Higher School of Communication of Tunis

Forest Fire Detection System

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1. Project Concept

1.1. Context

Forest fires are potentially devastating disasters that can spread rapidly and cause significant ecological and economic losses. In many parts of the world, human resources for monitoring these vast areas are limited. Therefore, it is imperative to use innovative technologies to quickly detect any signs of fire and enable a prompt and effective response.

1.2. Problem Statement

The problem addressed in this project lies in the urgent need to develop an innovative and effective forest fire detection system capable of autonomously monitoring extensive forested areas. Forest fires pose a serious threat to the environment, biodiversity, and the safety of inhabitants, requiring swift detection for early intervention by emergency services.

1.3. Proposed Solution

The solution we propose involves the development of a dedicated mobile application for early detection of forest fires, also incorporating fire location functionality. This application will leverage IoT technology by integrating IoT Edge cameras equipped with advanced image processing systems to monitor forest areas in real-time. These cameras will be capable of detecting fire signs such as smoke and flames. The captured data will be instantly analyzed using sophisticated image processing algorithms, enabling rapid and accurate fire detection while precisely locating the origin of the fire. Furthermore, our application will include an automatic alert system, sending real-time notifications to emergency services and concerned individuals as soon as a fire is detected. This solution not only provides proactive fire detection but also contributes to environmental preservation by enabling swift and coordinated interventions, thereby minimizing the damage caused by forest fires.

a. Architecture

Our architecture follows the model described below:

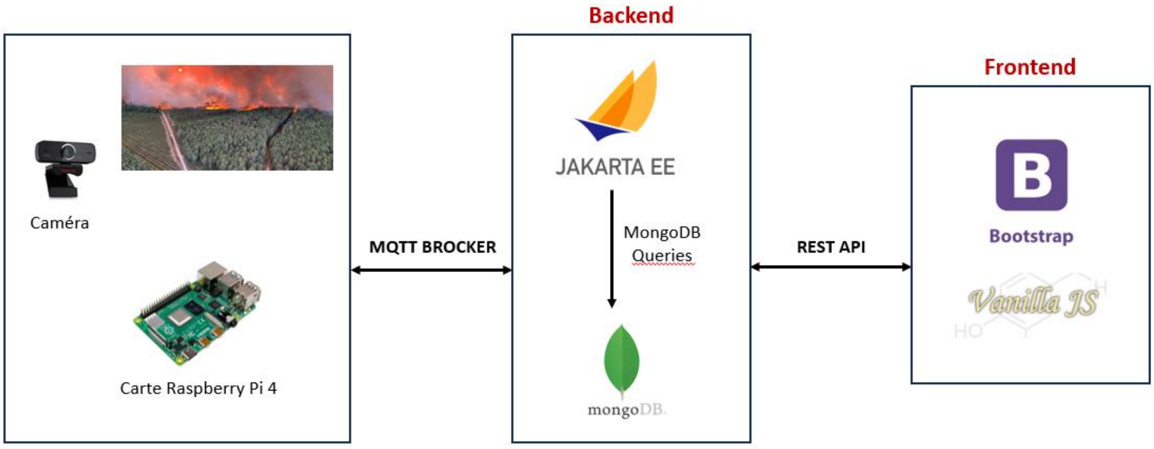

Figure 1: System Architecture

b. Clients :

The clientele for this application mainly includes:

- **Environmental Conservation Organizations:** Organizations committed to forest and biodiversity preservation can use this system to monitor deliberately ignited fires, contributing to the protection of fragile ecosystems.

- **Government Agencies:** Government agencies responsible for natural resource management and firefighting may be potential clients. This system can enhance the monitoring and intervention capabilities of emergency services in case of fires.

- **Farmers and Land Managers:** Farmers and land managers can use this system to monitor fire-prone agricultural areas, thereby helping protect their crops and assets from fires.

c. Objectives :

The objectives of our project are as follows:

- **Develop an early detection mobile application for forest fires:**

Design and develop a dedicated mobile application for real-time monitoring of forested areas with early fire detection.

• **Integrate cameras for continuous surveillance :**

Incorporate cameras to monitor forested areas, using machine learning models to enhance fire detection.

• **Implement image processing algorithms :**

Develop and manage image processing algorithms using MLOps practices for efficient training and deployment of models.

• **Implement an automatic alert system :**

The application will include an automatic alert system that sends real-time notifications to emergency services and concerned individuals as soon as a fire is detected. This will enable a swift and coordinated emergency response.

• **Integrate a precise localization system :**

A crucial project goal is to incorporate an accurate localization system into the application. This system will accurately determine the location where the forest fire originated. The localization feature will be integrated into alerts sent to emergency services, providing crucial information for a rapid and targeted response.

• **Establish an MLOps infrastructure :**

Establish an MLOps infrastructure for the continuous management, deployment, and updating of machine learning models used for fire detection.

d. Limitations :

The limitations of our project are as follows:

• **Weather dependency:**

The performance of fire detection by IoT Edge cameras can be affected by adverse weather conditions such as heavy rain, fog, or snow, limiting visibility.

• **Limited coverage:**

Surveillance is limited to the range of IoT Edge cameras. Areas not covered by these cameras remain vulnerable to fires.

• Reliability of IoT Edge cameras:

IoT Edge cameras must be reliable and resistant to weather conditions, technical failures, and acts of vandalism to maintain ongoing surveillance.

• Complexity of image processing algorithms:

The development of sophisticated image processing algorithms can be complex and may require substantial resources in terms of time and technical expertise.

• Possibility of false alerts:

Automatic alert systems may generate false alerts based on various factors, such as specific weather conditions or interferences.

