3D printed robot hand structure using four-bar linkage mechanism for prosthetic application

ABSTRACT

Trans-radial prosthesis is a wearable device that intends to help amputees under the elbow to replace the function of the missing anatomical segment that resembles an actual human hand. However, there are some challenging aspects faced mainly on the robot hand structural design itself. Improvements are needed as this is closely related to structure efficiency. This paper proposes a robot hand structure with improved features (four-bar linkage mechanism) to overcome the deficiency of using the cable-driven actuated mechanism that leads to less structure durability and inaccurate motion range. Our proposed robot hand structure also took into account the existing design problems such as bulky structure, unindividual actuated finger, incomplete fingers and a lack of finger joints compared to the actual finger in its design. This paper presents the improvements achieved by applying the proposed design such as the use of a four-bar linkage mechanism instead of using the cable-driven mechanism, the size of an average human hand, five-fingers with completed joints where each finger is moved by motor individually, joint protection using a mechanical stopper, detachable finger structure from the palm frame, a structure that has sufficient durability for everyday use and an easy to fabricate structure using 3D printing technology. The four-bar linkage mechanism is the use of the solid linkage that connects the actuator with the structure to allow the structure to move. The durability was investigated using static analysis simulation. The structural details and simulation results were validated through motion capture analysis and load test. The motion analyses towards the 3D printed robot structure show 70–98% similar motion range capability to the designed structure in the CAD software, and it can withstand up to 1.6 kg load in the simulation and the real test. The improved robot hand structure with optimum durability for prosthetic uses was successfully developed.

Keyword: 3D printed; Four-bar linkage mechanism; Prosthetic hand; Robot hand structure; Static analysis; Motion capture analysis