AI-Powered Smart Glove for Safety Monitoring & Control in Workspaces

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Project Title: AI-Powered Smart Glove for Safety Monitoring & Control in Workspaces

1. Introduction

The AI-Powered Smart Glove is a wearable, sensor-integrated solution designed to improve worker safety and enable intelligent environmental control in industrial workspaces. By combining low-cost sensors with real-time data monitoring, LabVIEW-based control, and machine learning classification, this project aims to deliver a smart, affordable, and scalable safety device. The glove collects critical data such as gas levels, grip force, and vibration feedback and uses AI to determine risk levels. Based on these levels, it activates actuators like OLED Screens, buzzers, and lighting systems through a National Instruments DAQ system [1].

Importance and Relevance: Industrial environments often expose workers to risks such as toxic gases, overheating machinery, and excessive mechanical force. A wearable monitoring device provides continuous, personal-level safety data - something often missed in conventional systems. This glove enables early detection and autonomous action, reducing human error, increasing efficiency, and enhancing worker protection.

Objectives:

- Real-time safety monitoring using affordable, off-the-shelf sensors.
- Integration with LabVIEW and NI DAQ for data acquisition and control.
- Machine Learning-based decision-making for autonomous risk handling.
- Control of actuators and programmable DC supply for alert and adjustment mechanisms.

2. Background and Context

Problem Addressed: Many industrial accidents occur due to delayed detection of harmful gases, overheating equipment, or unsafe handling of tools. Workers and supervisors often lack real-time feedback, leading to slow reactions and increased risks. While some monitoring systems exist, they are usually expensive, non-wearable, or lack AI-driven autonomous responses. The smart glove with OLED screens provides real-time visual alerts, improving decision-making and reducing response time.

Prior Research & Context: Several research studies and industry solutions focus on smart PPE (Personal Protective Equipment), IoT-based environmental monitoring, and AI-driven safety analytics[3]. However, most of these systems are either fixed installations or costly wearable tech[2]. Our approach combines cost-effective hardware, LabVIEW-based automation, and simple ML techniques (like decision trees or threshold classifiers) to deliver a compact solution tailored for low-cost industrial use.

Why Now: The growing push for Industry 4.0, smart factories, and sustainable safety practices makes this project both timely and necessary. Increased adoption of wearable tech and AI in industrial safety makes this proposal practical and relevant.

3. Objectives

- Design and fabricate a cost-effective smart glove (< 8000 LKR budget).

- Integrate force, vibration, gas, and temperature sensors with LabVIEW using NI DAQ.
- Design and build a custom force sensor circuit using an FSR (Force Sensing Resistor), including a signal conditioning circuit to ensure reliable analog data acquisition.
- Apply basic ML logic (e.g., decision tree classifier) to classify safety levels.
- Control two or more actuators (OLED Screen, buzzer, LED via programmable DC supply).
- Provide user alerts and autonomous environment control based on sensor data.
- Implement LED brightness control using a programmable DC power supply, adjusting intensity in 3 discrete steps every minute to indicate safety status levels (Safe, Caution, Danger).

4. Project Scope

In Scope:

- Fabrication of a self-built FSR sensor with signal conditioning.
- Integration of sensors (MQ-135, MPU6050, temperature sensor, FSR) into a glove.
- Real-time monitoring and control using LabVIEW and NI DAQ.
- Basic machine learning implementation for classifying safety levels.
- Control of actuators (buzzer, OLED Screen, LED) through LabVIEW.
- Implementation of 3-step LED brightness indication updated every minute.
- Use of a programmable DC power supply for hardware actuation.

Out of Scope:

- Arduino/microcontroller-based control or wireless communication.
- Advanced ML models (e.g., neural networks, deep learning).
- Remote/cloud-based data logging or GPS tracking.
- Battery-powered or mobile version (prototype is desktop/lab-based).

5. Estimated Cost

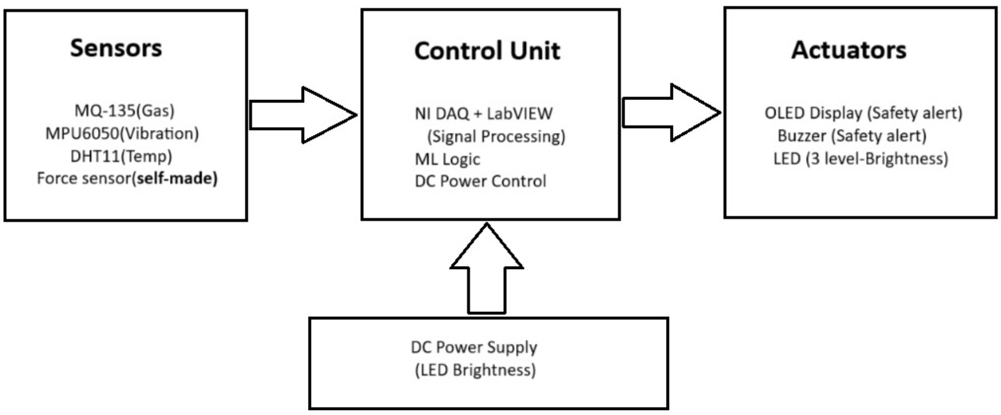
Component	Description	Approx. Cost (LKR)
MQ-135 Gas Sensor	Detects air quality/gases	Rs. 500
MPU6050	Vibration/acceleration sensor	Rs. 560–Rs.670
DHT11	Temperature & humidity sensor	Rs. 230–Rs.390
DIY Force Sensor	Custom-built pressure sensor with conditioning	~Rs.500
OLED Display	Alert message	Rs. 650
Buzzer Module	Alert mechanism	Rs. 150
Misc. Components (wires, etc.)	Cables, connectors. prototyping materials	Rs. 1,000
LED Module (3-level brightness)	Safety indicator	Rs. 200
	Overall Cost (App.)	**Rs.3990**

6. Methodology

System Overview:

- Sensors (MQ-135 for gas, MPU6050 for vibration, FSR for force, DHT11 for temperature) are mounted on the glove.
- FSR Sensor is custom-built using conductive material and foam, connected through a signal conditioning circuit [4].
- A lightweight rule-based or decision-tree classifier categorizes data into Safe, Caution, or Danger.
- All sensor signals are acquired via NI DAQ for data acquisition and processed by the Arduino Uno board for control and communication.
- Based on classification:
    - OLED screen displays alerts for poor air quality.
    - Buzzer activates for vibration or excessive force.
    - LED brightness changes in three stages every 20 seconds, powered by a programmable DC supply.

Justification: LabVIEW ensures reliable and industry-standard data processing. A glove format provides personalized monitoring, while simple ML ensures fast, low-latency decisions suitable for real-time industrial environments [1], [2].



Simple Block Diagram

7. Timeline

21.04.2025(1 week)	Component selection, hardware research.
28.04.2025(1 week)	Sensor testing and signal conditioning circuit design.
05.05.2025(1 week)	LabVIEW program development (DAQ + UI + ML logic).
12.05.2025(1 week)	Actuator integration and programmable DC control setup.
19.05.2025(1 week)	Full system assembly and performance testing.
26.06.2025(1 week)	Final report writing and presentation preparation.

7. Conclusion

This project delivers a low-cost, AI-powered, wearable safety system with real-world industrial applications. By leveraging widely available sensors, LabVIEW's control capabilities, and simple machine learning, the smart glove improves safety response times, promotes predictive monitoring, and enhances productivity. Its scalable, modular design makes it adaptable to various work environments. The OLED screen provides clear, immediate alerts for environmental hazards, ensuring timely responses. We seek approval to proceed with this impactful and innovative project.

References

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