BUILDING HAND ACTIVITIES APPLICATION FOR CEREBRAL PALSY CHILDREN

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Abstract
In this paper, we present an algorithm (CP_Hand_Activity) used to build an application that utilizes touch screen interface to help cerebral palsy (CP) children to develop and upgrade simple hand activities to reach more complicated functional activities which they can use in their daily lives. Our algorithm consists of four stages each with different number of levels; the CP's children should be able to finish these stages sequentially and in a specific amount of time until they are able to draw alphabet letter by using the electronic pen on the touch screen.
All information attained from the algorithm such as time to complete stage, number of successes and failures are recorded in a separate database which is used to monitor the advancement of each case by their therapist.

Keywords: CP_Hand_Activity, Cerebral Palsy, touch screen

1. Introduction

Cerebral Palsy (CP) describes a group of permanent disorders of movements and postures development, causing activity limitation, that are attributed to a non-progressive disturbances that occurred in the developing fetal or infant brain [1,2,3]. There is no known cure for CP, and medical intervention is limited to the treatment and prevention of its complications.

In the latest years there was more interest in using computer games in therapy when treating neuromuscular conditions which involves some brain cells damage.
Therapist in cooperation with advanced computer technology approach can motivate the CP children through playing games and doing activities resembling normal daily activities for longer time to practice more in their hands. These technologies range between using the virtual reality to the robot manipulator. Virtual reality games are based on technologies currently being developed and tested to improve motor and cognitive elements required for ambulation and mobility in different patients. While a robot manipulator is facilitating learning by young children who are generally unable to grasp objects. Developed software application allows the child to accomplish a series of multistep tasks by activating one or more single switches. This shows the importance of using computer software application in rehabilitation field.
In this paper we develop an algorithm that is used to build a software application that utilizes the touch screen interface to be used in physical therapy settings to stimulate neuroplasticy which will decrease spasticity, improve visual motor coordination and functional daily activities in spastic cerebral palsy children. Our algorithm consists of four stages. Each stage contains a certain amount of levels that the patient needs to finish it successfully. These different stages progresses children to use different groups of muscles and stimulate neuro development which stimulate neuroplasticy in child brain. This is done through a variety of activities such as catching moving objects, draw a line with different shapes, moving object in different ways, solve the puzzle, and filling the missing alphabets in a given word.
This paper is organized as follows. In Section 2, we briefly review the related work. Section 3 describes the proposed algorithm. The implementation and the experimental results are discussed in Section 4 and section 5 concludes the paper.

2. Literature Review

Cerebral palsy children require a great amount of care during their life span. They usually suffer from muscles spasticity which hinders their upper and lower extremities activities. Physical therapy is one of the rehabilitation approaches which provide musculoskeletal training decreasing muscle spasticity and improving their daily activity functions like writing, using spoon for eating, and using their upper extremities as much as possible to do normal activities. Physical therapists were facing a great amount of challenge in CP rehabilitation. That is mostly related to the fact that CP children have less interest in doing exercises by repeating activities for enough time to stimulate neurological development.
The number of CP children around the world is rising; the incidence in six countries surveyed in 2006 was 2.12–2.45 per 1,000 live births, [4, 5, 6] and the financial cost for CP children in USA, was $1.47 billion (0.14% of GDP) in 2003 [4].
Up to date, physical therapy alone gave moderate effect in treating upper extremities spasticity of cerebral palsy subjects [7].
There were clinical trials since long time to use modern technology in therapeutic setting. Nash et al [8] used visual biofeedback of muscle stretch reflex sensitivity which is provided via video games, and played by reducing reflex sensitivity to control spasticity in adult and children suffering from CP.
Szturm et al [9] was aimed to help CP children to use their extremities through playing games and doing activities resembling normal daily activities for longer time during the day which is expected to decrease neuromuscular tone and spasticity.
Schultheis et al [10] used virtual-reality in rehabilitation in their study which concluded that this advanced approach may benefit disabled subjects by improving their concentration on tasks and allow them to practice for longer time at any time of the day.

You et al [11] used virtual reality in treating chronic stroke patients and concluded that virtual reality approach induced cortical reorganization and associated locomotors recovery in chronic stroke. Jack et al [12] were able to confirm that virtual reality approach enhanced stroke rehabilitation by improving their upper and lower extremities abilities to finish the task. Cook et al [13] developed a robot manipulator to facilitate learning by young children who are generally unable to grasp objects. Results from this study had shown that young children who have severe disabilities can use the robotic arm system to complete functional play-related tasks.

Up to now, there is no software application that allows CP children to use touch screen to accomplish different tasks where he/she needs to use controlled muscles activity. In this paper we develop an algorithm that utilizes the touch screen interface to allow the CP children to use their hands and arms in reaching and completing tasks progressively by increasing the complexity and reduced the time.

