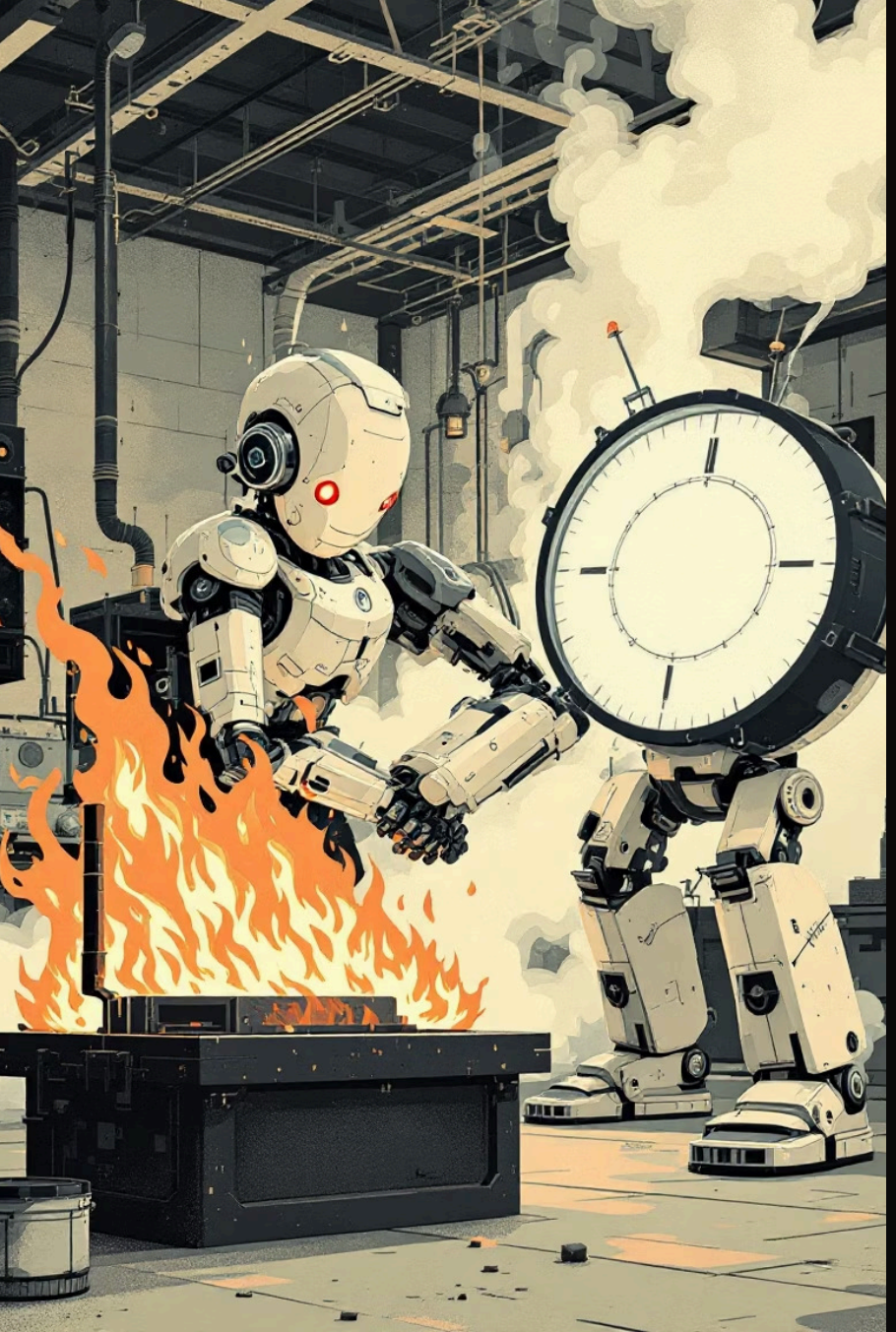


Autonomous Fire-Fighting Robot Vehicle

An intelligent robotic solution for rapid fire detection and suppression using sensor-guided technology

