Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

DEVELOPMENT OF A LOW-COST LIGHTWEIGHT EMG-CONTROLLED TRANSRADIAL PROSTHESIS

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ABSTRACT

The need for prosthetic devices has increased considerably over the years. Individuals who suffer from upper limb amputation lose the ability to perform tasks such as grasping in their daily life. Furthermore, the World Health Organization estimated in 2017 that between 85% and 95% of people who require the use of an orthopedic support device such as prosthesis or orthosis do not have access to them mainly because of the cost of commercial prostheses. For this reason, the present research work proposes the design and fabrication of a low-cost myoelectric transradial prosthesis. For the design of the prosthetic hand, a dataset with anthropometric measurements of the hand of Latin American individuals was obtained. The use of 3D printing was proposed to reduce its costs and implement hybrid manufacturing with rigid (PLA) and soft (TPU) materials. The myoelectric prosthesis has three degrees of freedom under DC micromotor actuation that can be controlled with the integration of two surface electromyogram (EMG) sensors located in the socket. The transmission mechanism system of the prosthetic hand is made of pulleys and ropes actuated by the motors in response to an impulse received by EMG signals. The designed prosthetic hand has measurements very close to the 50th percentile of the measurements of Latin American men and women. The thumb and index finger had independent movement, while the third motor powered the remaining fingers. The proposed control system used the processed EMG signals as the trigger followed by a PID controller with position feedback obtained from the motor's encoder. The proposed system has a low computational complexity that was programed on an Arduino nano. The prosthetic hand weight was 255 g, which is less than the 500 g recommended in the literature. Also, the total weight of the transradial prosthesis (including the socket) was 716 g, which is less than the 788.5 g and 1285.5 g of the average weight of the hand and mid-forearm in women and men respectively. The final cost of implementation was less than US$450, which is nearly 22 times less than the commercial prCosthesis price. In addition, the developed low-cost myoelectric transradial prosthesis performed different grasping tests to successfully demonstrate the functionality of the prototype in handling objects of various sizes and weights. This work presented an affordable functional upper limb prosthetic device that is within the average hand anthropometric dimensions of Latin Americans.