3. The proposed CP_Hand_Activity algorithm

Our algorithm consists of four stages presented in Table 1. These stages run sequentially. The patient must finish the first stage before continuing to the next stage. Each stage contains a set of levels that the patient needs to finish successfully through a certain of conditions related with time and number of hits. A series of studies used to assist in the selection of time and the number of hits that will enhance the ability of the patient to move his hands in the right way. All information attained from the algorithm such as time to complete stage, number of hits outside the object ..etc is recorded in a separate database which is used to monitor the advancement of each case by their therapist.
The First_Stage() presented in Table 2. The objective of this stage is to enhance the ability of the CP child to catch any moving objects such as ball, monkey, ..etc in the screen. This stage consists of three levels and the CP patient needs to finish each level successfully before continue to the next level. Otherwise the patient needs to repeat this stage many times until they succeed.

The child continues to the second stage Draw_Line_Stage() only if they pass the First_Stage() successively. Table 3 represents the Draw_Line_Stage(). In this stage the CP child need to follow specific curves with different slopes and shapes such as linear, sine-soydal, and zigzag. This stage contains three levels, the patient needs to finish each one within a specific amount of time and with the minimum number of hits outside the specific area. At the end, the time is recorded and based on it the patient is able to move to the next stage or stay in the same stage until he/she able finish the stage successfully.

The third stage is Moving_Puzzle_Filling_Stage() presented in table 4. The target of this stage is building, rearranging character; solve the puzzles, filling the missing character(s) in the right way to get the correct word or picture. This stage consists of four levels. The first two levels are Moving_Linear_Direction() and Moving_UP_Down_Direction() concentrate on moving object from one side of the screen to another side in a linear motion or up/down motion. In level three the patient arranges a puzzle. In level four Filling_Missing_Char() aims to test the ability of CP child to choose the right missing character. This level consists of three sublevels differ in number of characters of word, number of words to win and number of missing characters. The time computed in each level is stored in the database so the parents or the doctor can use these numbers to evaluate the status of the child.

The Fourth stage is Writing_Char presented in Table 5. This stage represents a major development in the child case as he/she is able to lift small object and use them such as the electronic pen (e-pen). The CP child needs to use the e-pen to connect the dots that represent the Arabic character shape. There are twenty eight characters in Arabic language. The twenty eight characters were subdivided to three groups based on complexity of each character pattern as presented in table 5.

4. Implementation

Based on the algorithm presented in section 3 , we developed an CP_Hand_Activity application that utilizes the touch screen interface to enhance the ability of the cerebral palsy patient. Our application was implemented by using the Active Server Pages (ASP.NET) in [14], and Vb. Net[15] to create the website, to manage patient account and to make it easy for CP children and their family to register and to record their information that is needed for future follow up and to communicate with the application through the website.
We used action script and macromedia flash [16] to create the game in different stages that will enhance the hand activities of the CP children. All these games built by using characters suitable for girls and boys with animation that encourage them to repeat it tell success.
Figure 1 presents the home page of the CP_Hand_Activity application. It contains four stages that need to finish it in a sequential manner. The patient will go to next stage after finishing the previous one successively. Repeated the process until the patient able to finish all stages, and hopefully this will enhance the hand activities and reduced the disordered movement in the hands. The result of each stage recorded in the database that help to monitor each case and take proper action based on the information received from the application. Figure 2 presents a sample of First_Stage() of the CP_Hand_Activity application where the patient needs to catch moving objects within a specific amount of time. The second stage presented in figure 3 where the CP child needs to follow specific curves with different slopes and shapes such as linear, sine-soydal, and zigzag. The fourth stage presented in figure 4 where the CP child needs to use the e-pen to connect the dotes to write the specific character.

The CP_Hand_Activity application was tested on five CP Children (Two boys, Three girls) their ages between five years to eight years. They were excited about using the application. It is very easy to use and practice moreover; it's designed in a manner that appeals the children to play with this application. Our Target is to apply this application on a large number of CP children in some institutes in Jordan that care about the CP children.

5. Conclusion

The CP_Hand_Activity application will give CP children opportunity to practice hand movement and encourage visual-hand control which will stimulate their control over muscle spasticity and will stimulate brain neuro plasticity. Playing games on touch screen will allow children to have physical therapy treatment by repeating muscles movement through games which will be more enjoyable activities for the child. This application gives the children a chance to practice for longer time which will stimulate brain cell development. We hope in the future able to build a home page system to treat CP children via computer games, by using online services or put the game on CD and build a system to improve CP children dynamic balance.

