**Real-Life Motivation**

Real-world scenarios such as post-disaster rescue, hazardous area inspection, and emergency logistics demand mobile robotic systems that are capable of both autonomous decision-making and human-assisted control. This project addresses those needs by developing a compact, intelligent mobile robot capable of obstacle avoidance and target following in real time.

By combining ultrasonic sensors and camera-based visual tracking, the robot can safely navigate complex and dynamic environments while detecting and avoiding obstacles. The integrated target-following functionality enables the system to recognize and track individuals, making it particularly useful for tasks such as material delivery or victim assistance in emergency or disaster zones.

In addition to its autonomous features, the robot offers manual control options via keyboard input or a web interface, allowing precise human operation when needed—especially in high-risk or sensitive environments where manual intervention may be crucial.

The project architecture showcases a complete real-time closed-loop system, from sensing and perception to decision-making and actuation. It is built on Ubuntu, with performance-critical logic developed in C++ for real-time responsiveness, and a Python-based web interface for ease of interaction and future scalability.

System capabilities include:

* Real-time obstacle detection and avoidance using sensor fusion
* Target recognition and tracking through computer vision
* Dual-mode operation: autonomous navigation and manual control
* C++ core logic for real-time control performance
* Python-based web UI for intuitive remote interaction

Example applications:

* Search-and-rescue support in earthquake or disaster-struck areas
* Remote inspection in hazardous or inaccessible environments
* Educational platform for embedded systems and autonomous robotics

**Sensor Selection Argument: Why Ultrasonic over Infrared for Obstacle Avoidance**

In this project, ultrasonic sensors were selected over infrared (IR) sensors for obstacle detection and avoidance. This choice was based on a combination of technical performance, environmental adaptability, and system reliability.

**1. Range Accuracy and Stability**

Ultrasonic sensors provide **more consistent distance measurements** across a wider range (typically 2–400 cm), whereas IR sensors are often affected by object color, surface reflectivity, and ambient light. Ultrasonic sensing uses sound waves, making it **less susceptible to interference from environmental lighting conditions**.

**2. Material and Surface Independence**

IR sensors rely on light reflection, which can vary dramatically depending on the object's material and surface characteristics. For instance, **dark or matte surfaces may absorb IR signals**, leading to false readings or detection failure. In contrast, ultrasonic sensors are generally **agnostic to surface color or texture**, enabling more robust operation in real-world, unpredictable environments.

**3. Environmental Versatility**

In complex and dynamic environments—such as disaster areas, where smoke, dust, or debris may be present—IR sensors may struggle due to scattering or absorption of light. **Ultrasonic sensors maintain reliable performance in such conditions**, offering a better fit for our target scenarios.

**4. Cost and Integration Simplicity**

Ultrasonic modules like the HC-SR04 are **affordable, easy to interface**, and well-supported by embedded platforms. Their **digital output and simple timing logic** make them ideal for real-time systems implemented in C++ on microcontroller or Linux-based platforms.