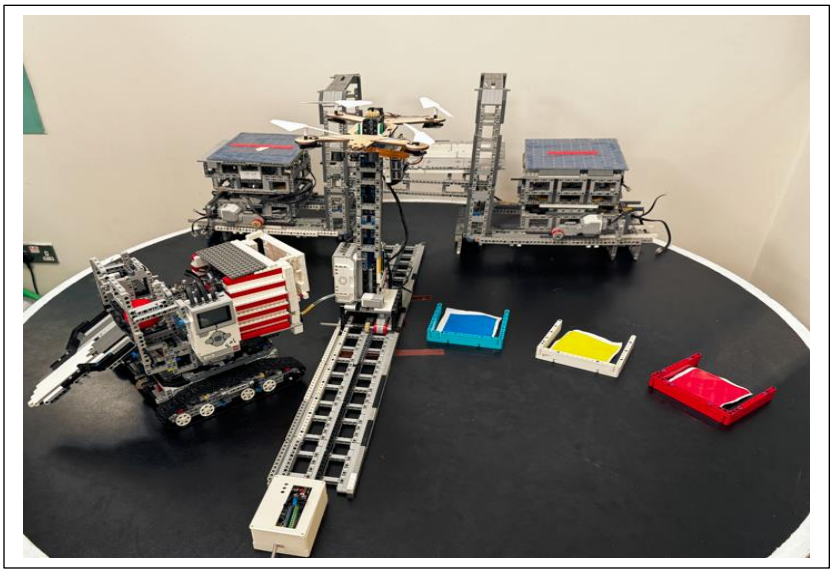
UNKNOWN TEAM

AHMAD BIN HANBAL SCHOOL



World Robot Olympiad 2024

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Team presentation:

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(15 years old, Programmer)

Summary of the project idea:

Our team**,** developed a robotic solution to address the growing danger of forest fires, in line with the WRO theme of **"The Force of Nature"**

Our research shows that the average response time for fire trucks to reach a fire is between 10 and 20 minutes. Acting within this time frame can significantly help control the spread of the fire.

Our team has developed a robotic solution that can detect fires early and automatically intervene to control the flames before the fire trucks arrive. This will greatly reduce the spread of the fire and minimize the damage.

Phase 1: Detection
In this phase, fire is detected immediately through specialized sensors designed to sense the outbreak of flames.

Phase 2: Response
In this phase, drones automatically move to the fire location.

- drones capture the exact coordinates of the fire.
- identify the type of fire and collect relevant data.
- This data is then transmitted to the civil defense and the intervention robot.

Phase 3: Intervention
Based on the type of fire and the transmitted data, the robot automatically moves to the fire site.

- The robot is equipped to extinguish the fire using the appropriate method, depending on the type of flames (e.g., water, foam, or dry chemicals).

This system aims to reduce response time, provide valuable real-time data to authorities, and ensure swift intervention to control fires before they escalate, minimizing damage and saving lives.

Robotic solution:

General aspects:

How did you come up with the idea?:

The development of the intelligent robot for firefighting came as an attempt to find an innovative solution to reduce fires, based on the urgent need to speed up response times and minimize damage caused by fires.

Reducing Human and Material Losses:

The idea emerged from the desire to minimize losses resulting from fires, whether in terms of property or lives. The concept of having a robot capable of intervening quickly as soon as a fire breaks out can significantly reduce these losses.

Increasing Response Effectiveness:

Rapid and precise movement based on the type of burning material is an innovative solution compared to traditional methods that rely on manual intervention. This solution aims to shorten the time between fire detection and the initiation of firefighting efforts.

Utilizing Technology to Analyze Flame Color:

The idea stemmed from the realization that the color of the flame provides important information about the type of burning material, enabling the robot to select the appropriate extinguishing substance, whether it be water, foam, or carbon dioxide. This reduces the need for direct human intervention, thus enhancing response effectiveness.

Improving Response in Hazardous Environments:

In industrial settings or forests, it may be challenging for firefighters to intervene quickly. The use of robots equipped with flame color analysis allows for automated and effective intervention in these environments, thereby reducing the risk of injury in such hazardous locations.

