LOW-COST 3D PRINTED PROSTHETIC HAND

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1. Introduction

While bionic hands are becoming increasingly advanced with added functionalities and dexterity, its high cost serves as a deterrent for people with upper limb deficiencies in developing countries that require it. 3D printed hands are thus an available alternative, though current models are simplistic and lacking in proficiency. This paper describes a 3D printed, sensor-based prosthetic hand, targeted to be low-cost, yet efficient in ease of use and maintenance. Through the use of a microcontroller and electromyography (EMG) sensor to control a pneumatic system, the hand is able to perform basic gripping motions, without unnecessary movement from the user. Unlike current models on the market, which utilise rigid materials for printing, the model uses a semi-rigid, flexible one to maintain a uniform grip pattern that enables the hand to grip objects of any shape and size. As an additional feature, the model also includes printed conductive matrixes on the fingertips that send sensory information to generate feedback to the user, allowing a more acute perception and gauge of the operation of the hand.

2. Research Methods

To fulfil the objective of creating a 3D-printed prosthetic hand device driven by an EMG-controlled pneumatic system, consisting of EMG-controlled pneumatic fingers and thumb, socket, and a conductive feedback matrix, a 3-step process was carried out. First, drafting the design of the prostheses required modelling and prototyping. Through the use of CAD software such as SolidWorks and Autodesk, 3D models were constructed and sent for printing using the Fused Deposition Modelling (FDM) method with ABS and NylonFlex materials. After printing, the models were analysed and re-designed or reprinted using different methods to attain satisfactory results. Thereafter, coding simulation was done to analyse the quality of the models printed. Simulation programmes were written to compute the exact Volumetric Efficiency (VE) [1] and Cascading VE. Lastly, as the system uses signals from the EMG sensor to activate the microcontroller, data obtained was analysed to draw out the characteristic frequencies that are specific to certain hand motions. In order to filter out unnecessary data from sensitivity of the sensors, Fast-Fourier Transform (FFT) was used, upon which it was determined that for testing, training data would be obtained from the default motion of a hook grip. Running the data through Gaussian Filter removed more of the noise and smoothened the graph, allowing the code to read the signals better and translate it into one smooth output in the form of an action.

3. Results

Final design of the prototype (Fig. 1) is made up of 4 pneumatically controlled fingers (Fig. 2), a thumb operated by a servo-hinge mechanism (Fig. 3 & 4) and a conductive feedback matrix.

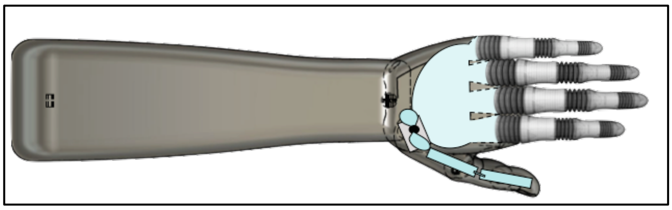


Fig 1. Render of assembled fingers, thumb and palm

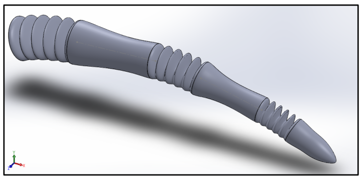
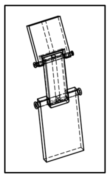


Fig 2. Prototype 3 – Finger with Grooved Segments



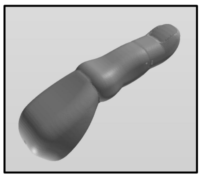


Fig 3. Hinge Mechanism; Fig 4. Render of Thumb

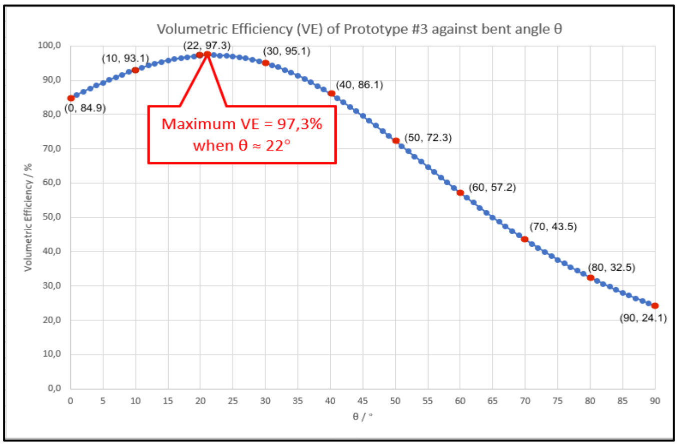


Fig 4. Graph of VE(%) against bent angle (°)

System is most efficient when the angle bent is relatively small as maximum VE reaches 97.3%. *(Fig. 4)* As for Cascading VE, the objective is to get η close to 100% so that different joints can be bent by similar degrees. The closer it is to 100%, the better the fingers would perform as a cascading pneumatic system.

4. Conclusion

Based on estimations of materials used, cost of the entire device should not go beyond $750 USD, which is cheaper than most alternatives in the market, which average to about $15,000 USD. Also, as cosmetics, functionality and ease of maintenance were factored into the design, it is likely to have user acceptance. Using an EMG-controlled, pneumatic system to control a prosthetic device is possible and has potential.

5. References

[1] SMC Pneumatics, Inc. (1997). A Manual for Fluid Power Components and Practical Applications. *Basic Pneumatics*, 25. Retrieved from http://www.smcpneumatics.com/pdfs/smc/basic_pneumatics.pdf