

Rehabilitation games with active markers for children with infantile cerebral palsy

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Abstract. This paper shows a combination of image processing technology and active markers in a medical application. Developing a human-computer interface prototype, the proposed system uses a PlayStation 3™ EyeCamera and active marker to perform neuromuscular rehabilitation games for upper limbs, as a tool to support rehabilitation therapies. As a case of study, we observed children with infantile cerebral palsy playing the rehabilitation games prototype during six months, obtaining a quite positive result. This paper shows a new low cost, attractive and effective tool, allowing multiple therapies of neuromuscular rehabilitation to satisfy different needs of patients.

Keywords: Rehabilitation, cerebral palsy, computer games, image processing, active marker.

1 Introduction

Today, the interaction between humans and computers becomes more and more common to support people's activities in a more natural way, giving more uses in different areas. Such as education [1], work [2], home [3], medicine [4], among others. The technology of human - computer integration or integration of robot and computer are used in rehabilitation of the medicine area [5,6] in the way it can achieve distinct type of rehabilitation. It is more attractive to patients performing tedious and repetitive exercises [7], on the other hand; it is also more economic compared to the traditional rehabilitation devices and allows patients to do their therapy at home. For all these advantages, computer is an excellent tool to support rehabilitation. [8] Shows that virtual reality technology offers an efficient way to help rehabilitation.

Currently there is a consensus, considering the cerebral palsy (CP) as a group of developmental disorders of movements and posture, causing activity limitations, which are attributed to a non-progressive attack on the developing brain in the fetal period and early years. From 1000 births, approximately 2 or 3 have CP [9].

According to the problem of children with cerebral palsy, a good technique of rehabilitation therapies will be very important. This paper shows the development of a human computer interface using image processing with a PlayStation 3™ EyeCame-

ra and a LED pen as an active marker. The system includes the development of neuromuscular rehabilitation games for upper limbs, in order to help children with infantile cerebral palsy on his therapy. And finally, this paper shows the result of case studies with children with infantile cerebral palsy.

2 Neuromuscular disease

Neuromuscular diseases are characterized by muscle weakness, which could result in difficulty of limbs movements and a decrease of the functional ability [10]. But it also, depending on the distribution of the weakness, difficulty in swallowing, chewing, speaking or breathing. Also secondary complications may occur; for example: contractures and scoliosis, which may just them, incapacitate the patient.

A relevant muscular and functional evaluation is necessary to document the natural history of the patient and then determine the outcome of the therapy.

The main treatment of neuromuscular diseases can be summarized in:

1. Maintenance or improvement of muscle strength.
2. Prevention of contractures or deformities.
3. Maintenance or improvement of function.
4. Stimulation or prolongation of ambulation. [10]

3 Human-Computer Interface with games of rehabilitation neuromuscular

3.1 Installing the device

To achieve the natural manipulation of the human-computer interface that we present requires a large computer screen or a TV or a projector connected to the computer, a webcam that detects all area of the screen and an active marker to manipulate the screen. In this case we use PlayStation 3TM EyeCamera as a webcam, because it presents a faster response time of the image than a normal web camera and the detection of image is more stable. We also use a projector and a color LED pen (red LED, green LED or blue LED) as active marker to manipulate the interface, such as shown in Figure 1.

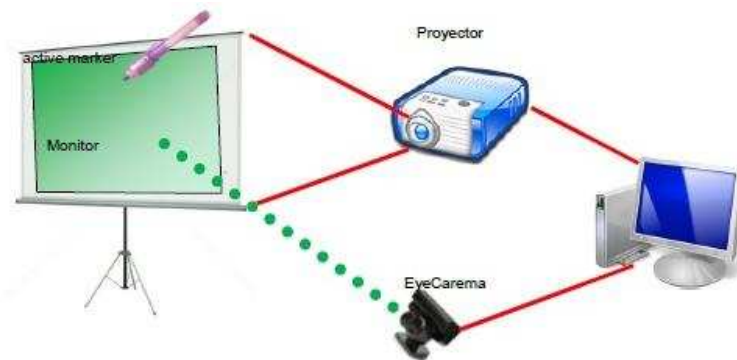


Fig. 1. Installing the device

3.2 Marker

The marker can be a device of control or an object that manipulates the software with another device capturing signals of marker and transmitting the signal to the computer. Currently there are different types of control devices; generally we can divide them into 2 types: active markers (which send signals to the device) and passive markers (which do not emit the signal, and wait until the device finds them).

