Anthropomorphic Testbed Hand To Test Orthotic Hand Devices

Melany Azocar [1]; Lokesh Saharan [2]

[1] *Undergraduate in Mechanical Engineering UTPB*, [2] *Assistant Professor of Mechanical Engineering*

THE UNIVERSITY OF TEXAS PERMIAN BASIN
COLLEGE OF ENGINEERING

Abstract

A study and design of an Anthropomorphic Testbed Hand were produced to understand the physical properties, range of motion, degrees of freedom, and generated force capacity of the human hand to be focused on the analysis of the sensorial problems and adaptability of an orthotic hand to the comfortability of the user.

Introduction

To first understand the malleability of an orthotic device during the testing studies, it is crucial to investigate the functions needed to achieve the comfort of individual users. The anthropomorphic testbed hand is focused on simulating the human kinematics and applied forces found in every day's variety of task. The human hand is connected to the wrist through the palm and is endowed with four DOF on all the fingers, five non-intersecting DOF on the thumb and six DOF on the wrist actuated by about forty muscles; in order to achieve likeness to the human hand, there should be a focus on the phalanges specific bone structure and design. When fabricating an orthosis is important to recognize the factors presented upon the trial of an orthotic device like regional pressure, weightbearing, pronation and supination, and even skin irritability.

