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Rehabilitation Robot for Carpal Tunnel Syndrome Patients

> “Pregnant women, people employed in the tea and cinnamon industries, in the hospitality sector where chefs engage in repetitive cutting tasks, musicians who play and practice musical instruments for extended periods, and employees in the IT sector where repetitive finger movements are used, are all prone to be diagnosed with this ailment.”

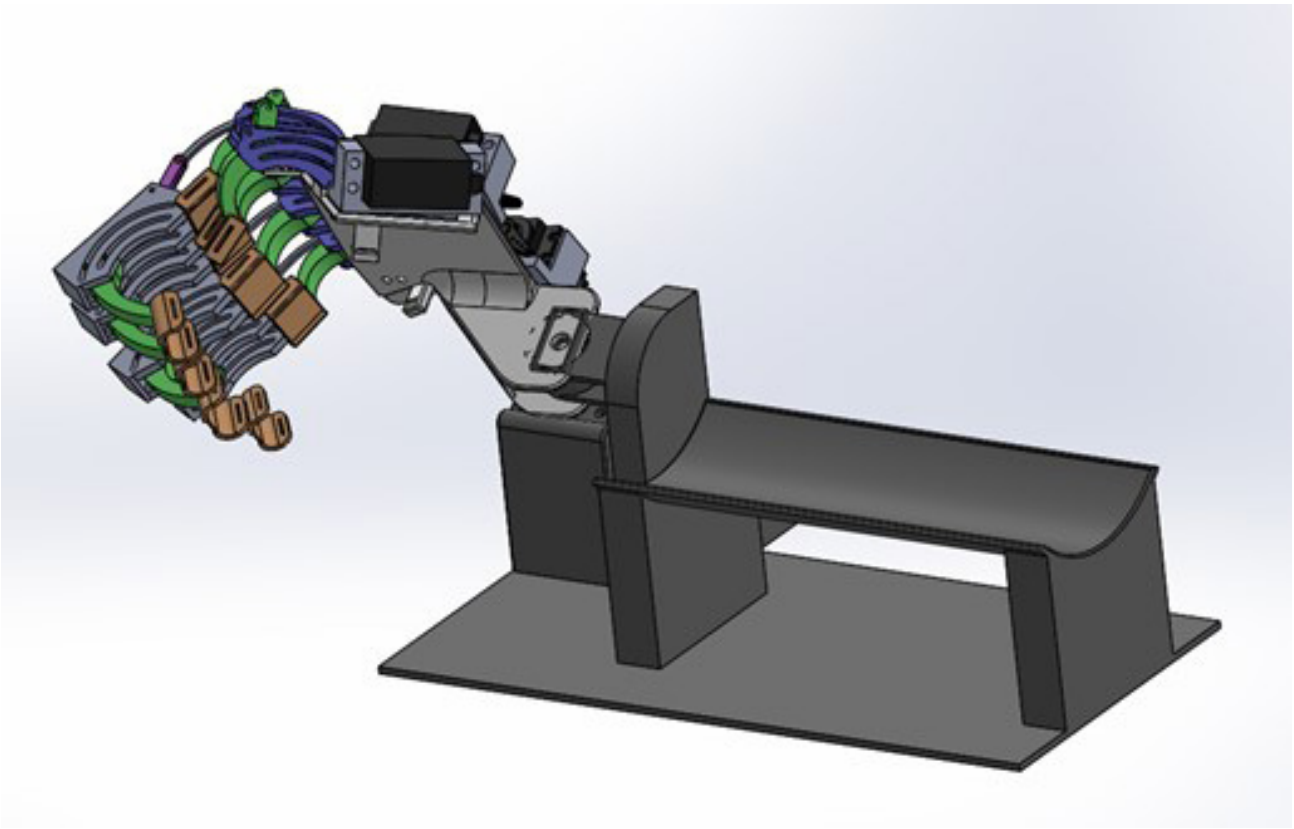
Carpal Tunnel Syndrome (CTS) represents a prevalent neurological condition frequently encountered among individuals engaged in repetitive hand movements, particularly those involving the wrist and fingers. Pregnant women, people employed in the tea and cinnamon industries, in the hospitality sector where chefs engage in repetitive cutting tasks, musicians who play and practice musical instruments for extended periods, and employees in the IT sector where repetitive finger movements are used, are all prone to be diagnosed with this ailment.

The carpal tunnel is the passage made of carpal bones and the roof is formed by the transverse carpal ligament and guides the tendons and the median nerve through the wrist to the palm and the fingers. CTS is caused by the compression of the median nerve at the wrist. This median nerve is one of the three major nerves that enable the movements of the hand. Symptoms of CTS include paraesthesia, numbness, burning sensation, pain, and restricted hand movements. The wrist, thumb, index finger, middle finger, and half of the ring finger are affected by CTS. CTS can be cured through nerve-guiding exercises at the early stages of diagnosis. Otherwise, surgical treatment must be performed, and rehabilitation exercises must be performed afterwards to regain the mobility of the person's wrist and/or fingers.

In order to perform therapeutic exercises, several types of upper limb and hand rehabilitation robots have been introduced in the literature. However, these available devices have several limitations such as the inability to support the full range of motion and detect/ record the progress of the rehabilitation.

The research was conducted by a group of final-year students in the Department of Mechanical Engineering at the University of Moratuwa, focusing on an innovative finger and rehabilitation robot for CTS (Carpal Tunnel Syndrome) patients. The proposed robot has been designed to be used in both domestic and clinical environments. It is supposed to be used in a stationary position and is capable of performing several rehabilitation exercises for the wrist and the fingers which are pre-defined according to patterns which are performed at the early stages of diagnosis where it can be cured through rehabilitation exercises and for the exercises performed for regaining the mobility after surgical treatments for more severe cases.

The sensors detect the patient's range of motion and display the data for the therapist, who can then determine the appropriate exercises. Finger exercises include flexion-extension, mimicking grasping patterns, while wrist exercises include flexion-extension and hyperextension. The rehabilitation program consists of three stages and several iterations, progressing according to the patient's



recovery, which can be observed through the data collected from the sensors. A GUI was designed to control the robot and communicate with the therapist.

The robot utilizes an under-actuation method and has 6 degrees of freedom that drive proximal interphalangeal, and distal interphalangeal joints of the four fingers using two servo motors. The thumb is actuated using a separate servo motor. A stepper motor actuates wrist movement. Most parts of the unit were manufactured using 3D printing technology with polylactic acid (PLA+) filament, while some critical parts were made from mild steel sheets. A mathematical model was developed to simulate the movements of the linkage system. The effectiveness of the robot has been verified through simulations and experiments. The range of motion of the finger and wrist rehabilitation units were tested and compared with the range of motion of natural hand.

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