

Fire-Fighting Robot

Fire accidents in homes, laboratories and small industrial setups demand a first response that is faster than human intervention. This project presents an autonomous fire-fighting robot capable of detecting, approaching and extinguishing small flames without human control. The system is built around an ESP32 microcontroller, chosen for its processing speed, rich I/O and integrated Wi-Fi for optional manual override.

Fire detection is implemented with three IR flame sensors (760–1100 nm) arranged across the front of the robot, providing roughly 120° of directional coverage. The ESP32 continuously samples the three channels and compares intensity values to estimate the bearing of the flame; a threshold-plus-hysteresis algorithm rejects ambient IR noise. Locomotion uses a four-motor differential-drive chassis driven by an H-bridge motor driver. The navigation loop steers the robot toward the strongest flame signal until the centre sensor dominates, indicating the fire is directly ahead, at which point the robot halts at a calibrated standoff distance.

Extinguishing is performed by a mini water pump drawing from an onboard tank, with a servo-mounted nozzle that sweeps $\pm 60^\circ$ to spread water across the flame zone. A water-level sensor interlocks the pump to prevent dry-run damage, and a timeout routine commands the robot to retreat and sound a buzzer if the flame persists beyond a set interval. An HC-SR04 ultrasonic sensor provides obstacle avoidance during the approach phase.

The prototype was tested against candle-scale flames in an indoor arena and consistently detected, approached and extinguished the flame within seconds of line-of-sight acquisition. The report documents the system architecture, sensor calibration, control algorithm, power design and test results, and discusses limitations such as sunlight interference and tank capacity.