**SOCIALLY RELEVANT MINI PROJECT**

**Title of the project:** Fire rescue navigation aid using sonar sensors in smoke filled environment.

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**ABSTRACT**

Fire incidents commonly produce extensive loss of life and property because of poor visibility and confusion generated by thick smoke. Under these critical situations, it becomes extremely difficult for firefighters to maneuver in unfamiliar indoor conditions when they are trying to find victims or exit routes. Conventional vision-based navigation aids, like IR or thermal imaging cameras, are likely to malfunction or go out of order in hot and smoky environments, apart from being expensive and power hungry. This project addresses these disadvantages by suggesting a low-cost sonar-based navigation aid that will help firefighters navigate under zero-visibility conditions by offering real-time proximity information using ultrasonic sensing technology.

The system utilizes more than one ultrasonic sensor (HC-SR04) placed in a strategic way on a microcontroller board (Arduino Uno/ESP32) to continuously sense the distance of obstacles within reach. Depending on the sensed distance, an alarm system in the form of a buzzer, LED, or vibration module is activated to lead the user safely through obstructed or small spaces. The prototype combines a small power supply, motor driver, and battery pack, making it portable and reliable to use in emergency missions. The system logic, coded using embedded C/C++, computes the distances of obstacles and triggers proper warnings within less than one second, providing near real-time response.

Experimental testing under controlled conditions of smoke proved that the system had a distance measurement error less than 10% for ranges of up to 3–4 meters, even in moderately heavy smoke conditions. The findings attest that sonar-based sensing is not influenced by degradation of visibility, as opposed to optical sensors. This work therefore introduces a robust, low-cost, and effective navigation aiding solution for rescue teams and firefighters working in hostile, smoky environments with possible extensions to autonomous fire robots and industrial worker wearables