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ELECTRONIC FITNESS TRAINING DEVICE: A SMART WEARABLE SYSTEM FOR REAL-TIME EXERCISE FORM CORRECTION

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Incorrect exercise techniques continue to be a widespread issue in modern fitness culture with consequences ranging from mild muscle strains to serious spinal injuries. In this regard, a novel electronic fitness training device was proposed to offer real-time corrective feedback on physical exercises performed. The device consists of two units based on the ESP32 microcontroller and programmed as master and slave modules that communicate via WiFi. Each unit, which includes an MPU-6050 gyroscope-accelerometer sensor for activity monitoring, is coupled with a vibrotactile feedback mechanism enabled through a vibrating motor. The ESP32 cores utilize FreeRTOS, which supports multi-threading, enabling simultaneous data collection, processing, and communication. Both devices are intended to be worn on the wrist; the master device receives motion data from the slave device, enabling bilateral movement comparison during exercise. To improve measurement accuracy and minimise the sensor noise, a Kalman filter algorithm was embedded into the system firmware. By applying this filter to the raw gyroscope and accelerometer data, the angular uncertainty of the system was improved from ±4° to ±2°. The system performs real-time error calculations by comparing the positional data of both devices. When detected deviations exceed predetermined thresholds, the vibration motors activate continuously until the correct posture is restored. Performance evaluations were performed for bicep curls and shoulder press exercises, and the resulting errors were detected with a response time of less than 100 ms. In addition, the device is able to track the number of repetitions and the duration of exercises performed, and further, it provides feedback in real-time through an OLED display. The system highlights the potential for implementing affordable embedded systems technology for delivering real-time feedback on exercises performed. Therefore, minimising the risk of injury and enhancing the safety and effectiveness of fitness training would be possible.

Keywords: Exercise monitoring, Injury prevention, Kalman filter, Real-time feedback, Wearable technology