UNIVERSITI TEKNOLOGI MARA

THE DEVELOPMENT OF FINGER REHABILITATION DEVICE FOR EARLY STAGE PARALYZED STROKE SURVIVOR

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Mechanical Engineering

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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 1st October 2015 to conduct the final examination of Abdul Hakim bin Ab Rahim on his Masters of Science thesis entitled "The Development of finger rehabilitation device for early stage paralyzed stroke survivor" in accordance with Universiti Teknologi MARA act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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ABSTRACT

Functional recovery of upper limb after stroke is crucial to restore the ability to perform activities of daily living (ADL). This thesis presents a robotic rehabilitation approach based on repetitive passive exercise aimed to help early stage stroke survivors exercise their finger doing extension and flexion at the comfort of their home. This exercise for the finger's muscle is crucial in order to delay if not prevent it from suffering spasticity and contracture which can cause pain to the patient. This research was to obtain the configuration of a finger for kinematic analysis, to design an optimized finger exoskeleton module to assist finger movement, and to evaluate shape memory alloy (SMA) to be used as device actuator. Mathematical simulations of a two compound pendulum which represent simplified model of a finger were done based on Lagrangian equations, controlled using proportional-derivative (PD) feedback controller providing necessary torque to direct the links to mimic actual finger trajectory from flexed to extended position. The maximum value of torque recorded was at at 0.0030Nm for proximal and 0.0027Nm for distal. A new finger rehabilitation mechanical module was designed with the concept of exoskeleton for optimal style of finger handling and ease of use. It focuses on moving two main phalanges of the finger, proximal and medial phalange. The device, Cable Actuated finger Exoskeleton (CAFEx) deploys *Shape Memory Alloy* (SMA) wire as an under-actuation approach to deliver the needed 2-DOF movement. The advantages and challenges of using SMA wires rather than conventional actuators are discussed. However, a prototype of another similar finger rehabilitation device, HANDEXOS was fabricated using PLA material and used to validate the actuator working principle. Analysis shows 0.31mm minimum diameter of SMA wire need to be used to supply a 12N force to move the prototype Tests conducted on the wires suggest that it must have sufficient weight and must be stretching at high temperature rather than room temperature in order to have an optimum range of recovery. However, attempts of recording the wire temperature in real time have not succeeded which constrained a deeper understanding of the wire behavior. The prototype and actuation were successful in proving the concept of giving assistance to extend the finger from flexed position. Further optimization of the design and actuation can bring the CAFEx at a competitive level and ready to be tested on a human subject with the approval of ethics committee.

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