A Novel Robust and Low-Cost Anthropomorphic Myoprosthesis: Utilizing an Articulated Soft Robotic System and Convolution Kernel Compensation-Based Non-Invasive EMG Decoding for Bionic Restoration of Upper Limb Function to Amputees

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The myoprosthesis developed in this research is a novel prototype to enable complete biomimetic performance in a bionic hand, accurately implementing gesture extraction and a soft polyarticulated robotic design for joint and muscle biomechanical mimicry. There are over 3mm people worldwide living without an upper limb. Current prostheses often require implants or open brain surgery, cost above $15,000, and have no biofeedback. Many are made of rigid materials and lack accurate gesture recognition (error <4.25%) to replicate human hand synergies in grasping and manipulation tasks. A 2022 meta-analysis revealed that these issues result in a high (~40%) abandonment rate of upper-limb prostheses. This project presents the only bionic limb prototype to successfully integrate: haptic pressure feedback in all fingers, 97% accurate live-time EMG decoding via gradient convolution kernel compensation algorithm, a compliant five-finger end effector with four joints per finger, wrist and elbow flexion/extension, and a 3D-printed design optimized for daily living activities. It uses low-cost devices, including an Arduino, custom printed circuit boards, several haptic/spatial sensors, and servomotors to achieve dextrous movements and costs $379.89 to build. Results indicate that this prosthesis replicated 0.90 ± 0.83 of the range of motion in the human arm anatomy at a production cost 94.74% lower than the myoelectric prosthetic arms currently on the market. After ten trials with (n=12) transradial and transhumeral amputees, the prosthesis restored 74.312% of hand function on average. When paired with a closed-loop control exoskeleton, the prosthesis can be teleoperated, facilitating other biomedical applications, such as robotic surgery.

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