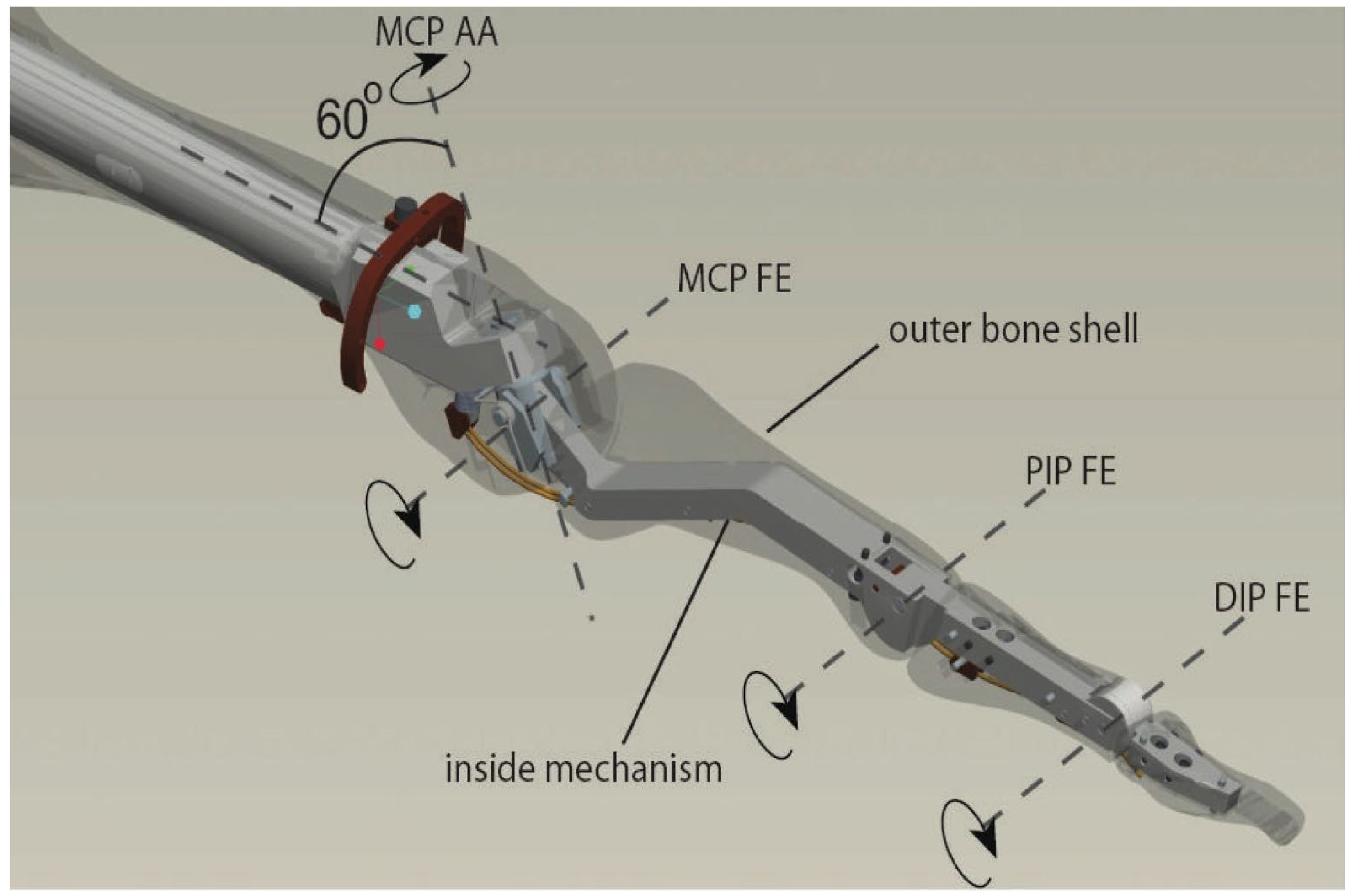

Figure 1. ACT hand inner and outer structure.

Methods and Materials

For this study, the approach began with identifying the exact measurements of the phalanges and metacarpals of the left hand, taking into consideration the phalanges length from the Metacarpophalangeal (MCP) to the Proximal joint (PIP) and the Distal Phalangeal Joint (DIP), and the breadth, and depth of the hand, wrist, and fingers. In addition to the measurements involved on the development of the ACT hand, the finger joints corroborate on the recognition of the allocation of different degrees of freedom, ranges of motion, and axis of rotation for each individual finger. as shown in Figure 1, one DOF of the index finger achieve abduction-adduction motion, with its joint axis oriented at 60 degrees [1]. Throughout the modeling of the design, Solidworks was used for the visualization and interpretation of the measurements of the hand.

