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Implementation of Skateboard for Arm Movement Rehabilitation of stroke patients

Abstract. *The objectives of this research were (1) to design and implement a skateboard for arm movement rehabilitation, (2) to apply a skateboard in stroke patients who need constant restoration of arm movements, (3) to produce cost-effective rehabilitation tools, (4) to provide guidelines for the development of medical applications with a skateboard for arm movement rehabilitation which can work in all four modes in the direction of the arm movements. The first mode consisted of the movement in the left-right direction, the second mode was the movement in the forward-backward direction, the third mode moved in the circular direction, and the fourth mode moved in number 8-shapaed direction (clockwise and counterclockwise).The developed skateboard could adjust the speed of the movement of three levels including LOW, MEDIUM and HIGH to meet the patients' needs. The number of physical therapy sessions can also be set as needed. There was also an LCD display for ease of use. It could be concluded that skateboard could properly rehabilitate arm movement at the desired direction and speed. The skateboard could be able to meet the basic needs of the weak arm exercise. Moreover, there was also a display making it easy for users to quickly access information, reducing the duration of patient treatment. It also could excellently reduce the workload of physical therapists.*

Streszczenie.*.W artykule przedstawiono wykorzystanie deskorolki do rehabilitacji pacjentów z niedowładem ręki po wylewie. Odpowiedni układ steruje ruchem kół napędzanych silnikiem prądu stałego. Możliwy jest ruch w dowolnym kierunku i z dowolną prędkością.* ***Wykorzystanie deskorolki z napedem elektrycznym do rehabilitacji pacjentów z niedowładem ręki po wylewie***

Keywords: Stroke, Microcontroller, Arm Movement, Rehabilitation.
Słowa kluczowe: wylew, deskorolka, rehabilitacja.

Introduction

There are currently many stroke patients in Thailand and the number tends to increase every year. It is also ranked as the 4th leading cause of death after cancer, accidents and heart disease, respectively [1]. Therefore, it can be deemed that stroke is a problem with top priority. Most of stroke survivors often end up with disability and impaired mobility, sensory perception and learning [2]. From the study conducted by Tipchatyotin et al [3], it was found that 98 % of patients with stroke would have arm weakness and 73.5% would still have arm weakness after treatment, this results in the patient often using good arm in daily routines and activities resulting in the weak side to not be used causing muscle atrophy and ends up with greater disabilities [4].

Arm of stroke patients with hemiparesis is likely to recover less than the leg [5-6]. The rehabilitation would be the fastest during the first 3-6 months after the stroke. Therefore, treatment and rehabilitation of stroke patients should focus on the restoration of the arm and hand by repeatedly stimulating arousal and practice the functional movement rehabilitation is helping patients who survived to be able to help themselves to have the least disability or to help patient to be able to live and have better quality of life even with disability [7].

Medical rehabilitation equipment is considered an expensive imported product [8]. The cost of production is expensive and complicated to use both in the aspects of the system and program used in practice [8]. From the problem, the researchers have an idea to design and implement a skateboard to restore the arm movement, which controls the movement of the arm in the set and different directions by using microcontroller and the arm movement speed can be adjusted to improve the patient ability. It can be continuously used, stimulus response and continuous arm rehabilitation. The production cost is also low and it is easy to use and easy to install by general people.

Theory and Principle

Moving with DC motor

DC motor is driven by direct currents to control the speed of the motor by supplying the power for a period of times, and the direction of the rotation, which depends on the input voltage to be integrated. The motor rotation direction control requires integrated circuit to help in the control circuit using the H-Bridge with the circuit being as depicted in Fig. 1 [9].

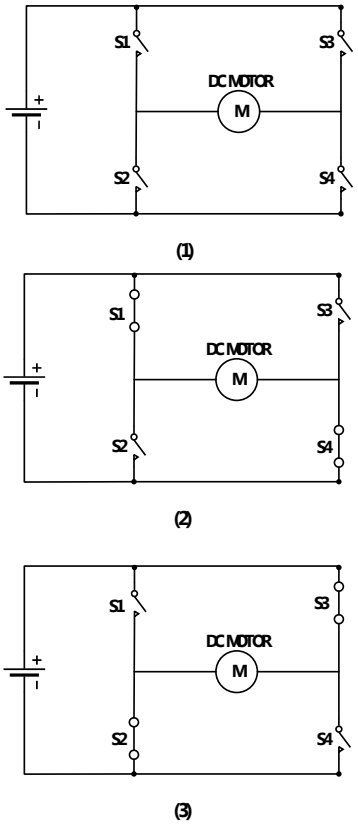

Fig.1. The control of motor rotation

Wheels Driven

Besides the battery and the electric motor, one of the most important components in the robot is the positioning of the robot and the proper weight distribution. The robot uses four motors to drive four wheels forward, back, right, left,

and in the desired direction, which will allow the skater to restore the arm movement is able to rotate in the desired direction. The motor and wheel movement directions are shown in Figure 2 [10].