In this project we developed some active markers, and we compared their advantage and disadvantage. We design glove with infrared LED, hook and loop fastener ring with an infrared LED, pen with color LED and hook and loop fastener bracelet with color LED. Here we use hook and loop fastener to adjust the size of the wrist and finger of the user. See Figure 2



Fig. 2. Active markers

When comparing the detection result of infrared LED marker and the LED color marker, it showed that to detect an infrared marker, a filter is needed to remove the

ambient lights, but it is not very effective. When the environment is a little lighter there may be too much intervention, if the infrared light is far, it wouldn't be detected. On the other hand, for the LED color marker, though we use a filter to remove most of the lights and colors, as this is search by specific LED color you can find less intervention, it doesn't depend much on ambient light like infrared. Also, in the future we'll be able to involve multi user games at the same time by having different LED colors.

Infrared LED and color LED are unidirectional, light is focused on the top, if the top of LED is turned in another direction, the light that is seen on the camera will be decreased a lot, it even disappears. This problem causes detection fault. To solve this problem we painted black color on the top, put LED inside a small sphere of glass and filled with hot melt, so that LED's light will be in all different directions.

3.3 Image processing to detect active marker

First, it captures the image from the camera, then it gets the data from each pixel of the image in RGB format, and compares the data of each pixel with data in RGB of color LED light. When the color LED light is found in image, it returns his position x, y. Environment interference is strong enough to make the program get confused and it detects incorrect point. To avoid this problem we put a filter on the lens of EyeCamera. See Figure 3.

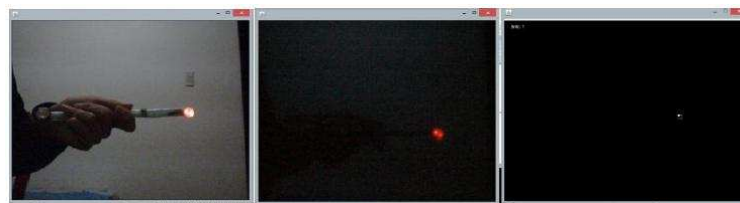


Fig. 3. Regular image with point detection filter.

3.4 Computer games for rehabilitation of upper limbs

We developed two games of neuromuscular rehabilitation for upper limb; car game rehabilitates continuo movement of upper limbs, and frog game rehabilitates movement of upper limb and movement of thumb.

Car game

This game works in following way: The car has to move in his road with the active marker. If marker is outside the road it will emit a sound that represents an error and errors committed during the game will be recorded. If the user puts the marker outside car's location it will emit another sound, which means it's not a valid movement. When user reaches the final goal sound of applause, it will mean that the user has

finished this level, the game saves automatically: game level, user name, date, and time that user takes to finish the game's level up to milliseconds and number of times that user spent outside of the road. The present game has various roads recommended by the doctor and divide levels by difficulty in order to help users to perform their rehabilitation and exercising different arm movements. See Figure 4.

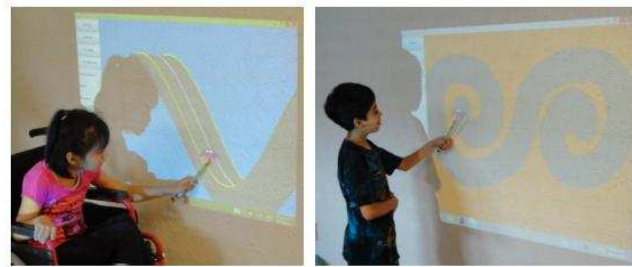


Fig. 4. Car game

In this program there is also a tool that allows the doctor or therapist to design a specific path and size of the road for different patients according to their needs.

The doctor or therapist can check on a chart, the results of the games of each patient or all patients, or state a specific level of game, and it is also possible to see on a graph, an specific exercise that the patient performed during a period of time.

Frog game.