The Growing Need for Automated Fire Response

Why Automation Matters

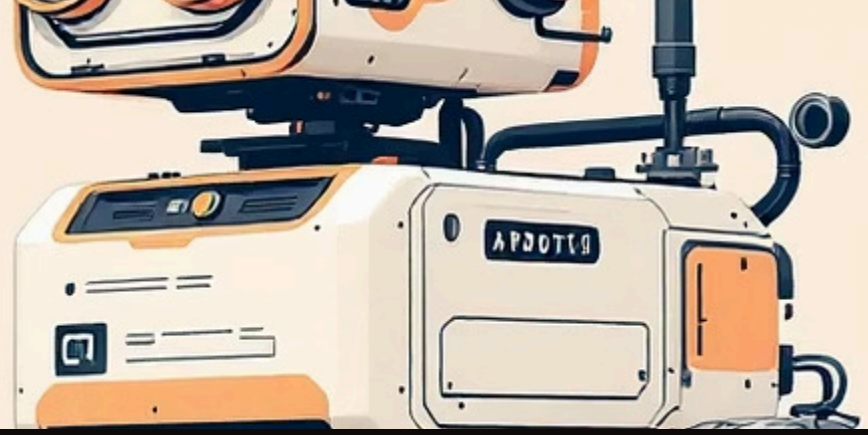
Traditional fire-fighting methods often involve significant human risk, especially in hazardous environments. Response time is critical—every second counts in preventing fire spread.

Autonomous systems can navigate dangerous areas, detect fires early, and respond instantly without endangering human lives.

Real-World Applications

- Industrial facilities and warehouses
- Chemical storage areas
- Remote locations with limited access
- Residential and commercial spaces

Our solution addresses these challenges with smart, cost-effective technology.



Project Overview

Detection Range

Three flame sensors covering 30-150 degrees for comprehensive fire detection in front of the vehicle

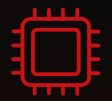
Autonomous Navigation

Vehicle automatically moves towards detected fire source using sensor input and motor control

Precision Suppression

Servo-mounted water pipe rotates to target and extinguish flames with focused water delivery

Core Components



Arduino Uno

The brain of our robot—processes sensor data, executes control logic, and coordinates all subsystems for intelligent decision-making

L298N Motor Driver

Controls DC motors for vehicle movement, enabling forward motion, turning, and stopping based on Arduino commands

Flame Sensors (×3)

Infrared-based sensors detect fire within 30-150 degree coverage area, providing directional information for navigation

