Novel Auto-Leveling Footwear System for Postural Stability Support

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Falls are the second leading cause of unintentional injury death worldwide, responsible for over 684,000 deaths annually. Existing solutions leave critical gaps. Preventive approaches like strength training and mobility aids reduce fall risk over time, but cannot correct balance in the moment. Reactive solutions like fall detection alerts and wearable airbags typically activate after a fall has already begun. Existing insole systems typically only monitor gait and do not actively correct balance. This project introduces a wearable, closed-loop footwear system that detects postural instability in real time and corrects it before a fall occurs. The system combines sixteen pressure sensors and a 6-axis IMU to continuously monitor balance. A Random Forest machine learning model, trained on over 520,000 raw sensor readings across 40 trials, classifies 8 postural states. When instability is detected, three independently controlled air bladders in the forefoot, midfoot, and hindfoot automatically inflate without user intervention to shift the center of pressure back toward stability based on lean direction. Commercial bladders were too large, so custom bladders were designed and fabricated to fit within the system and target specific instability zones. To evaluate effectiveness, Center of Pressure (CoP) displacement was measured during sustained leans with the system active versus inactive. Results showed CoP displacement reductions of 64.8% forward, 61.6% backward, and 27.8% to the right, demonstrating significant postural stability improvement. This technology extends beyond fall prevention and can be adapted for athletes, construction workers, rehabilitation patients, and any application requiring real-time balance support.

Awards Won:

Third Award of $1,200

Westlake University: Westlake University is awarding Pre-college Summer Program Scholarships, covering the program fee, lodging, food, insurance, round-trip international airfare, and excursions in Hangzhou &amp

Shanghai this summer, to up to six finalists.