

A NOVEL DESIGN OF A SINGLE ACTUATOR DIFFERENTIAL MECHANISM TO CONTROL A PROSTHETIC HAND

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ABSTRACT

Most of the commercial prosthetic hands use five to six actuators to control all the fingers of the hand. The high number of actuators increase the weight and the cost of these prosthetic hands. Therefore, by reducing the number of actuators, the weight and the cost of the prosthetic hand will reduce significantly. This research proposes a novel design of a differential mechanism that is controlled by a single actuator to generate the differential motion of the five fingers. The proposed differential mechanism and the prosthetic hand were designed and simulated using SolidWorks®. A motion analysis study was performed to understand angular displacement of the DC motor with respect to the fingers using the proposed differential mechanism prior to fabricating all the components of the prototype using additive manufacturing. It was found that the DC motor needed to rotate an angle of 264.7 degrees to actuate all the fingers causing them to touch the palm. Current prototype includes a DC motor, gears, pulleys, differential mechanism drive, motor controller, and a microcontroller to successfully actuate all five fingers of the proposed hand. The overall weight of the proposed hand is 250 grams that is almost half the weight of the current prosthetic hands in market. The prototype testing shows that the hand was successfully able to grab a cutter, an electric tape, and a wrench using a potentiometer that controls DC gear motor for opening and closing of the fingers.

Keywords: Prosthetics, differential-drive, SolidWorks, microcontroller, robotics

INTRODUCTION

The last two decades have seen great advancements in additive manufacturing and the robotics technology. 3D printing has been widely used in the design of prosthetics, as it is an affordable option to many amputees worldwide. Currently, there are 2.6 million people with amputation in the United States [1]. Around 150,000 people of those amputees are registered with hand amputation [1]. Some of the reasons that cause the hand to be amputated include severe hand injuries such as severe hand burns, injury caused from accidents. Other reasons include diabetes, bone cancer, rhabdomyosarcoma, osteomyelitis, etc. Some of the commercial prosthetic hands such, as Bebionic, iLimb and Vincent Hand are available in the market to help hand amputees restore some of the functionalities of their lost hand [2]. However, these prosthetic hands are still expensive (ranging from $10K - $20K) and many hand amputees cannot afford them. One reason that contribute to the expensiveness of these prosthetic hands is the high number of actuators they are using. Many of them use five to six actuators to control all five fingers [3]. The cost and weight of the prosthetic hand can be decreased by using a single actuator and a differential mechanism assembly, which will help amputees to afford it and potentially use it for their activities of daily living. Previous research has led to the development of several differential mechanism designs used in controlling under actuated robotic devices. Some of these differential mechanisms are based on compliant structures [4], lever-based linkages [5], differential pulleys [6], and a continuum bar-based mechanism [7]. This project proposes an innovative single actuator low-cost 3D printed prosthetic hand that uses a pulley based differential-mechanism to actuate all fingers.