Servo Motor

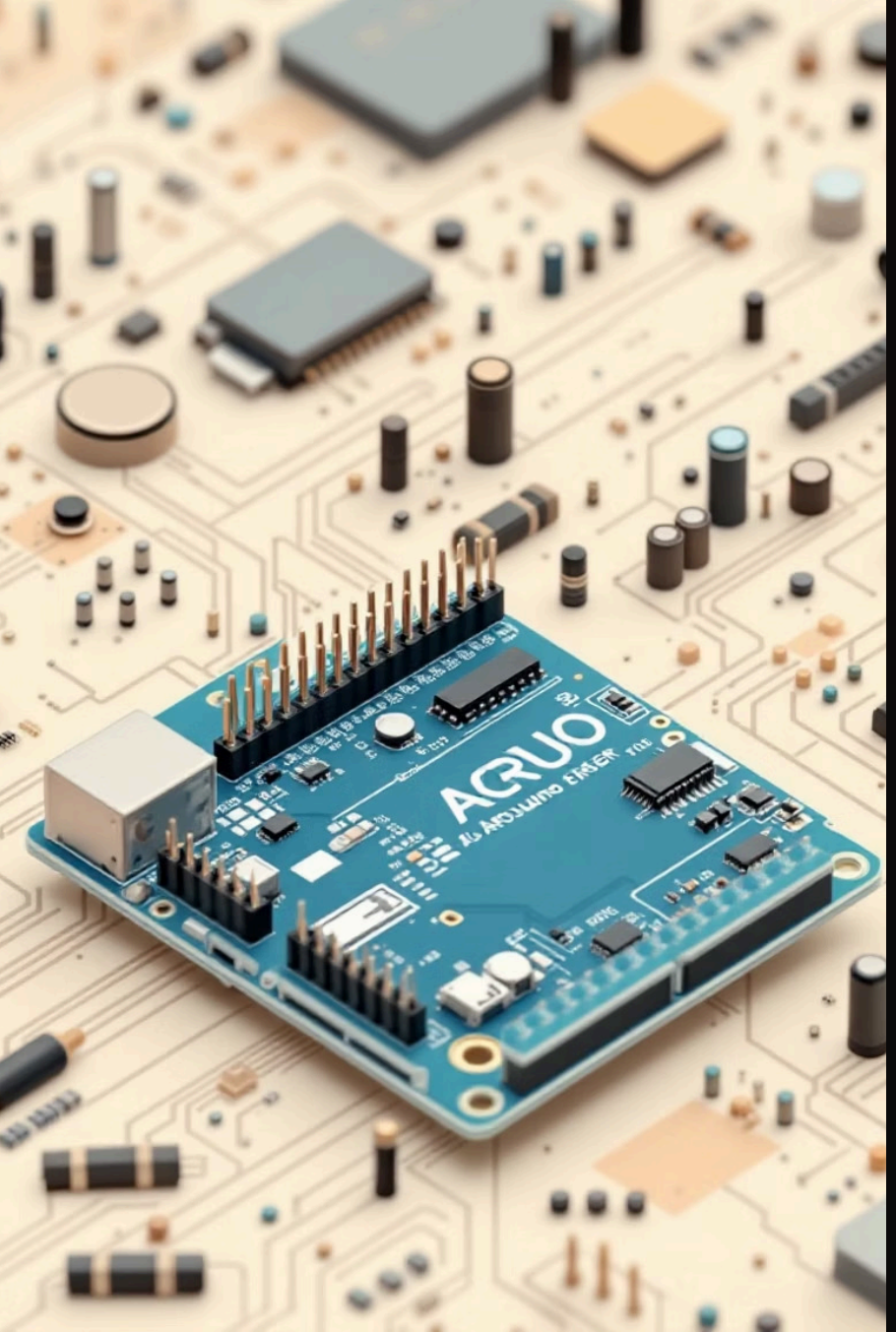
Precisely rotates the water delivery pipe across the detection range to target flames accurately

Water Pump

Pumps water through the delivery system when fire is detected, powered by transistor-based circuit

Supporting Electronics

Transistors, diodes, capacitors, resistors, and jumper wires ensure stable operation and circuit protection