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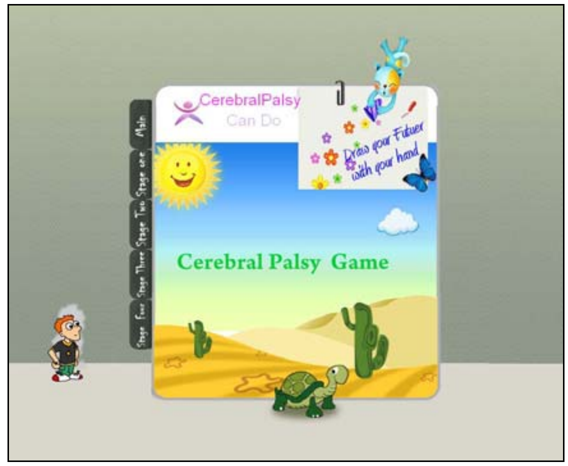

Figure 1. The main page of the CP_Hand_Activity application

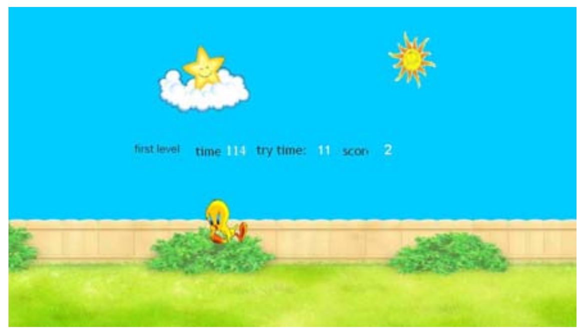

Figure 2. Sample of First_Stage() function (Hit the Tweetie moving character)

Figure 3: Sample of second stage Draw_line_Stage() (Draw curve represented by the top of the houses)

Figure 4: Sample of the fourth stage Draw Writing_Char()

Table 1: The CP_Hand_Activity() Algorithm

	CP_Hand_Activity()
	{

1.	First_Stage();
2.	Draw_line_Stage();
3.	MovingAndPuzzle_Stage();
4.	Writing_Char();
	} // end of CP_Hand_Activity

Table 2: The First_Stage() Function

	First_Stage () **{** //Comments: 1.This stage increases the ability of the CP child to catch the moving objects 2.It contains three levels. The differences between levels are time to catch object , time to pass level ,and number of objects the CP child is able to hit.
1.	**Level1()** **{**
1.1	Run_Game1(); // this game utilizes the touch screen interface
1.2	If (time <=120 seconds AND HitSuccess=8 picture AND HitTime <=15 sec) {
1.2.1	Return Pass;
1.2.2	Level2();}
	Else
1.2.3	{ cout<< "Fail Try Again";

1.2.4	Level1();
	}
	} // end of level1()

2.	**Level2()** **{**
2.1	Run_Game2();// this game utilizes the touch screen interface
2.2	If (time <=90 seconds AND HitSuccess=9 pictures AND HitTime <=10) **{**
2.2.1	Return Pass;
2.2.2	Level3();}
	Else
1.2.3	{ cout<< "Fail Try Again";

1.2.4	Level2();
	}
	} // end of level2()

3.	**Level3()** **{**
3.1	Run_Game3();// this game utilizes the touch screen interface
2.2	If (time <=64 seconds AND HitSuccess=8 pictures AND HitTime <=8) **{**
2.2.1	Return Pass;
2.2.2	Draw_Line_Stage();}
	Else
1.2.3	{ cout<< "Fail Try Again";

1.2.4	Level3();
	}
	} // end of level3()

	} // end of First_Stage() function

Table 3: The Draw_line_Stage() Function

	Draw_Line_Stage () **{** //Comments: 1. This stage helps the patient to follow different curves to enhance the ability of muscles to move in different directions 2. It contains three levels. The differences between these levels are the shape of the curve, number of hits outside specific area and passes time.
1.	**Linear_Line()** **{**
1.1	Run_Game4();// this game utilizes the touch screen interface
1.2	while (time < 2 minute) DO {
1.2.1	If (time <=1 minute AND outside hit<=6 hits) {
1.2.1.1	Return Pass;
1.2.1.2	Sine_Soydal_Line ();}
	Else
1.2.1.3	{ cout<< "Fail Try Again";

1.2.1.4	Linear_Line();
	}
	} // end of linear_line()

2.	**Sine_Soydal_Line()** **{**
2.1	Run_Game5();// this game utilizes the touch screen interface
2.2	while (time < 2 minute) DO {
2.2.1	If (time <1 minute AND outside hit<=5 hits) {
2.2.1.1	Return Pass;
2.2.1.2	Zigzaq_Line();}
	Else
2.2.1.3	{ cout<< "Fail Try Again";

