
Display	• User must bend one of their fingers and the hand indicator will light the same finger. • If the cycle is complete, the applause sounds will be heard.
Sequence	• User bends their hand according to light on LED finger display in sequence. • If children bend the correct finger with specific strength, smiley faces and MP3 will generate 'good' voice • If user is bending the incorrect finger with specific strength, sad faces and MP3 will generate 'wrong' voice • If the cycle is complete, the applause sounds will be heard.

The design controller is using closed-loop system with Arduino Mega as the main controller. The circuit is realized using Proteus Software and then converted to printed circuit board, PCB. The operation of the design circuit is based on Table I. Based on the table, children have to ON the button to start the exergame. There are three stages based on level of difficulty; display, random and sequence. The system is having two inputs that are the start and stop button and the LED hand indicator. Meanwhile the outputs are the light indicator (smiley and sad face), the LCD display and the sound (in MP3). The feedback of the system is the sensor which will be operating when the strength of the finger bend is sufficient. Fig. 3 shows the circuit diagram of the whole system.

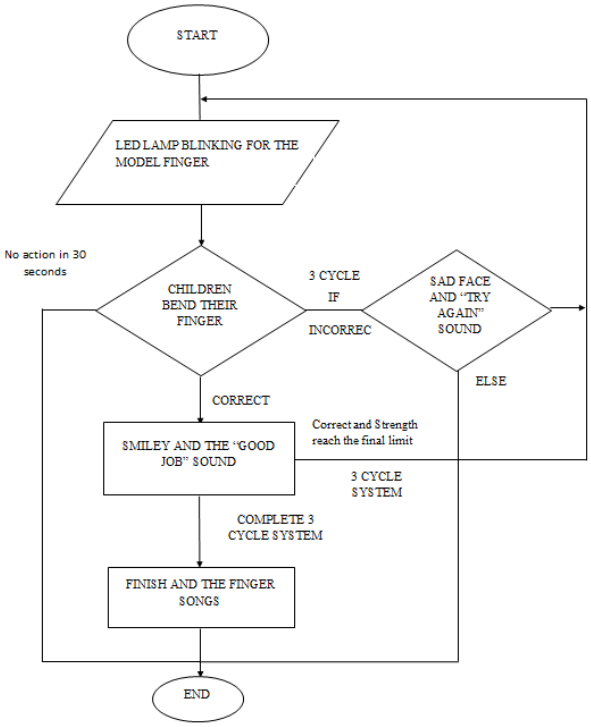

Fig. 2 Flow chart of operation of the system Sequence and Random programmed

TABLE II
Sequence of Finger Model Blinking

Finger	Cycle 1	Cycle 2	Cycle 3
Thumb	1	3	2
Index	5	2	1
Middle	2	1	4
Ring	3	4	5
Baby	4	5	3

IV. Results

In order to study the feasibility of the exergame, six children with moderate ASD aged between 7-9 years old were considered. The children are undergoing occupational therapy at one of autism centres in Malacca. The subjects of this study were selected according to these criteria: the children with ASD and able to understand therapists' instructions. The feasibility study is first step to do before clinical data are collected. Each participant needs to complete three programs

of the exergame as mentioned in Table I. The session was entirely video recorded and the success percentage of subject doing exercise is taken. Fig. 4 shows one of the participants using exergame during trial session. All six participants show great interest in this exergame and most of them think that it is a game and not an exercise aid. Four participants could independently perform the task after a short introduction to the system. No one shows frustration and wants to quit the task although they were informed that they could withdraw at any time without reason. Table III shows the successful percentage of each subject in the trial session (first time use with their right hand), in terms of understanding and following instruction of the exergame. During this trial, the spring of each ring is adjusted to minimum strength so that the subject can easily bend their finger. Base on the table, all the six subjects can easily bend their finger according to Display Program, and five children have successfully followed Sequence Program. It is also indicated that all subjects easily followed instruction and understood the function of exergame.