System Architecture

Sensor Input

Flame sensors continuously monitor environment and send signals to Arduino

Processing

Arduino analyses sensor data and determines fire location and distance

Navigation

Motor driver receives commands to move vehicle towards fire source

Suppression

Servo positions water pipe, pump activates to extinguish flames

Working Principle: Detection & Navigation

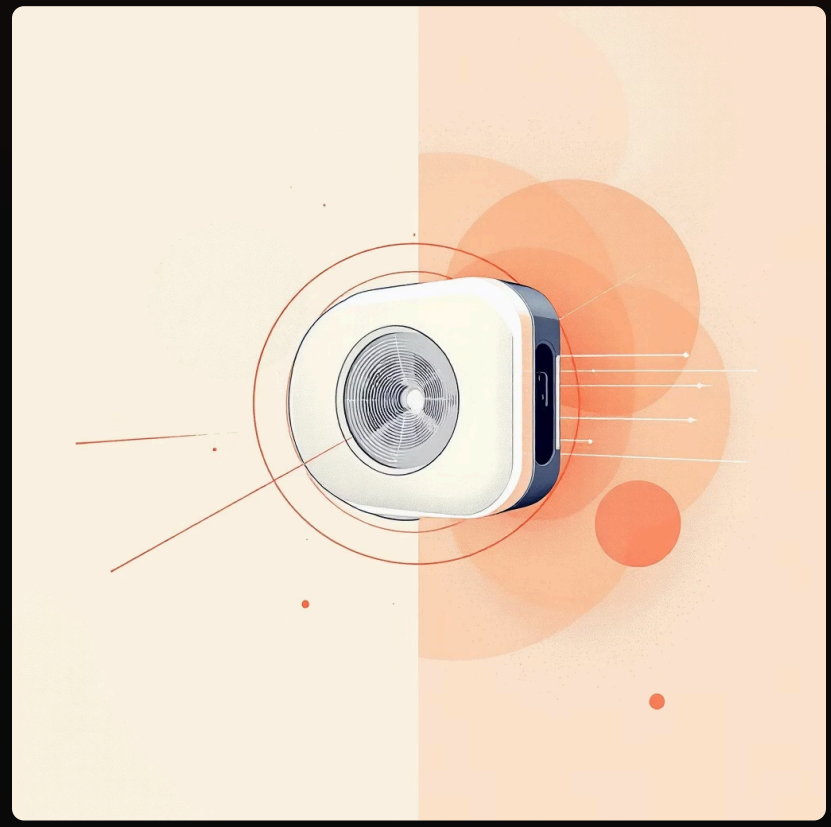
Phase 1: Fire Detection

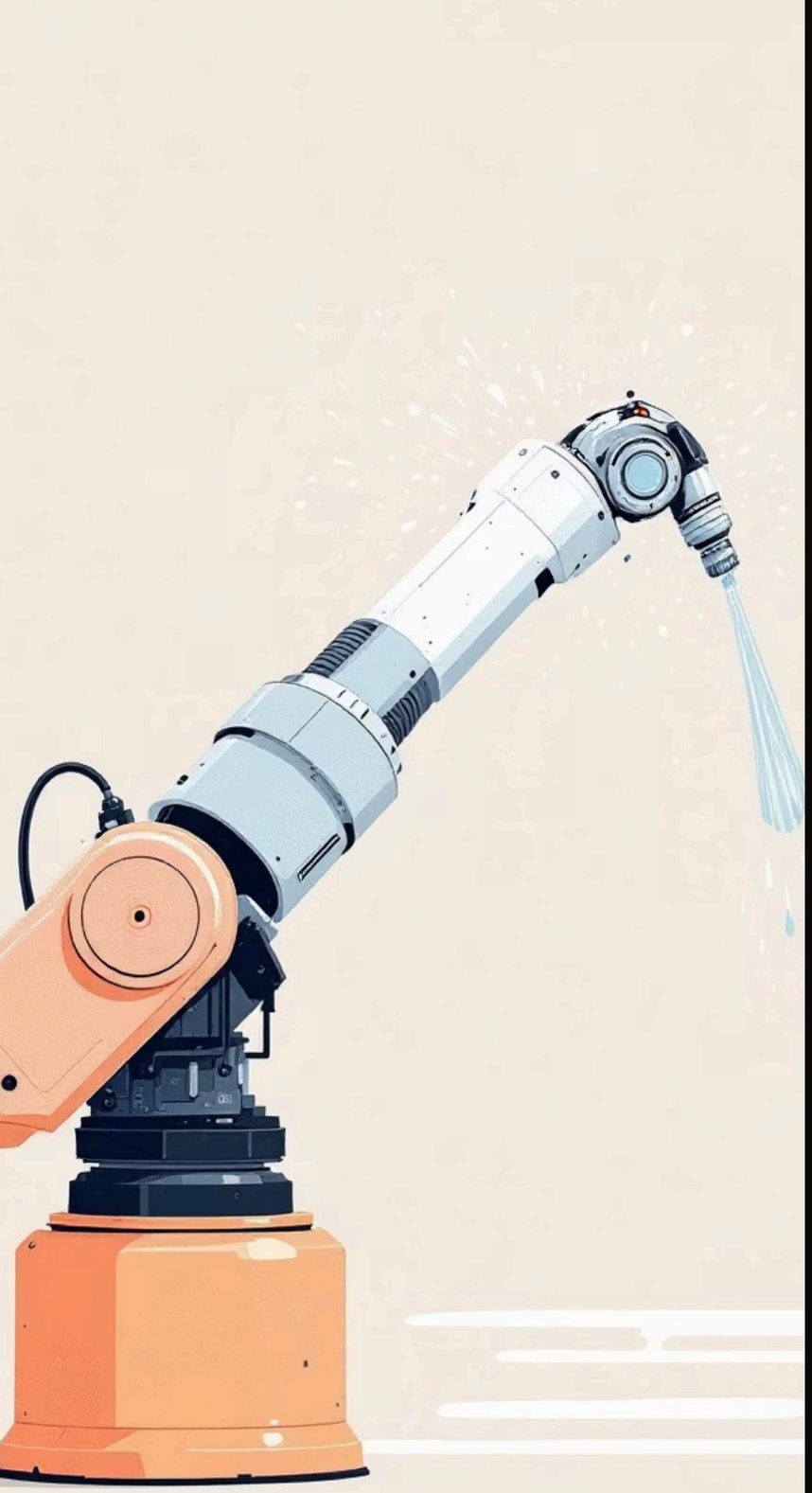
The three flame sensors are strategically positioned to provide overlapping coverage across a 120-degree arc in front of the vehicle. Each sensor operates in the infrared spectrum, detecting the specific wavelengths emitted by flames.

