4D Printing of Gripper Using Optimized Liquid Crystal Elastomer Actuators for Prosthetic Manufacturing

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With 35–40 million people worldwide requiring prosthetic or orthotic services, only 1 in 10 receive the care they need, primarily due to high costs. Soft robotics has emerged as a promising alternative to rigid systems by utilizing flexible, elastic materials for enhanced adaptability and control. This project introduces a novel prosthetic manufacturing method using optimized Liquid Crystal Elastomer (LCE) and 4D printing technique to create a heat-activated, AI-enhanced soft robotic gripper. LCEs offer fast response times, strong activation force, and large reversible deformation. An LCE actuator was fabricated mainly using RM257 and RM82 monomers, enabling precise control over response time and flexibility—leveraging the fast actuation of RM257 with heat and the soft, adaptable nature of RM82. The LCE is the ink for 3D printing the soft actuators. An LCE-nanomaterial composite was developed, reducing the response time from seconds to nearly instantaneous. The gripper integrates a flexible heater for remote activation housed in a 3D-printed thermoplastic support structure. Ongoing experiments explore electroplating methods to optimize performance. Flex sensors were mounted on the back of each finger and connected to a microcontroller, enabling real-time feedback on movements. A machine learning-based object recognition system allows the prosthetic to identify objects based on shape and size for precise handling. This method can reduce prosthetic costs by over 85% while enabling easy replication and patient-specific customization. This study demonstrates that LCE-based actuators, combined with AI-driven recognition, offer a transformative solution—paving the way toward affordable, high-performance prosthetics that can meet the needs of millions.

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