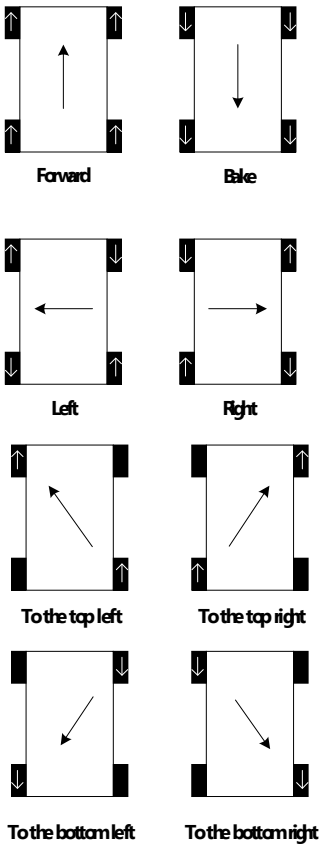

Fig.2. The motor and wheel movement directions

Wheels Driven

Recently, the electronic circuits and electronic systems have been continuously controlled by microcontroller [11-15]. Arduino is a type of an AVR microcontroller. Its uniqueness is being an open source or open systems that can be adjusted or modified by users [16]. Arduino can be easily developed with C language and a converter that can be developed to function on any operating system which has a high working speed. Therefore, it was selected for this research [17].

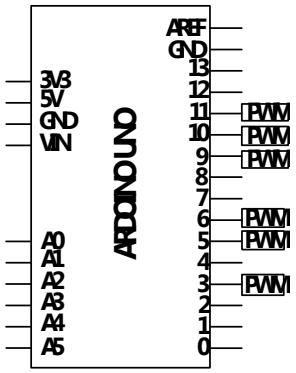

Fig. 3. UNO Arduino microcontroller

L298 N DC motor driver board

An important motor control component is the motor driving board which must be suitable for the selected motor. Inputting data through the Arduino serial monitor window and L298N motor driver board can be applied to the control program through the serial port such as the creation of applications running on the computer and control via the serial port [18].

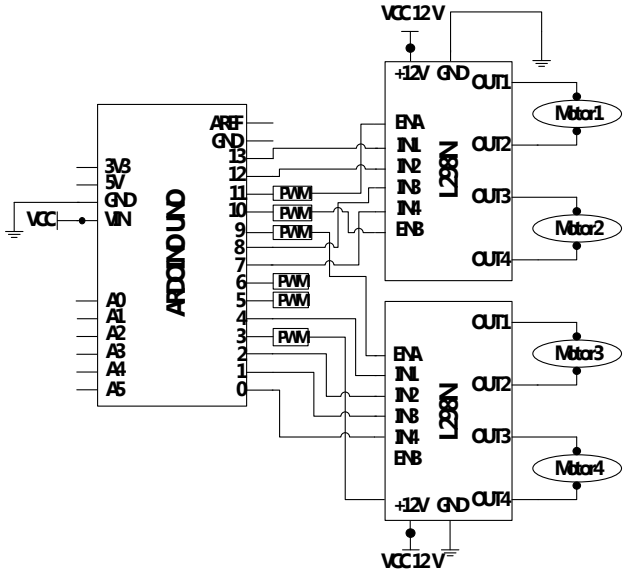

Fig.4. L298N DC Motor Driver Board

The blcok diagram of the prposed skateboard for arm movement rehabilitation is shown in figure 5 wherein the main control circuit design using Arduino UNO microcontroller that has been designed in conjunction with equipments, push button, lock set, displaying screen, and motor control unit by designing analog push button circuit linked to analog ports, at pin A0, A1 sets the display to the stand A4, A5, and control the motor at pin 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, as shown in figure 6.

