The Development of an Emotion-Responsive Interactive Installation Using Ultrasonic Sensing and Microcontroller-Based Physical Computing

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Abstract

This research presents the design and development of an emotion-responsive interactive installation prototype aimed at promoting emotional well-being through immersive human technology interaction. Inspired by the symbolic metamorphosis of butterflies representing personal growth, vulnerability, and transformation, the system applies physical computing to translate human proximity into responsive kinetic butterfly movements that correspond to different emotional states. The prototype was developed using an ESP32 microcontroller integrated with HC-SR04 ultrasonic sensors, N20 micro-motors, and an L298N motor driver. The ultrasonic sensors detect the distance and movement of a person approaching the installation, triggering progressive butterfly wing movements that simulate gradual awakening and natural flight. All processes are controlled in real time through the ESP32, enabling smooth and continuous motor operation. The system is powered by a battery-based wired electrical configuration to ensure stable and reliable functionality. Technical testing was conducted to verify sensor responsiveness, motor accuracy, and system stability under simulated interaction conditions. Results confirmed that the system successfully detects proximity and produces intended butterfly movements in real time, demonstrating readiness for future public exhibition. In addition, multimedia elements including ambient lighting and spatial soundscapes were incorporated into the installation design to reinforce emotional immersion and create a calming atmosphere that supports emotional reflection and healing. This research contributes to the intersection of physical computing, interactive multimedia art, and well-being technology, demonstrating how embedded systems and sensory design can be developed to support emotional awareness and human-centered experience design.

Keyword: Interactive Installation, Emotional Well-being, Physical Computing, Multimedia Art, ESP32