SIFR Smart insole: The Cutting-Edge Wearable

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Sports trackers are an indispensable tool for effective training; however, their ability to analyze motion dynamics and ergonomic load distribution remains limited. To bridge this gap, we propose a smart shoe insole enabling detailed plantar pressure analysis using embedded sensors. Comparable solutions are either unavailable to non-professional users or offer limited functionality. Two pressure-sensing approaches were investigated: piezoresistive sensors based on Velostat® foil and capacitive sensors using a polydimethylsiloxane (PDMS) dielectric. Prototypes were evaluated under dynamic loading with a STEP Lab EA05 electromechanical actuator. Capacitive sensors demonstrated superior repeatability and long-term stability, despite higher cost and increased measurement complexity due to small relative capacitance changes. To improve sensitivity and reduce material usage, a porous PDMS dielectric was developed using sugar granules. After curing and dissolution of the sugar, a PDMS foam structure was obtained, significantly enhancing sensor measurability while lowering production costs. Experimental data were used to derive a mathematical model of sensor behavior under load. Based on these findings, a flexible printed circuit board (PCB) was designed integrating pressure sensors with an FDC1004 capacitance-to-digital converter and interfaced via I2C to an ESP32-C6–based control unit. The system includes a 6-axis inertial measurment unit(IMU) LSM6DS3, SD card storage, battery management circuit, and an RGB status LED. A functional prototype validated the concept by reliably generating plantar pressure maps.

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