2.2.1.4	Sine_Soydal_Line();
	}
	} // end of Sine_Soydal_line()

3.	**Ziqzaq_line()** **{**
3.1	Run_Game6();// this game utilizes the touch screen interface
3.2	while (time < 2 minute) DO {
3.2.1	If (time <1 minute AND outside hit<=4 hits) {
3.2.1.1	Return Pass;
3.2.1.	Puzzle_Stage ();}

2	
	Else
3.2.1.3	{ cout<< "Fail Try Again";
3.2.1.4	Ziqzaq_Line(); } **} // end of Ziqzaq_Line()**
	} //end of Draw_Line_Stage() function

Table 4: The Moving_Puzzle_Filling_Stage() Function

	Moving_Puzzle_Filling_Stage () **{** //Comments: 1. This stage helps the patient to rearrange characters or puzzles 2. It contains four levels. The Differences between these levels are time to catch object , time to pass level ,and number of objects hits
1.	**Moving_Linear_Direction()** **{**
1.1	Run_Game7()// The main idea is to move seven flowers from one location to a vase in another location using the linear direction. The CP patient needs to finish it within 7 seconds/flower
1.2.1	If (time needs to move each flower >7) {
1.2.1.1	cout<<"Fail try again";
1.2.1.2	Moving_Linear_Direction ();}
	Else
1.2.1.3	{ cout<< "Pass";

1.2.1.4	Moving_UP_Down_Direction();
	}
	} // end of Moving_Linear_Direction

2.	**Moving_UP_Down_Direction()** **{**
2.1	Run_Game8()// The main idea is to move seven flowers from one location to a vase in another location Up and Down direction. The CP patient needs to finish it within 7 seconds/flower
2.1.1	If (time needs to move each flower >7) {
2.1.1.1	cout<<"Fail try again";
2.1.1.2	Moving _UP_Down_Direction ();}
	Else
2.1.1.3	{ cout<< "Pass";

2.1.1.4	Puzzle();
	}
	} // end of Moving_UP_Down_Direction

3.	**Puzzle()** **{**// the CP patient need to rearrange the parts of the given puzzle within a specific period of time
3.1	Run_Game9();// this game utilizes the touch screen interface
3.2	If (time >120 seconds)
3.2.1	{ Cout<<"Fail try again";
3.2.2	Puzzle ();}
	Else
3.2.3	Filling_Missing_Char(); } //end of Puzzle()
4.	**Filling_Missing_Char()** **{**
4.1	**Level1()** **{**
4.1.1	Run_Game10();// this game utilizes the touch screen interface
4.1.2	Number of characters=3 per word
4.1.3	Number of missing char=1
4.1.4	For i=1 to 6 do
4.1.4.1	if Time For each word <= 15 second then
4.1.4.1.1	{ Cout<<"pass"
4.1.4.1.2	Level2();}
	Else
4.1.4.1.3	{ Cout<<"Fail"
4.1.4.1.4	Level1();}
	} //end of level1()
4.2	**Level2()** **{**
4.2.1	Run_Game11();// this game utilizes the touch screen interface
4.2.2	Number of characters=4 per word
4.2.3	Number of missing char=2
4.2.4	For i=1 to 4 do
4.2.4.1	if Time For each word <= 15 second then
4.2.4.1.1	{ Cout<<"pass"
4.2.4.1.2	Level3();}
	Else
4.2.4.1.3	{ Cout<<"Fail"
4.2.4.1.4	Level2();}
	} //end of Level 2()
4.3	**Level3()** **{**
4.3.1	Run_Game12();// this game utilizes the touch screen interface
4.3.2	Number of characters=45per word
4.3.3	Number of missing char=3
4.3.4	For i=1 to 3 do
4.3.4.1	if Time For each word <= 15 second then
4.3.4.1.1	{ Cout<<"pass"
	Else
4.3.4.1.2	{ Cout<<"Fail"
4.3.4.1.3	Level3();}
	} //end of Stage 3
	} // **end of Filling_Missing_Char()**
	} // end of Moving_Puzzle_Filling_Stage

Table 5: Writing_Char() Function

	Writing_Char()
	{
	//Comment {The 28 Arabic characters are divided into 3 groups according to ease of writing. Group A include (“ ل ,ز ,ر ,ذ ,د ,ث ,ت ,ب ,ا “). Group B include ي , و,م ,ق ,ف ,ط ,ظ ,ك ,ه ,“) ”), Group C include (" {.(" ه ,ك ,ظ ,ط ,غ ,ع ,خ ,ح ,ج ,ش ,ص ,ض ,

1.	For i=1 to 28 **do {**
1.1	choose letter
1.2	If Dot Match letter is correct
1.2.1	Cout<<"PASS ":
	Else
1.2.2	Cout<<"Fail";
	} //end of Writing_Char()