Innovation in Addressing Environmental Challenges:

In light of climate change and the increased incidence of natural fires such as wildfires, it has become essential to seek innovative solutions based on advanced technology. This idea represents a response to this pressing need.

What other ideas did you explore before choosing this one?

Initially, we considered developing a robot designed to locate fires through ground navigation. However, after further evaluation and brainstorming, we recognized the need for a comprehensive solution that addresses the critical issue of rapid response to fire incidents. This led to the evolution of our concept into a fully integrated system that encompasses the following stages:

Detection:

The process begins with advanced sensors that detect the presence of fire. These sensors continuously monitor the environment for any signs of combustion, ensuring early detection.

Automated Drone Deployment:

Once a fire is detected, drones are automatically deployed to the scene. These drones are equipped with cameras and advanced imaging technology to provide real-time data on the situation. Their aerial capabilities allow them to reach difficult-to-access locations quickly, overcoming the challenge of speed in response.

Flame Analysis:

The drones analyze the color of the flame, which serves as an indicator of the type of material burning. This analysis helps in determining the most effective extinguishing method.

Robotic Intervention:

Following the assessment, an autonomous firefighting robot is dispatched to the exact location. This robot is designed to extinguish the fire using the appropriate materials based on the analysis of the flame color. Whether it's water for solid materials, foam for flammable liquids, or carbon dioxide for gas fires, the robot acts swiftly to mitigate the threat.

Comprehensive Emergency Response:

The entire system works seamlessly to ensure a rapid and effective response to fire incidents. By integrating detection, aerial assessment, and robotic intervention, we aim to enhance fire safety and significantly reduce response times.

Did you find similar solutions? If so, how is yours different?

Through our research, we found that there are similar ideas to ours in the field of firefighting. Several advanced solutions rely on modern technologies, but each differs in details and features. Here are some of the most notable solutions:

Early Detection Systems Using Artificial Intelligence:

These systems rely on cameras and sensors to detect fires at an early stage and analyze data using artificial intelligence techniques.

Drones for Fire Monitoring:

Drones are used in surveillance operations to gather accurate data about fires in remote areas; however, they do not directly intervene in extinguishing flames.

Robots in Firefighting:

There are robots designed to tackle specific types of fires, but these robots often lack the ability to make decisions based on real-time data analysis.

Automatic Fire Suppression Systems in Buildings:

These systems work automatically upon detecting a fire, but they are unable to adapt to the type of fire or provide a quick assessment of the situation.

Drone Projects for Fire Extinguishing:

Some projects are developing drones equipped with extinguishing agents, such as foam or water, but their use remains limited.

Comparison with Our Idea:

Our idea stands out by integrating multiple technologies into a single system that begins with fire detection and relies on flame color analysis to select the appropriate extinguishing agent. This solution combines drones and robots, making it more comprehensive and effective compared to previous solutions.

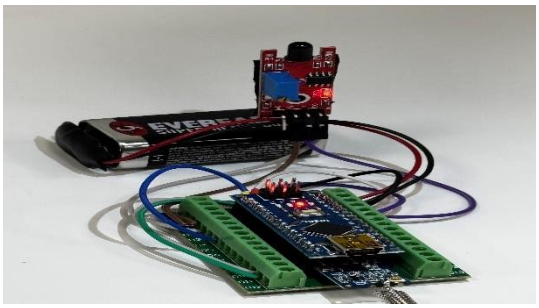
Technical aspects:

Mechanical Construction:

Phase 1: Detection

In this phase, a flame sensor is used to detect the presence of fire, and it is connected to an Arduino board, which serves as the main control unit. When the sensor detects flames, it sends a signal to the Arduino board. Based on the programming in the Arduino, a message is activated for transmission using the HC12 transmitter.

