Design, build and control the rehabilitation robot to move fingers

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ABSTRACT

This research presents design and development of prototype fabric-based wearable soft exoskeleton. The soft glove assists the flexion and extension motion of the user's hand with adjustable speed. The cable method is used to help bending fingers and for extending the fingers, spring blades have been used, the cables are gathered with the help of the gearbox engine and the fingers return to their normal state by reversing the direction of the engine and the force of the springs. With bandwidth modulation circuit and programming in the microcontroller, the movement and speed of the built robot is controlled. In order to determine the appropriate placement of components, including spring blades and cables, robot simulation was performed in SolidWorks software, and with the help of experimental tests, suitable spring blades were selected in terms of strength and force. The resulted soft glove is attached on human healthy hand for assisting the finger flexion and extension. Based on the test result, the proposed system obtained the highest average for the duration of learning to work with it, which indicates the user-friendliness. the parameter related to the feeling of comfort of the fingers in the glove has the lowest average due to the dense structure of the glove.

KEYWORDS

Stroke, Fingers rehabilitation, Wearable robots, Cable power transmission method

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1. Introduction

Patients can actively participate in rehabilitation training with exoskeleton robots, which have been proven to improve physiological function to a reasonable extent by stimulating the nervous system and are able to provide long-term repetitive, task-oriented therapy sessions[1]. Traditional exoskeletons involve the use of complex rigid systems that impede the natural movement of joints, thereby causing discomfort to the user[2]. Therefore, in order to increase the functionality of robot, the proposed structures move towards fabric structures to adapt more to the hand and we have tried to avoid using complex equipment as much as possible. Among the innovations of the research, we can mention the simple and low-parameter control algorithm and adjusting the speed of the fingers with the help of the bandwidth modulation circuit, for this purpose, two mechanical limit switches including metal chassis and spring blades and electric micro switches placed on the motor pulley are used. Other features of the design include manual and automatic modes, which provide the ability to adjust the opening and closing of the fingers.

2. Methodology

. Designed model will be selected first in two-dimensional form in Solidworks as shown in "figure 1" and then with the help of dynamometer, suitable dimensions of spring blades according to "Table 1"which were founded after experimental tests. In this robot, the actuator is connected to the head of the spring blades that match on the joints of four fingers using a cable, and the overall movement of the finger is done by this mechanism, which pulls the cables and the fingers together, and with the rotation of the motor in the opposite direction, the fingers extend and it takes place with the help of spring blades.

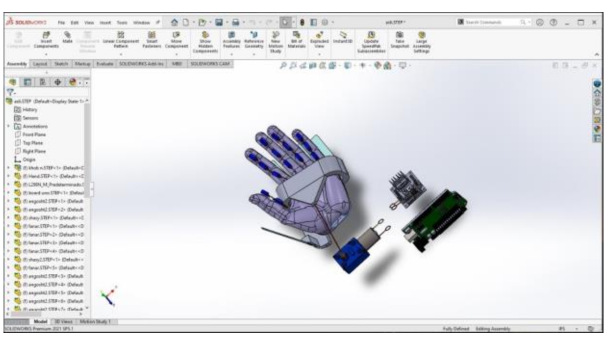

Figure 1. Final design in solidworks

Table 1. Selected blades for each finger

Size of blade for finger	Middle finger	Index and ring finger	Little finger
Length (mm)	125	105	85
Width (mm)	11	15	15

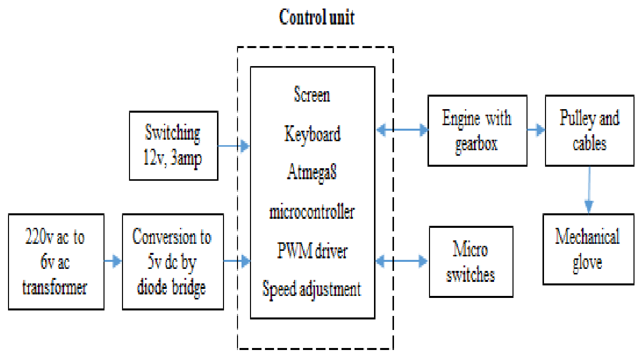

Figure 2. Block diagram of mechanical glove system for finger rehabilitation

According to the block diagram in "Figure 2", the way to set up the system is that after connecting to the city electricity, a 220V AC to 6V AC transformer was used to convert alternating current to direct current, and a diode bridge was used for Voltage conversion to 5v dc, which is the voltage required to start the microcontroller, keyboard and screen.12V voltage conversion was done for the gearbox motor. Determining the opening and closing limit of the fingers was done experimentally and the location of the limit switches was determined. The movement of the fingers is such that with the rotation of the pulley in the clockwise direction and with the help of the return of the spring blades to the original position, the fingers extend and with the movement of the motor in the direction Anticlockwise, the corresponding cables are stretched and the fingers are bent. You can communicate with the control unit with the help of the speed adjustment screw and the keys on the keyboard.

3. Discussion and Results

to evaluate the desired parameters in this experiment which are the ease of using the rehabilitation system, the reliability of the rehabilitation system, the interaction of people with the rehabilitation system and the overall evaluation of the rehabilitation system, the use of a scoring form was considered for the statements presented and 3 questions related to the evaluation of the desired parameters and 1 question related to the overall evaluation of the device were assigned. Also, the way of scoring the questions is by assigning an integer in the range of 1 to 5, where 1 means completely disagree and 5 means completely agree with the statement. This evaluation was tested on 10 people with healthy fingers, the results of which are shown using a bar graph in "Figure 3".

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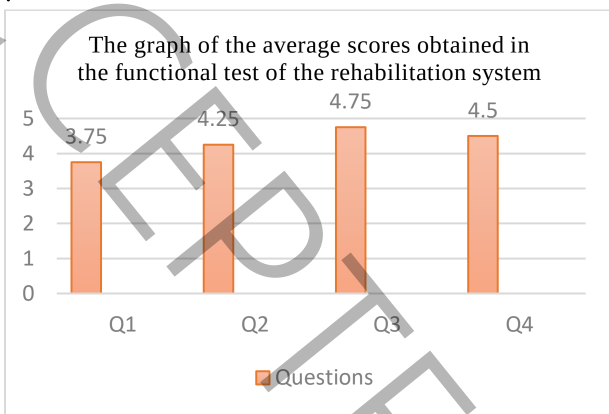

Figure 3. Average score of each question

3.1. Evaluating the impact of engine speed changes during movement

If the speed is at its lowest value, due to the force of the springs, the motor does not have enough power to close the hand and the fingers do not fully bend, so the speed adjustment screw must be set at a certain value between high and low speed to have enough power to bend the fingers. But when the fingers open, the springs add to the power of the engine and even at low speed, the hand opens quickly. It is better not to set the speed adjustment screw to the highest value in order to avoid damage to the micro switches and rapid stretching of the fingers. Figure 4 shows the final structure of the finger rehabilitation system prototype.

Figure 4. The final structure of the mechanical glove

4. Conclusion

A robot with a soft structure was designed that can move all four fingers of the patient (except the thumb) with the help of a motor with a gearbox and a path for the tendons. The tendon mechanism is one of the best choices in terms of price, good appearance and portability. For the commercialization and construction costs of desired project, we can point out the placement of the engine next to other parts in a structure called the control box and the use of a touch screen and completing the appearance of the system with the purpose of commercialization and the use of a rechargeable battery power source.

References

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