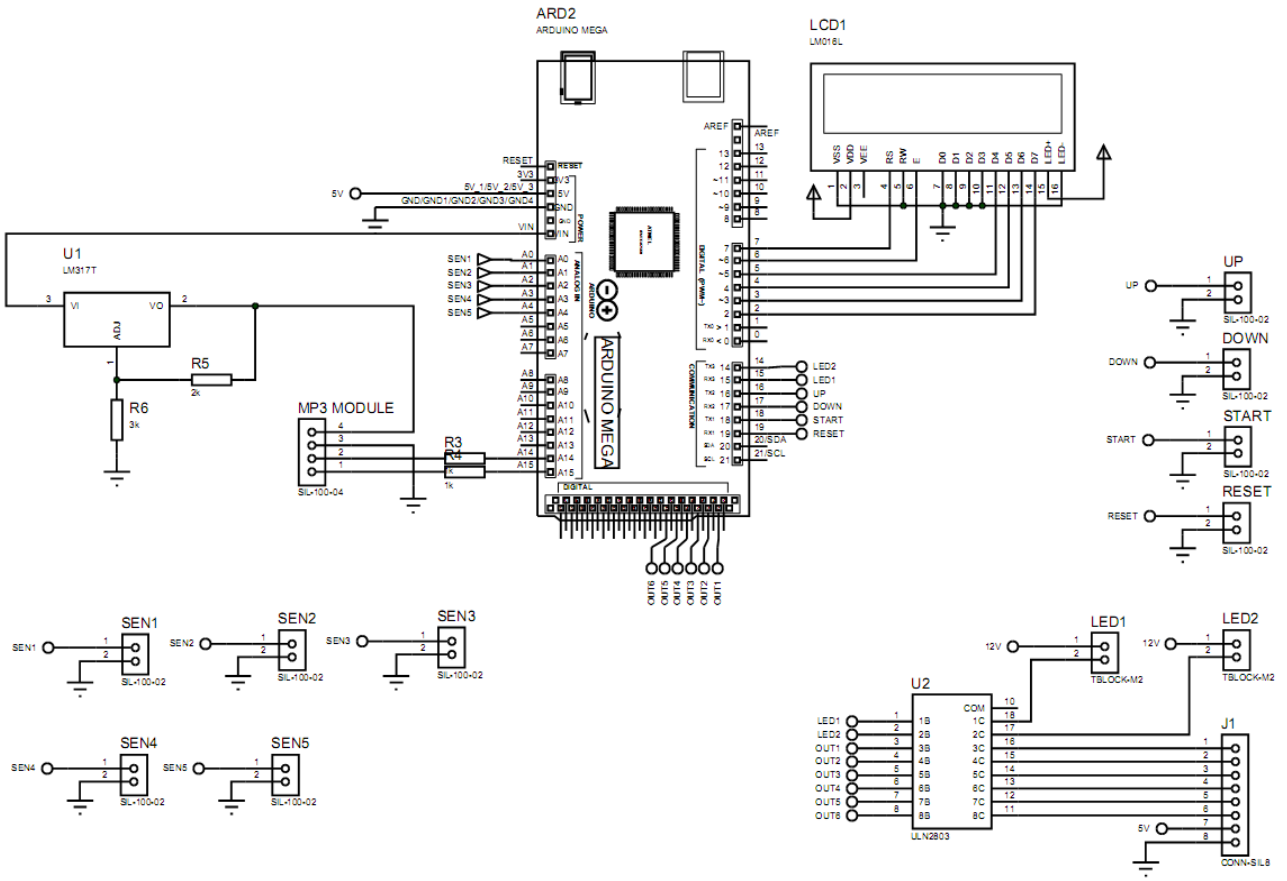

Fig. 3 Circuit Diagram

Fig. 4 Participant using exergame during trial session

With guidance of occupational therapist, participants also need to answer a short survey question that indicates the participant perception towards this exergame. The questionnaire consists of 5 questions where users ranked their preferences from one to five on a Likert scale ranging from: strongly disagree to 5: strongly agree. All the statements are positively worded items. The questions are:

1. I can easily use this exergame
2. The exergame is interesting
3. The organization, sequencing and overall arrangement of this exergame is well designed and presented
4. I like to do this exercise everyday
5. I understand how to perform the task in this exergame

The results for the five survey questions are presented in the form of radar chart as Fig. 5. From the chart, 66.6% or 4 out of 6 subjects strongly agreed that they can easily use the exergame, while 50% strongly agree that the exergame is

interesting. In addition, 100% subjects strongly agree with survey Question 3. Meanwhile, 50% and 83% strongly agree for survey Question no 4 and 5 respectively.

TABLE III
PERCENTAGE OF SUCCESS DURING TRIAL SESSION

Subject	Program				
	Display %	Sequence %	Random %		
			Cycle1	Cycle2	Cycle3
1	100	100	80	100	100
2	100	80	60	80	80
3	100	100	100	100	100
4	100	100	80	80	80
5	100	100	100	80	100
6	100	100	80	100	80

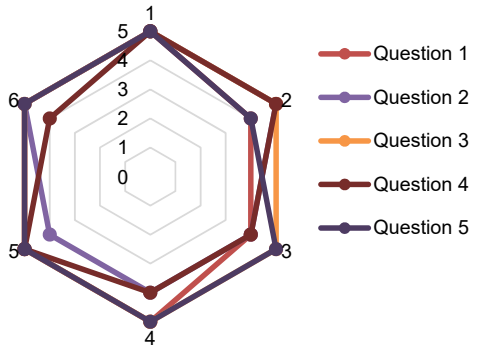

Fig. 5 Responds to survey question

V. CONCLUSION

Many autistic children experience fine motor skill delay as compared to normal children. The exergame is designed to attract autism children in doing their fine motor skill. The feasibility studies with six autistic children were conducted and it is found that the children are interested in using exergame and could quickly get used to it. This study provides important guidance for future investigations of the exergame potential for accessing and improving fine motor skill among autistic children

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