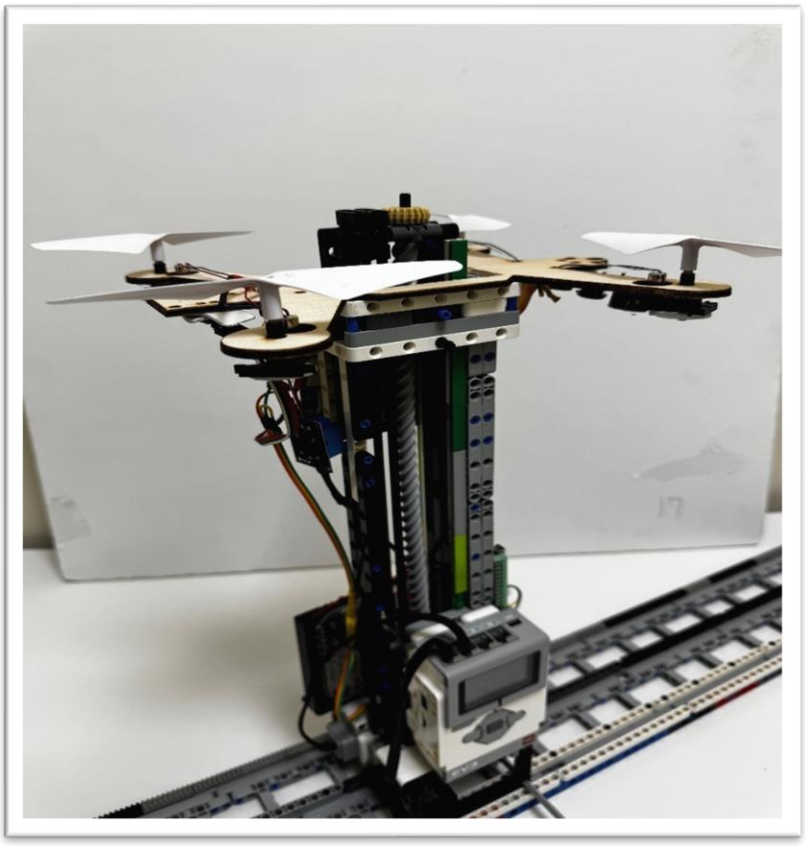
1	Flame Sensor	1
2	Arduino Nano	1
3	HC12	1
4	Power supply	1



Phase 2: Response

This phase integrates all the elements to work together for a rapid response upon fire detection, where the drone moves toward the fire and captures important visual data, contributing to improved emergency response and coordination of firefighting efforts.