• Need for regular maintenance:

IoT Edge cameras and image processing systems require regular maintenance to ensure proper functioning, which can pose logistical and cost challenges.

2. Technological Choices :

2.1. Server-Side

• MongoDB

MongoDB Atlas is the global cloud version of the database for modern applications. Its design is easy to modify, and it has a rich and comprehensive documentation.

• Mosquitto - MQTT Broker

Mosquitto is an open-source MQTT (Message Queuing Telemetry Transport) broker that can be installed on a Raspberry Pi and almost all operating systems (macOS, Windows, Linux, etc.). MQTT is a fast and lightweight communication protocol particularly well-suited for home automation and connected devices.

2.2. Middleware

• Jakarta EE

Java, coupled with its JEE framework, allows for the easy development of modern and high-quality web applications. JEE technologies provide application stability and high-performance gains.

• WildFly

WildFly is a free Java EE application server written in Java and released under the GNU LGPL license. WildFly can be used on any operating system that provides a Java virtual machine. Our choice is justified by several reasons, including its flexibility and lightweight nature, which will assist in creating our application without issues. Additionally, it supports secure and reliable communication by establishing a TLS connection between the server and our MongoDB database.

2.3. Client-Side

• Bootstrap

Bootstrap is a free and open-source CSS framework focused on responsive and mobile-first front-end web development.

• VanillaJS

Vanilla JS is a fast, lightweight, and cross-platform JavaScript framework for creating incredible and powerful JavaScript applications.

2.4. Hardware Used

• Raspberry Pi 4 Board

The Raspberry Pi 4 board serves as the brain of our system. It is a versatile small-sized nano-computer that offers remarkable computing performance despite its compact size. Equipped with a powerful processor, USB ports, HDMI ports, and network connectivity, the Raspberry Pi 4 acts as the control center of our irrigation system. It can be easily connected to a display, providing a user-friendly interface for monitoring and configuring the system.

• IoT Edge Camera:

A camera equipped to detect smoke and flames and operate in challenging environmental conditions, especially in forested areas.

3. Business Models

3.1. 4P Marketing Matrix

In crafting our business strategy for the Smart Irrigation System, we embrace the 4P Marketing Matrix (Product, Price, Distribution, and Communication) as a vital guide to effectively address the evolving needs of the market.

• Product Policy :

Our Product will be the focal point of our Marketing strategy. It is an innovative technology combining both hardware and software components integrated into a user-friendly hybrid application.

•Product-related services :

After-sales services, regular updates, and warranties for up to 3 years.

Diversity in features, options, and designs to meet specific customer needs.

• Price Policy :

For positioning our product in the Tunisian market, we adopt a skimming policy in the absence of direct competition. The solution's price depends on the features the customer wishes to implement in their system.

•Commercial discount policy:

Pricing based on chosen features by the customer.

Discounts and promotions for implementing more than 2 features.

Flexible payment terms: bank transfers, online payments.

Exceptional discounts in case of quality issues or non-compliance.

• Distribution Policy:

We ensure efficient distribution by directly delivering our solutions to customers. This direct approach ensures maximum visibility and accessibility of the product in the Tunisian market.

• Communication Policy:

To promote our solution, we employ various communication techniques, including online and offline advertising.

Online advertising: social media, demonstrations at agricultural fairs.

Internet communication: newsletters, social media marketing.

Offline advertising: radio, press, displays, brochures.

Public relations: press releases, event sponsorship to enhance credibility in the market.

4. Deliverables

The deliverables of the Smart Irrigation System project are as follows:

- Conceptual Document :

Detailed document specifying requirements, services to be provided, and constraints of the solution.

Structured presentation of the architectural design and detailed system design.

- Executables and Sources :

Complete set of instructions and files hosted on GitHub.

Source code for the IoT (Internet of Things) solution and the mobile application developed for the smart irrigation system.

- Technical Documentation :

Comprehensive list of libraries, technologies, and tools used in the development of the solution.

Bibliographic references and links to online resources used during the project.

- Demonstration Video :

Mp4 format video file presenting a complete demonstration of the proposed solution. The video illustrates the system's operation, including sensor integration, data collection, real-time analysis, and interaction with the mobile application.

5. Constraints:

5.1. Work Methodology :

We have chosen to adopt the Extreme Programming (XP) method for managing our project, an approach that pushes the principles of agile development to the extreme.

XP emphasizes customer satisfaction, the implementation of iterative development, and the practice of continuous integration.

The XP method relies on:

- Strong responsiveness to changes in customer needs.
- Teamwork
- Quality of work delivered
- Early and thorough testing
- XP is based on five core values:
- Communication
- Simplicity
- Feedback
- Respect
- Courage

5.2. Time Constraint:

The allocated time for the project may not be sufficient to achieve a stable version of our application. A robust solution should include unit tests to ensure flawless operation of the application. Therefore, if we cannot cover all possible scenarios with unit tests, unexpected issues may arise in the developed solution.

5.3. Gantt Chart :

The Gantt method aims to establish an optimal schedule for the various stages of the project over a given period, taking into account several factors, including:

- The estimated duration for each task.
- Dependencies between different tasks.

- Deadlines to meet.
- Resources available for task execution.

Our project involves a set of tasks, and the progression of our work is organized as follows:

Task number	Task name	Duration	Start	Finish	Precedessors
1	Planification	4 days	27/10/2023	30/10/2023	
2	Conception	7 days	01/11/2023	06/11/2023	1
3	Developement	1 month	07/11/2023	06/12/2023	2
4	Test	4 days	07/12/2023	18/12/2023	3
5	Deployement	8 days	19/12/2023	27/12/2023	4
6	Project Delivrables	4 days	28/12/2023	01/01/2024	5

Figure 2 : Project Steps