2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Design and Analysis of a Finger Rehabilitation Exoskeleton

Maryam Norouzi, Morad Karimpour, and Mohammad Mahjoob

Abstract— **Considering movement characteristics of human finger, a novel mechanism for rehabilitation of a hand finger was developed. The kinematics of exoskeleton was analyzed in SolidWorks and validated using SimMechanics. The results showed that the exoskeleton functions properly and provides good kinematic compatibility with the movement of the finger.**

I. Introduction

Stroke is one of the main causes of significant hand disabilities [1]. The rehabilitation exoskeletons are designed to help patients recover their hand functions. However, the main design challenges are their wear time, geometric features, affordability, and acceptable bulk/weight [2].

In this study, a novel lightweight, compact, affordable, and easy-to-use mechanism for a finger rehabilitation exoskeleton is designed that fits various hand sizes. The novelty of this structure is its power transmission mechanism. Also, for the first time in this mechanism, miniature motors with helical shafts were used. Two mentioned features made the structure less complex and made the device lighter and smaller than traditional devices. First, according to the anatomy of the finger, the number of mechanism's links and their dimensions/ geometry were modeled in SolidWorks software such that they could generate the full range of motion (ROM) and do not interfere with the finger. Then, the desired path for finger extension exercise was defined, and the mechanism's motion was analyzed in SolidWorks and SimMechanics. The results were promising, and the design met the requirements.

II. Mechanism Design

The main point in the design of the mechanism was its capability in following the natural movements of human finger without harming the finger and interference with it during rehab exercise. The final device is a three-link mechanism with two curved links and a small fingertip holder. The exoskeleton final design and dimensions are shown in Figure **1**. Two tiny parts are attached at the beginning and the end of the first link, and a nut where the motor's shaft pass through is driven to each of them to convert the rotary motion of the motor to linear motion. In this mechanism, linear force is applied to each link by a ZGA12 gearbox-motor with a helical shaft at the motor shaft's coincidence point to the idler nut.

Maryam Norouzi is with the Mechanical Engineering Department, Univ. of Tehran, Tehran, Iran, (e-mail: norouzi.maryam@alumani.ut.ac.ir).

Morad Karimpour is with the Mechanical Engineering Department, University of Tehran, Tehran, Iran, (e-mail: m.karimpour@ut.ac.ir).

Mohammad Mahjoob is with the School of Engineering, Science and Technology, CCSU, New Britain, CT, USA, and Center for Advance Orthopedic Studies, BIDMC, HMS, Harvard University, Boston, USA (corresponding author; e-mail: mmahjoob@ccsu.edu).

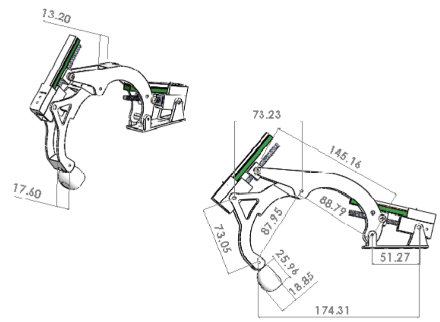

Figure 1. The proposed mechanism and its dimensions

III. Simulation and Results

The mechanism was simulated in SolidWorks and SimMechanics by applying a 5N linear force. The simulation results in both software showed that the mechanism could cover the finger workspace and follow the defined path with an accuracy of 3 degrees without any interference with the finger. The results of the simulation in SimMechanics are shown in Figure 2.

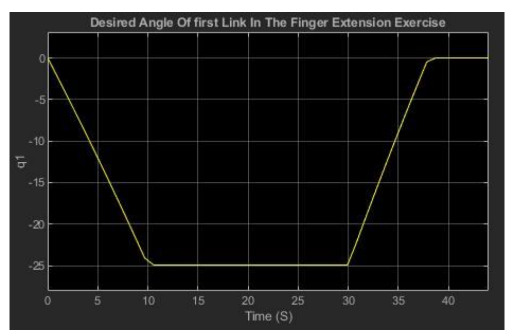

Figure 2. Simulation results in SimMechanics software

IV. Discussion & Conclusion

The proposed mechanism for finger hand rehabilitation exoskeleton is simpler, lighter, and smaller than traditional rehab devices. It is capable of actuating a finger safely in its workspace. The motion analysis of the device showed an acceptable performance for the newly designed mechanism.

References

[1] Wang, L., Peng, G., Yao, W., Biggar, S., Hu, C., Yin, X., & Fan, Y. (2020). Soft robotics for hand rehabilitation. *Intelligent Biomechatronics in Neurorehabilitation*, 167-176.

[2] du Plessis, T., Djouani, K., & Oosthuizen, C. (2021). A Review of Active Hand Exoskeletons for Rehabilitation and Assistance. Robotics 2021, 10, 40.