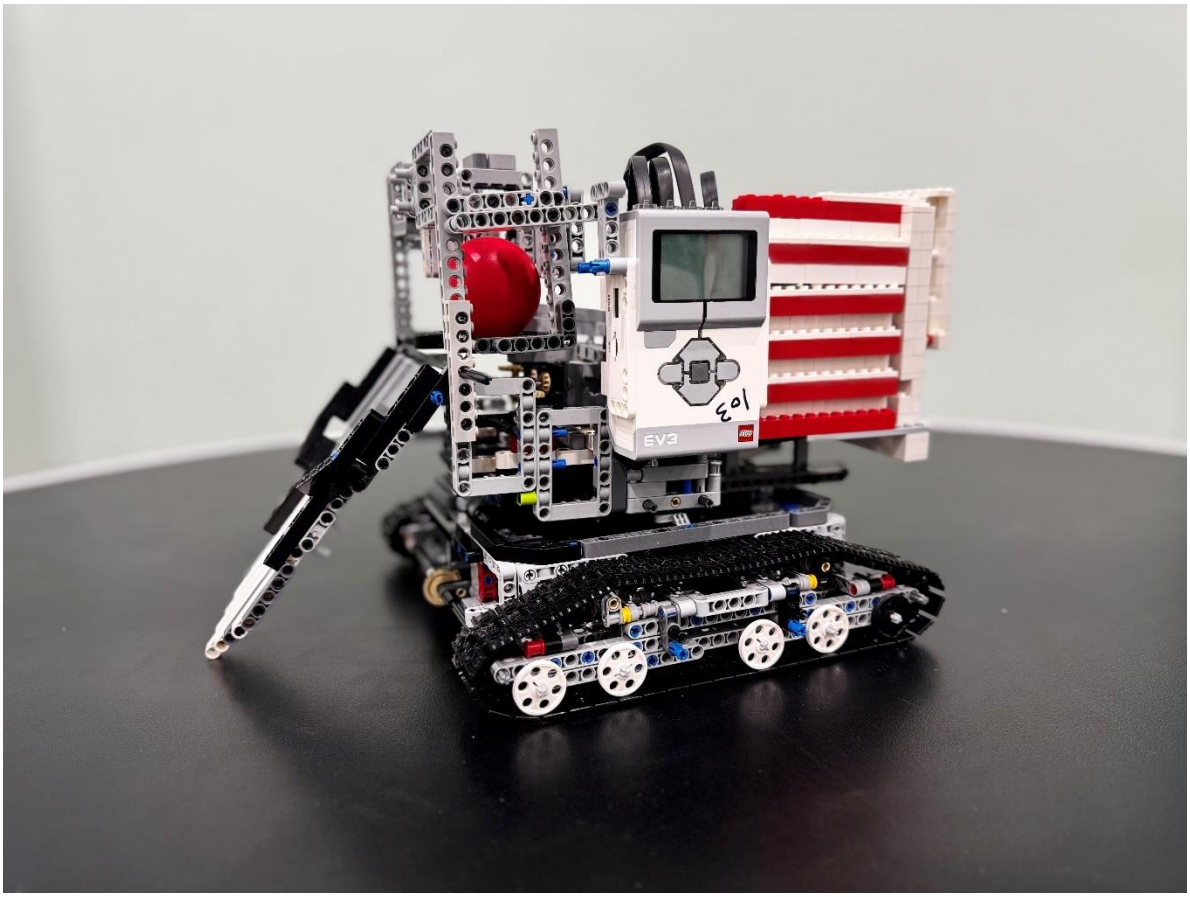
1	HC12 Receiver	1
2	Raspberry Pi 5	1
3	Arduino Nano	1
4	Ev3 brick	1
5	EV3 large motors	1
6	EV3 medium motors	1
7	Embedded Camera	1
8	Drone Motors	4
9	Servo Motor	1
10	Ev3 color sensor	1



Phase 3: Intervention

The fire extinguishing process in this phase is based on analyzing the color of the flame, where the robot determines the burning material and selects the appropriate extinguishing substance. This system enhances the effectiveness of the response and reduces the risks associated with the fire by utilizing advanced techniques suitable for each type of fire.

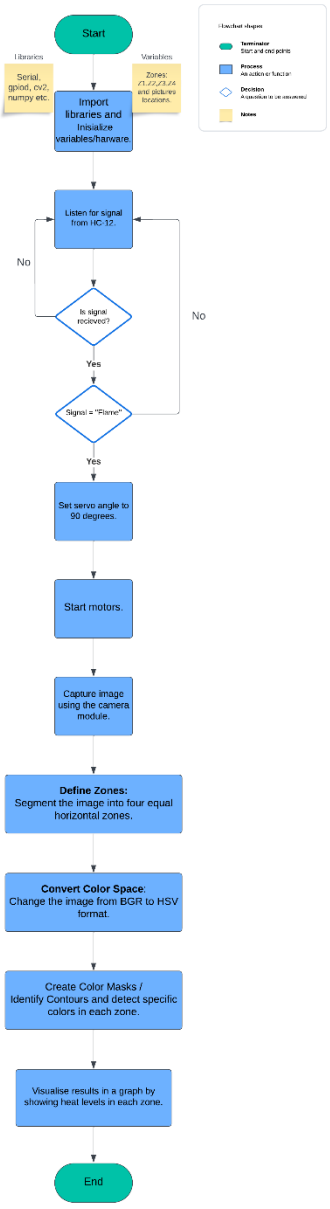
1	Ev3 brick	1
2	EV3 large motors	1
3	EV3 medium motors	1
4	PIXY CAM	1



Coding

Raspberry pi/ Arduino code:

This robot is designed to autonomously detect and extinguish fires by leveraging computer vision and color analysis techniques. The robot processes real-time camera feeds to detect flame colors such as red, yellow, and orange using OpenCV's HSV color spaces. The detection system divides the image into four zones (Z1, Z2, Z3, Z4), and directs the robot's water nozzles to the correct zone based on where the fire is detected. The system also features data visualization using Plotly, providing real-time insights for the operator.