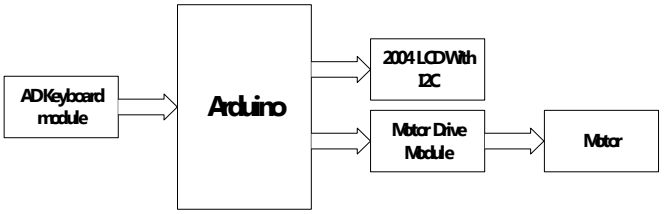

Fig.5. Block diagram of proposed skateboard

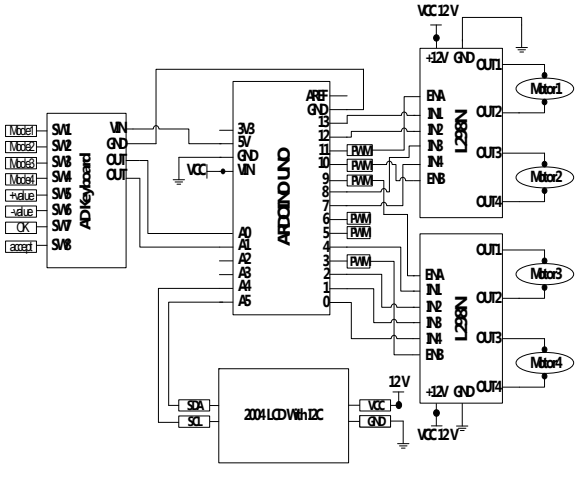

Fig.6. Arduino UNO main microcontroller panel

Simulation Results

The proposed skateboard for arm movement Rehabilitation that has been developed and completed is shown in figure 7, the skateboard structure was made of acrylic as a major contributor to the construction of the base, making the structure of the unit strong and long lasting. The weight is suitable for use. Skateboard is characterized by the ability to move the arm continuously, gradually. There are four modes of operation: Mode 1, left - right, Mode 2, forward - backward, 3 - circle and 4 –number 8-shaped mode (clockwise and counterclockwise). User can adjust the movement speed of the skateboard in 3 levels: low, medium, and high. There is display screens that are easy to use, and the patient can understand more easily.

Fig.7. Skateboard for arm movement rehabilitation

The skateboard to rehabilitate arm movement performance results can be recorded according to the schedule shown in Table 1.

Table 1: Results of skateboard to rehabilitate arm movement performance in mode1(left- right direction)

No.	Left-RightMode		
	LOW 63 round/second	MEDIUM 80 round/second	HIGH 95 round/second
1	05.78	05.86	05.90
2	06.36	06.24	06.32
3	05.84	06.33	06.38
4	06.98	06.45	06.34
5	06.33	06.34	06.46
6	05.79	06.35	06.33
7	06.98	06.53	06.41
8	06.37	06.31	06.43
9	06.43	06.38	06.35
10	06.34	05.85	06.42
Mean	**6.32**	**6.26**	**6.33**

From the tests conducted on the skateboard in 4 modes, 10 times per mode. It was found that the low speed setting was appropriate for patients with very high arm movement. If the speed is set at high, it would work well for patients with less movement in the arm, the patient does not have to move much. The improvement in patient would depend on the consistency of use and the suitability of the patient with the operation mode of the skateboard to rehabilitate arm movement in physical therapy.

Table 2: Evaluation results from 5 physiotherapists

Item	N=5		Level
	$\bar{x}$	SD	
1. Design and Construction	4.36	0.71	Good
2. Technical	4.24	0.66	Good
3. Usability	4.20	0.70	Good
Average total	**4.24**	**0.69**	**Good**

Table 2 and figure 8 show the efficiency evaulation according to the expert review. It is found that the system of efficiency was highest level as the mean score was 4.24 (S.D. = 0.69).

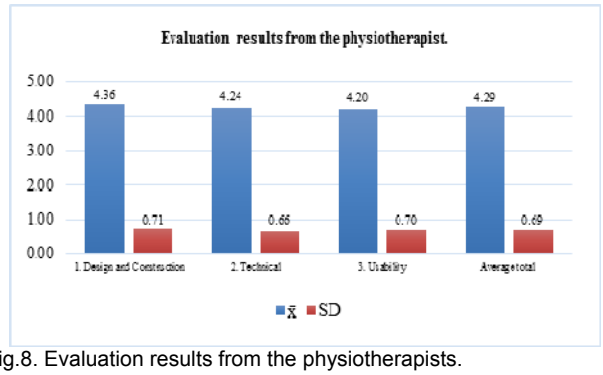

Fig.8. Evaluation results from the physiotherapists.

Conclusion

In this paper, the skateboard to rehabilitate arm movement is implemented. From the tests conducted on the skateboard in all operating modes, it was found that the machine was able to work according to all 4 objectives: mode 1: left-right, mode 2: forward-backward, mode 3: circle mode, and mode 4: figure eight (clockwise and counterclockwise) and the speed can also be adjusted to 3 levels according to the suitability of the patient, able to meet the basic needs of the weak arm exercise. Moreover, there is also a display making it easy for users to quickly access information, reducing the duration of patient treatment. It also excellently reduces the workload of physical therapists. In sum, results from the research showed that skateboard could properly rehabilitate arm movement at the desired direction and speed.

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