Frog game is for exercising upper limbs movements and also exercising thumb movements (press the button to turn on the light).

This game works in the following way: the frog has to eat all cakes by pointing the marker in each cake and press the button, turning on the light to eat the cake, the frog must avoid hitting the bombs, when it collides with a bomb, the game emits error sound and it counts an error; when all cakes are eaten, the game emits a clapping sound meaning that user has finished the level of the game. Either user or therapist can choose the difficulty of the game in the same level, eating cakes in order or not, with bombs or not, bombs with movements or not.

The doctor and therapist can also create their own levels of this game, selecting number of bombs and cakes, marking their positions, selecting the direction of the routes of each bomb. This game also offers the search of the results of the patient's performance, using a chart or graph. Such as shown in Figure 5.



Fig. 5. Graph result

4 Study case

Our study case has been done during 1 month to 6 months with children aged 6-10 years with cerebral palsy. Table 1 shows the observation and progress of these children. We have also tried during a period of time with children from 1 and half to 4 years with cerebral palsy, but this game is difficult for them, they get distracted very easily, most of them cannot play this game alone, they need their parent's help. So we just didn't use these cases.

During the test time with children from 6 to 10 years, they made very positive progress. One of them can do the exercises alone, and every time he makes better exercises, points more exactly the road with the marker and finishes with less time and less errors. In the beginning he couldn't reach higher levels, after a period of therapy he could reach a higher level, now he can finish high levels within a short time and having few or zero mistakes. Table 2 shows the progress comparing the average results of beginning and after 4 month.

Table 1. Patient's data

	P1	P2	P3	P4	P5
Age	10 years	9 years	8 years	6 years	7 years
Exercised hand	Left	Right	Left	Right	Right
Time of exercise	6 month	1.5 month	2 month	1 month	2 month
Time of each therapy	30 minutes	30 minutes	30 minutes	30 minutes	30 minutes
Position of	standing	sitting	sitting	standing	standing
Hand common use	Right	Right	Left	Right	Right
Description at beginning stage	Only arrive level 4	Cannot hold pen well and can't paint with strength	Cannot do exercise alone	Cannot do exercise alone	Cannot do exercise alone
pro-gressing	Arrive to all levels with good results, can do fine work like opening the door with key, catch a ball	Can cut and paste on a straight line, paint with more strength and inside of frame	Can exercise until level 3	Can exercise until level 5	Can exercise until level 4

The case of frog game has also had good progress, child P1 has participated for 3 months and a half. In the beginning P1 couldn't press the button with his thumb of the left hand, which is the hand he's been doing the therapies with. He couldn't even holding the marker well, he needed right hand support, after 3 months the child can hold marker with left hand very well and press the button with his thumb.

For children with cerebral palsy, the present project is not only an exercise therapy to upper limbs but it is also an exercise to identify colors, objects and through the different sounds they can identify its meaning. In one single therapy several goals are achieved; both rehabilitation of upper limb, also color recognition and identification of objects and sounds. This way children find interesting to do their rehabilitation therapy.

Table 2. Comparing average result of child P1

Level	In the beginning		4 month later	
	Time (s)	error	Time (s)	error
1	26.516	3.33	19.100	0.33
1 A	16.171	4.33	13.235	2
2	9.047	1	11.67	0.66
3 A	53.500	13.33	28.846	1
4	24.166	3	12.046	0.33
4 A	21.400	4	15.520	0.66
5 A	99.635	61.5	38.604	3
5 B	46.133	2.25	12.197	0
6 A	47.154	7.75	32.045	1.667
6 B	69.639	19	20.460	3
6 C	93.631	5	31.368	3.66

5 Conclusion

The present paper shows the use of image processing in the rehabilitation area, offering neuromuscular rehabilitation games to help patients, and showing through the case study very positive results and progress of children who participated in this case study. This gives us more confidence that the rehabilitation games are very good tools to help in rehabilitation therapies and that they are not only for the therapies of movement but also offer another extra advantages. The best thing of this project is that it can be used for different kind of rehabilitations, different therapies, to satisfying needs of different patients, only by changing the game.

The next step of this project is to continue creating different types of games for different therapies in order to offer a software tool containing various games for diverse needs of patient.

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