1.Fire Detection Using OpenCV and HSV Color Spaces:

The robot spots flames by analyzing images with the HSV color model, which splits up color from brightness. This helps in picking up on flames better, even if the lighting isn't perfect.

Flowchart explanation:

Start: The system is powered on, and the camera and sensors are initialized.

Capture Image: The robot's camera captures a real-time image of the environment.

Convert Image to HSV: The captured image is converted to the HSV color model for more accurate flame detection under varying lighting conditions.

Divide Image into Zones: The image is divided into four zones (Z1, Z2, Z3, Z4) to precisely locate any detected flames.

Flame Detection (Using OpenCV):

The program analyzes the image for specific flame colors (red, yellow, blue, green) in each zone using OpenCV.

If a flame is detected in any zone, it is highlighted and saved for further analysis.

Control Servo and Motor:

Based on the detected flame zone, the robot adjusts the servo and motor to direct the nozzle towards the fire.

Activate Extinguishing mechanism: The robot activates the water spray to extinguish the fire in the identified zone.

Data Visualization: The system plots a bar chart using Plotly to visualize the intensity of the fire across the four zones, providing real-time data for the operator.

End: After the fire is extinguished, the system returns to monitoring the environment for new flames.

```python
import cv2
import numpy as np

def detect_red(image_path):
    image = cv2.imread(image_path)
    hsv = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)
    lower_red = np.array([0, 100, 100])
    upper_red = np.array([10, 255, 255])
    mask = cv2.inRange(hsv, lower_red, upper_red)

    if np.any(mask):
        print("Red color (flame) detected")
```

The image is divided into four zones, and each one gets checked for flame colors (like red, yellow, blue, green). This way, the robot knows exactly where the fire is and can focus on those areas.

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2. Camera Integration with Picamera2:

Using Picamera2, the robot takes high-res pictures (1920x1080) to get a clear look at what's going on. It processes these images on the spot, so it can react quickly.

```python
from picamera2 import Picamera2

def capture_image():
    picam2 = Picamera2()
    picam2.start()
    picam2.capture_file('/path/to/image.jpg')
    picam2.stop()
```

3. Zone-Based Color Detection:

The robot breaks the image into four zones and checks each one for flames by analyzing specific colors (like red for fire). It uses the HSV color model to isolate flame colors, making the detection more reliable. Once it identifies a flame in a zone, it assigns that zone a number and highlights the detected fire areas with rectangles for better visibility.

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4. Data Visualization Using Plotly:

The robot uses Plotly to create a line chart showing which zones have the most fire activity. This helps you see at a glance where the fire is strongest and needs immediate attention.

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5. Motor and Servo Control:

The servo motor signals from the Raspberry Pi to the EV3 to move the drone towards the fire. After reaching the fire, the fires intensity is detected by using the appropriate colors for demonstration.

```
#include <Servo.h>

Servo myServo;
const int RELAY = 8;    // Motor control pin
const int SERVO_PIN = 3; // Servo pin

void setup() {
    Serial.begin(9600);
    myServo.attach(SERVO_PIN);
    pinMode(RELAY, OUTPUT);
    digitalWrite(RELAY, LOW); // Motor off
}

void loop() {
    if (Serial.available()) {
        String input = Serial.readString().trim(); // Read input

        if (input == "9") {
            digitalWrite(RELAY, HIGH); // Activate motor
            delay(25000); // 25 seconds
            digitalWrite(RELAY, LOW); // Turn off motor
        } else if (input == "2") {
            digitalWrite(RELAY, HIGH); // Turn motor on
        } else if (input == "3") {
            digitalWrite(RELAY, LOW); // Turn motor off
        } else {
            Serial.println("Unknown command");
        }
    }
}
```

