Autonomous Fire Extinguishing System

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Objective:

Replace current sprinkler system systems that are:

- Expensive
- Difficult to Install
- Slow-responding
- Damaging

QR CODE TO TESTING VIDEO FOLDER

Executive Summary

Design Highlights:

- Autonomously detects fire
- Extinguishes using a Water Mist
- App with bluetooth connectivity
- Easy installation
- Acts in less than 15 seconds
- Weight: Less than 50 pounds
- Size: Less than 5 cubic feet
- Expected cost of less than $250

Contributions and Impact

Team Contributions:

- Created Scope and Requirements with Sponsor
- Designed System from Start to Finish
  - Researched and decided on key features
  - Iterated targeting mechanism
  - Coded an App using HTML
  - Designed control system using Arduino IDE

Societal and Environmental Impact:

- Protect residential buildings from fires
- Reduce water consumption for extinguishing fires
- Reduce waste produced by consumable extinguishing containers

Acknowledgements

"Fire Suppression System Requirements." *BuildOps*, 2024,
"MLX90640-D110 Thermal Camera - Waveshare Wiki," *Waveshare.com*, 2025. (accessed Feb. 24, 2025)
"XIAO INTRODUCTION | Seeed Studio Wiki," *Seeedstudio.com*, Jul. 04, 2023.

Key Feature

App (Figure 3):

- Displays: Temperature, Battery Level, Fluid Level

Targeting Mechanism (Figure 2):

- Gear System to shorten lever arm
  - 2 Servo Motors for Pitch and Yaw Axis
- Hole in Center for Wiring
- Spacial Volume: 9 in. x 9 in. x 7.5 in.

Extinguishing Fluid:

- Water Mist
  - Minimizes Water Damage
  - Non-Toxic
- Rechargeable Container

Detection Method:

- Infrared-Thermal Imaging Camera
  - Not obscured by smoke
  - Temperature Detection Range:
    - ≈ 40- 300 °C ± 2 °C
  - Detection Distance:
    - 1-10 m ≈ 3.2-32 feet

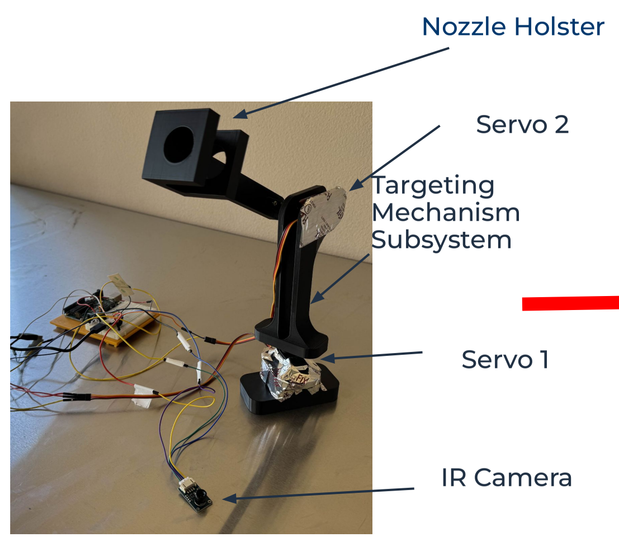


Figure 1. Targeting Mechanism V1 (Old Design)

Analysis

Analysis for Pressure Vessel Optimization:

- Pressure to Velocity Formula:

$$V=\sqrt{\frac{2q}{\rho}}$$

Where q is the dynamic pressure and ρ is the fluid mass density (water).

- Formula for Mass Flow Rate:

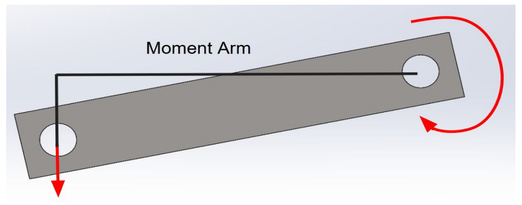
$$\dot{m} = \rho A V$$

Where A is the area of the hose opening and V is the stream velocity.

- Optimize tank by dividing tank capacity by mass flow rate to obtain max spray time

Analysis on Lever Arm:

- Simple analysis showed lever arm was unstable and inefficient



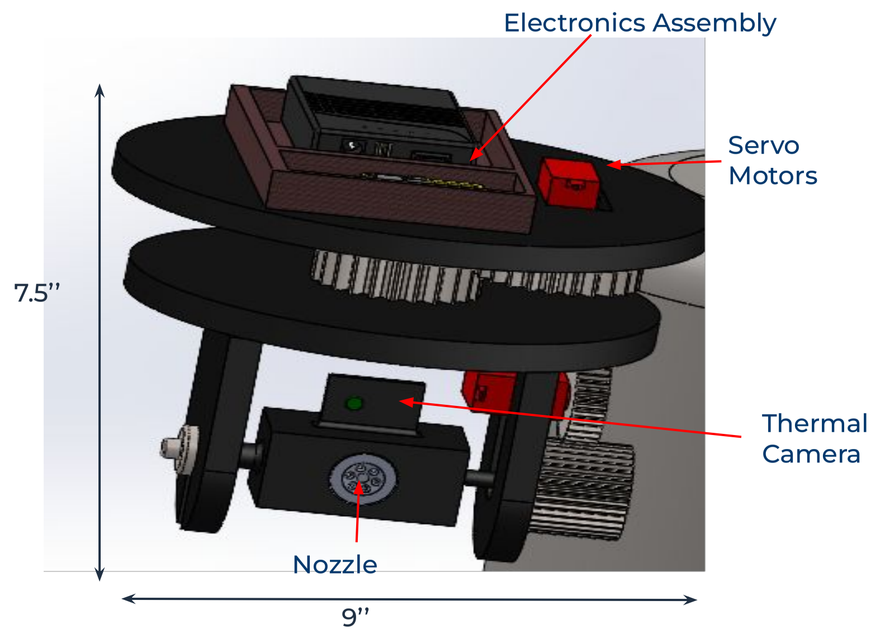


Figure 2. Targeting Mechanism V2 (Current Design)

Final Design

Targeting Mechanism Version 1 (Figure 1):

- Moment arm was too long
- Servo motor provides insufficient torque to drive components
- Unstable during operation
- Resulted in tangled wires

Targeting Mechanism Version 2 (Figure 2):

- Improved Stability
  - Centered location of nozzle
  - Reduced long arms
- Tangling of wires fixed by routing through middle
- Visually appealing design for roof

Future Improvements

Shortcomings	Proposed Solutions
Material Weaknesses	Implement Aluminum Parts
Limited Range	Custom Nozzle Design
Delays Caused by App	Improve Code Efficiency
Wifi Compatibility	Include Wifi compatibility with XIAO ESP32C3

Figure 3. App (Current Design)