When fire is detected: Sensors send digital signals to the Arduino, which determines the fire's direction based on which sensor(s) are triggered.

Phase 2: Autonomous Movement

The Arduino processes sensor inputs and sends control signals to the L298N motor driver. The vehicle automatically navigates towards the fire, adjusting its path based on real-time sensor feedback until it reaches the optimal suppression distance.





Working Principle: Suppression System

01

Vehicle Stops

Upon reaching target distance, Arduino commands motors to stop, stabilising the platform for accurate water delivery

02

Servo Positioning

Servo motor rotates the water pipe across the 30-150 degree range, scanning to locate the exact flame position

03

Water Deployment

Motor pump activates through transistor circuit, delivering pressurised water to extinguish the fire effectively

04

Verification

Sensors continuously monitor for remaining flames; system repeats suppression cycle if necessary until fire is fully extinguished

Circuit Design & Electronics

Power Management

- **Arduino power supply:** 5V regulated for logic circuits
- **Motor driver:** Separate power for high-current motor operation
- **Pump circuit:** Transistor-based switching with flyback diode protection

Signal Processing

- **Pull-up resistors:** Ensure stable sensor readings
- **Capacitors:** Filter noise and stabilise voltage
- **Diodes:** Protect against back EMF from motors

Control Logic

The Arduino code implements a state machine with multiple modes:

1. Scanning mode: Monitoring sensors
2. Navigation mode: Moving towards fire
3. Suppression mode: Extinguishing flames
4. Idle mode: Awaiting next detection

This modular approach ensures reliable operation and easy debugging during development.

Demonstration & Performance

<3s

Detection Time

From flame appearance to vehicle response initiation

120°

Coverage Angle

Total detection and suppression range for comprehensive protection

5-...

Suppression Time

Average time to fully extinguish detected fire source

Testing Results: Our prototype successfully detected and extinguished flames in controlled environments. The system demonstrated reliable sensor accuracy, smooth navigation, and effective water delivery across the full operational range.

Conclusion & Future Scope

Project Achievements

Successfully developed a cost-effective autonomous fire-fighting robot using readily available components. The system demonstrates reliable fire detection, intelligent navigation, and effective suppression capabilities.

Key Learnings

This project enhanced our understanding of embedded systems, sensor integration, motor control, and real-time decision-making algorithms. We gained practical experience in circuit design and troubleshooting.

Future Enhancements

- Integration of camera for visual fire detection
- Wireless control and monitoring system
- Multiple agent coordination for larger areas
- Enhanced obstacle avoidance capabilities

Impact: This technology has potential applications in industrial safety, home automation, and emergency response systems, contributing to safer environments and reduced fire-related risks.