6.Signal Transmission Using HC-12:

```
#include <SoftwareSerial.h>

const int flamePin = 2;   // Flame sensor pin
const int hc12TX = 10;    // HC-12 TX pin
const int hc12RX = 11;    // HC-12 RX pin

SoftwareSerial HC12(hc12TX, hc12RX);

void setup() {
  Serial.begin(9600);
  HC12.begin(9600);
  pinMode(flamePin, INPUT);
}

void loop() {
  int flameDetected = digitalRead(flamePin); // Read flame sensor
  delay(2000); // Delay before checking again

  if (flameDetected == HIGH)
    HC12.println("1");  // Flame detected
  else
    HC12.println("SAFE");  // No flame detected
}
```

The code initializes the HC-12 module and flame sensor. It continuously checks the flame sensor's status. If it detects a flame, it sends a signal ("1") to indicate danger. If no flame is detected, it sends a "SAFE" message. The `hcv` pin powers the HC-12 module.

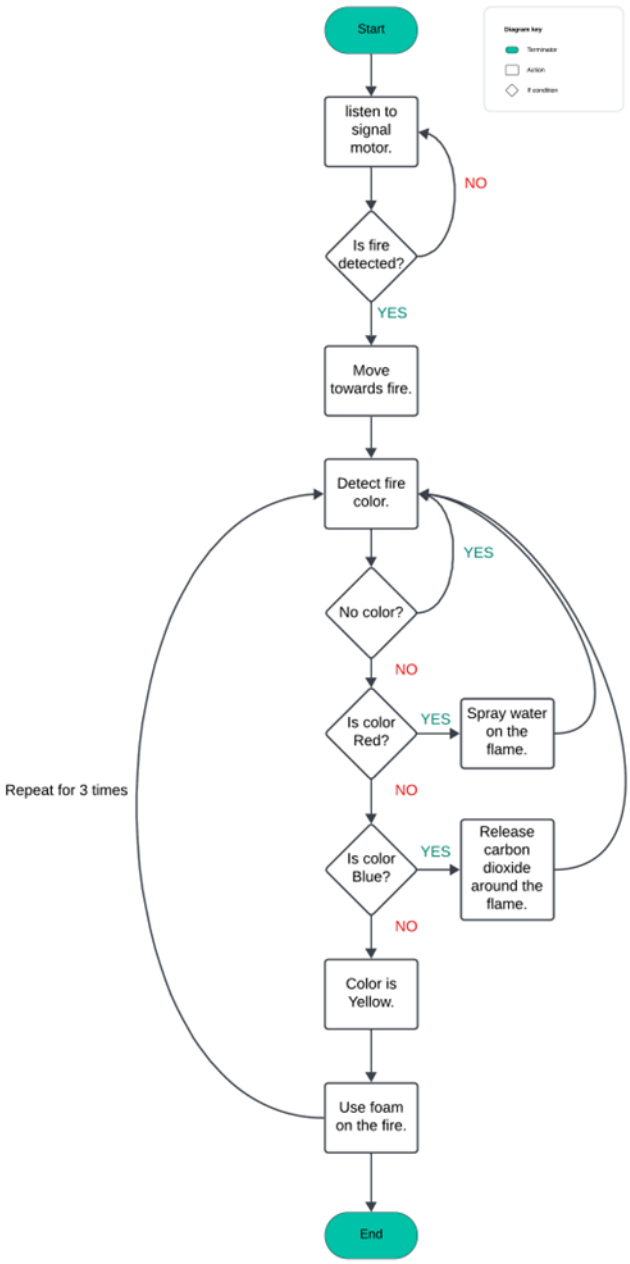
7.The robot listens for a signal from the HC-12 module to know when a flame is detected. When it gets the "FLAME" signal, it starts the extinguishing process by aiming and putting out the fire in the right zone.

```
import serial

ser = serial.Serial('/dev/ttyAMA0', 9600)

def check_signal():
    if ser.in_waiting > 0:
        signal = ser.readline().decode('utf-8').strip()
        if signal == "FLAME":
            print("Flame detected!")
```

EV3 Program:



EV3 Flowchart Explanation:

Start: The process begins with the robot ready to listen for signals from the motor.