Results

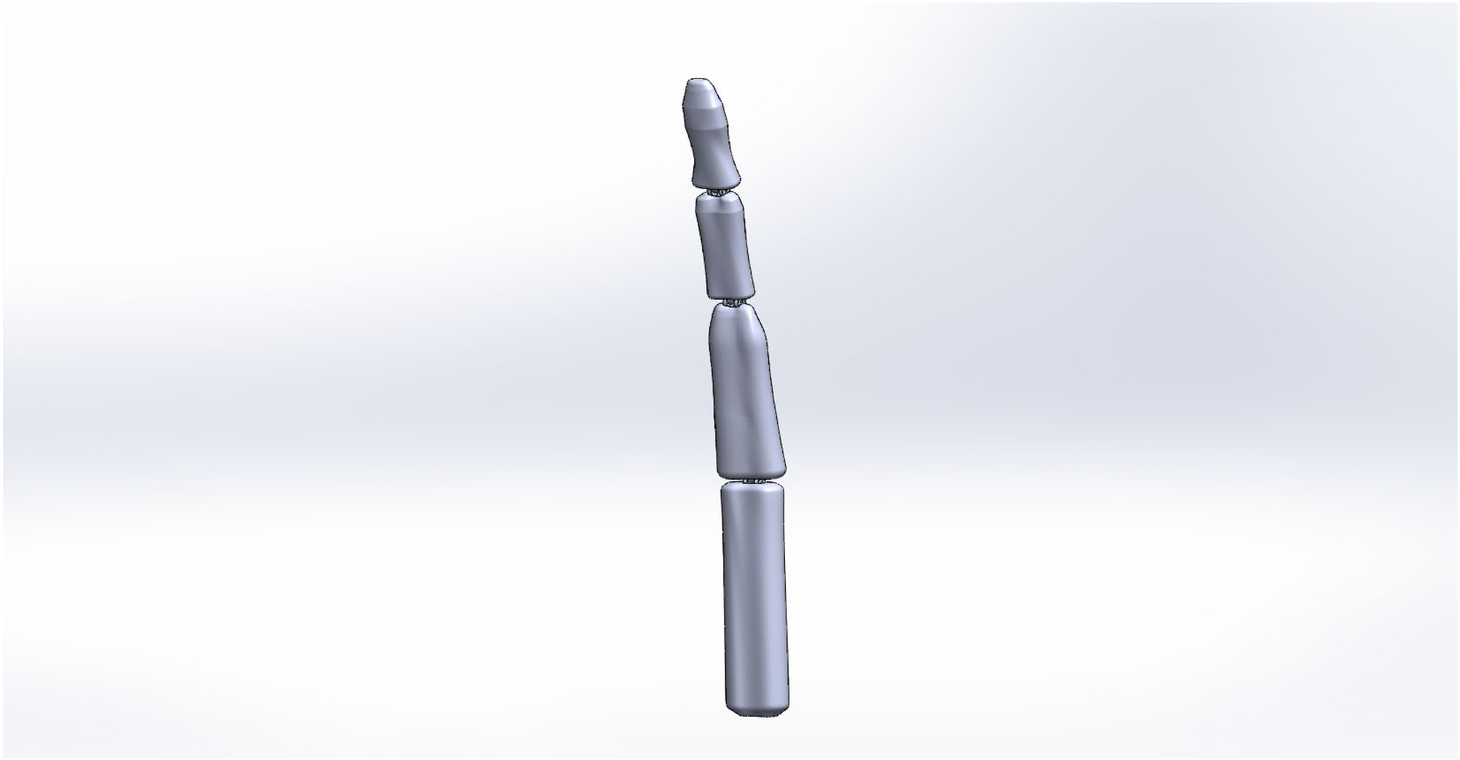

Figure 2. Index finger, skeletal structure.

Figure 3. Left hand, skeletal structure.

Discussion

While the design and literature review of the ACT hand was explored, another important factor taken into consideration is the joint range of motion and its limitations regarding specific finger of the hand, as seen in Table 1, and the wrist position affecting the finger joint properties. As an orthotic device can be used to mobilize a tissue, immobilize a structure, or a restriction of joint motion, the reviewed information and data brings into recognition the possibility of the reduction of problems and discomfited factors attributed in some orthotic devices for the modification and adaptability to the user.

Table 1. Finger Joint Motion Limits.

ACT HAND FINGER JOINT MOTION LIMITS

Finger	*Joint*	*Minimum*	*Maximum*
Index	MCP	30° extension	90° flexion
		35° abduction	35° adduction
	PIP	0° extension	110° flexion
	DIP	0° extension	70° flexion
Middle	MCP	30° extension	90° flexion
		35° abduction	35° adduction
	PIP	0° extension	110° flexion
	DIP	0° extension	70° flexion
Thumb	CMC	40° extension	40° flexion
		40° abduction	40° adduction
	MCP	60° extension	60° flexion
		15° abduction	15° adduction
	IP	20° extension	80° flexion

Conclusions

This study explores the analysis of the dynamic interactions occurring in the human hand to be mimicked into an Anthropomorphic Testbed Hand for the study and testing of orthosis devices. As orthotic devices encounter some difficulties for the user's perfect wear and commodity, it is crucial to understand the surface anatomy and inner functionality of the human hand like the degrees of freedom and joint motions presented in each individualized finger in order to generate a detailed recognition of the incommodities found in orthotic devices.

References

1. A. D. Deshpande et al., "Mechanisms of the Anatomically Correct Testbed Hand," in IEEE/ASME Transactions on Mechatronics, vol. 18, no. 1, pp. 238-250, Feb. 2013, doi: 10.1109/TMECH.2011.2166801.
2. Vergara, M, Agost, MJ, Gracia-Ibáñez, V. Dorsal and palmar aspect dimensions of hand anthropometry for designing hand tools and protections. Hum Factors Man. 2018; 28: 17– 28.
3. Xiong, Cai-Hua & Chen, Wenrui & Sun, Bai-Yang & Liu, Mingjin & Yue, Shigang & Chen, Wenbin. (2016). Design and Implementation of an Anthropomorphic Hand for Replicating Human Grasping Functions. IEEE Transactions on Robotics. 32. 652-671. 10.1109/TRO.2016.2558193.