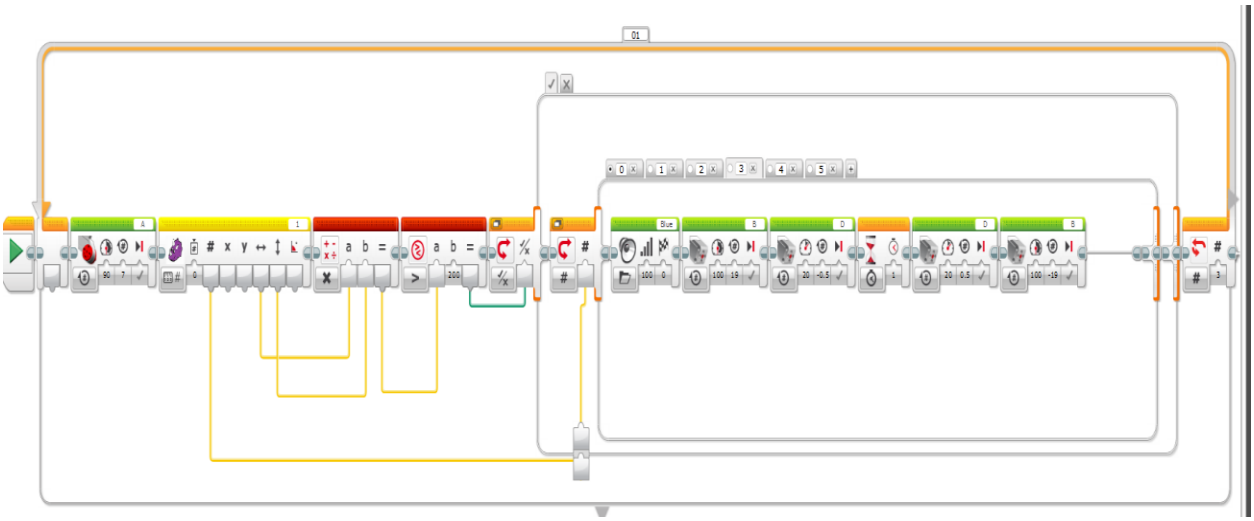
Signal Detection:
The system checks if there's a signal indicating fire detection. If no fire is detected, the robot continues to listen.

Movement Towards Fire:
If a fire is detected, the robot moves towards the source of the fire.
Fire Color Detection: Once near the fire, the robot assesses the color of the flames. If no color is detected, it repeats the detection process.

Identifying Flame Color:
If the detected color is Red, the robot sprays water on the flame and repeats this action three times to ensure the fire is extinguished.
If the detected color is Blue, the robot releases carbon dioxide around the flame to suffocate it.
If the detected color is Yellow, the robot uses foam to suppress the fire.

End: After executing the appropriate action based on the flame color, the process concludes.

- **If the color is red**, the robot sprays water to extinguish the fire.
- **If the color is blue**, the robot drops a blue ball(Carbon Dioxide).
- **If the color is yellow**, the robot drops a red ball(Foam).



Social Impact & Innovation:

Impact on Society:

Who Benefits from our Project?

- **Communities at Risk:** The primary beneficiaries of the robotic firefighting solution are communities located near forested areas, particularly those vulnerable to wildfires. This technology aims to safeguard homes, livestock, and agricultural land.
- **Firefighters and Emergency Services:** The robot can assist firefighters by quickly identifying and suppressing small fires before they escalate, enhancing the safety and efficiency of firefighting operations.
- **Environmental Conservation Groups:** Organizations focused on environmental conservation benefit from reduced wildfire occurrences.

How Important is the Problem We Are Solving for Society?

If this project is implemented in reality, several groups will benefit from it, including:

Concrete Example of How/Where the Idea Can Be Used

Use in Forests:

The project idea can be applied in forest areas prone to wildfires. Forests are among the most vulnerable environments due to natural factors like drought and wind, as well as human activities. By using an advanced detection system that includes drones and robots, the response of firefighting teams can be enhanced, reducing damage.

Users:

1. Firefighting Teams:
    - Local and state firefighting teams can use this technology for quick fire detection, helping them reach fire sites faster.
2. Government Agencies:
    - Agencies responsible for forest and environmental protection can use this technology for monitoring and environmental analysis.

Number of Beneficiaries:

- Local Communities:
    - Communities near forests, which can number in the thousands, will benefit from the protection of their homes and properties.
- Firefighting Teams:
    - Around 50-100 members of local and state firefighting teams can directly benefit from improved emergency response techniques.
- Environmental Organizations:
    - Environmental conservation organizations dealing with forest and wildlife protection can benefit from the data provided by these systems.

Benefits:

- Reducing Losses:
    - Early detection of fires and notifying firefighting teams can significantly reduce human and material losses.
- Environmental Protection:
    - It will help preserve biodiversity and minimize damage to the ecosystem.

Future developments:

1. **AI Predicting Fire Intensity:** AI can analyze real-time sensor and camera data to predict how intense a fire will become and where it will spread. This technology could help firefighters make faster and better decisions, prioritizing high-risk areas and improving resource management.
2. **Low-Frequency Sound Waves for Fire Extinguishing:** Using low-frequency sound waves to put out fires is a promising development. These sound waves can disrupt the fire's oxygen supply, extinguishing it without water or foam. This method is efficient and less harmful to the environment, especially useful in delicate ecosystems or where water isn't readily available.
3. **Adjustable Bridge for Firefighting Vehicles**: A movable bridge system could create shortcuts for firefighting vehicles, allowing them to bypass obstacles or traffic and reach fire sites faster. This system could be critical in urban areas where quick access is often delayed due to road congestion or blockages.
4. **Robot to Rescue Animals:** A specialized robot, deployed from a drone, could be used to rescue animals in areas affected by fires. Equipped with sensors and cameras, this robot could navigate through hazardous environments, locate animals, and guide them to safety or physically carry them out of danger.
5. **Small Robot for Hard-to-Reach Areas:** In tight spaces or areas difficult for humans to access, a small robot can be deployed from a drone. These compact robots could enter places like collapsed structures or deep forest areas, assess the situation, and assist in firefighting or rescue operations by reaching areas that are otherwise inaccessible.

Innovation & Entrepreneurship:

<table>
<tr>
<td rowspan="2">Key partners include:

• Manufacturers of drones and robots.
• Government agencies and research institutions working in environmental and emergency management fields.</td>
<td>Key Activities:

• Continuously developing and improving the system.
• Conducting field tests to ensure system efficiency and reliability.
• Training firefighting teams on how to use the new technology.</td>
<td rowspan="2">Value Proposition:

The project offers an innovative solution to the problem of fires by integrating advanced sensing technologies, drones, and robots. The goal is to accelerate the response of firefighting teams and reduce potential damage by enabling early fire detection and providing accurate data.</td>
<td>Customer Segments:

Firefighting Teams: Local and state teams that need advanced tools to assist them in their tasks.

Government Agencies: Agencies responsible for environmental protection and forest management.

Local Communities: Individuals living near forested areas facing fire risks.</td>
<td rowspan="2">Customer Segments:

Firefighting Teams: Local and state teams that need advanced tools to assist them in their tasks.

Government Agencies: Agencies responsible for environmental protection and forest management.

Local Communities: Individuals living near forested areas facing fire risks.</td>
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<tr>
<td>Key Resources:

• Drone and robot technology.
• Expertise in programming and software development.
• Partnerships with firefighting and environmental agencies.</td>
<td>Distribution Channels:

The system will be marketed through partnerships with firefighting teams and government agencies. Trade shows and seminars can also be used to demonstrate the system's benefits and capabilities.</td>
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<tr>
<td colspan="3">Cost Structure:

Major costs include:

• Research and development costs for system development.
• Manufacturing and marketing costs.
• Technical support and training costs.</td>
<td colspan="2">Revenue Streams:

Potential revenue includes:

• Selling advanced fire detection systems with drones and robots.
• Offering technical support and training services.
• Subscriptions for software updates and maintenance.</td>
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</table>

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