TED UNIVERSITY

CMPE491/SENG491
Computer Engineering Senior Project
Software Engineering Senior Project

PyroGuard Fire Detection System

Project Specifications Report
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1. Introduction

This document focuses on the constraints and the requirements for the development of a fire detection and prevention system, named PyroGuard Fire Detection System. It serves as a guide to understanding the hardware, software, time, budget, environmental, operational, safety and regulatory, professional, and ethical aspects of this project alongside arguing the constraints in these matters. It also involves a more in-depth discussion of the professional and ethical issues that may be related to this project. The document also presents the project requirements that include data collection and annotation, model development, hardware integration, notification system, calibration, and customization.

1.1. Description

The project is aiming to create a system that will mostly use already-existing sources to achieve fire safety and control. This will include the detection of fire early on, as well as an alarm system that will be activated if the PyroGuard Fire Detection System is to detect the presence of fire.

The fire detection will be using live camera footage and utilizing deep learning and various image processing techniques in order to analyze, and process acquired images and video footage. Our intention here is to be able to identify any flames almost immediately, starting from the moment a spark ignites, with the purpose of avoiding any physical and material damage.

After the system detects a flame, an alarm system will be activated, and the next step will be to locate approximately where it is. The location of the fire will then be compared with the locations of predetermined fire-extinguishing stations kept in the system. Once the nearest fire-extinguishing station is found, the user will be notified.

1.2. Constraints

1.2.1 Hardware Constraints

- Camera Quality: The cameras used must have high-resolution capabilities and low light functionality to ensure accurate fire detection.
- Network Bandwidth: Sufficient network bandwidth is necessary to transmit video footage from the cameras to the processing unit in real-time.
- Processing Power: The system requires adequate processing power to analyze the video footage, detect fire, and perform the necessary computations for locating the fire extinguisher in real-time.

1.2.2 Software Constraints

- Algorithm Accuracy: The fire detection algorithm must be highly accurate to minimize false positives and false negatives.
- Real-Time Processing: The system must be capable of processing video footage and providing alerts in real-time to be effective in preventing damage.
- Compatibility: The software should be compatible with various operating systems and camera models.

1.2.3 Environmental Constraints

- Lighting Conditions: The system should be able to accurately detect fire regardless of the lighting conditions.
- Weather Conditions: The cameras and system should be robust enough to function under various weather conditions if they are placed outdoors.

1.2.4 Operational Constraints

- User Interface: There should be a user-friendly interface for the system administrators to interact with the system.
- Maintenance: The system should be easy to maintain, with clear guidelines for troubleshooting and repairs.
- Reliability: The system must be reliable and have a low rate of failure to ensure it works when needed.

1.2.5 Safety and Regulatory Constraints

- Compliance: The system must comply with all relevant safety and privacy regulations, such as Civil Defense Law (No.7126), KVKK (No. 6698), TSE etc.
- Testing and Validation: Adequate testing and validation must be conducted to ensure the system's safety and effectiveness.
- Emergency Protocols: The system should have clear and effective emergency protocols in place in case of a false alarm or system failure.

1.2.6 Budgetary Constraints

- Development Costs: The costs for developing the system, including hardware, software, and labor, have an initial budget determined as 200$. If later on in the project outside sponsors for the project are found, the budget will be updated.
- Operational Costs: The costs for maintaining and operating the system should be considered and kept within budget.

1.2.7 Time Constraints

- Project Deadline: The project should have a clear timeline, with milestones for development, testing, and deployment. It is expected to be completed in June 2024.
- Response Time: The system must be able to detect fire and provide alerts within a predefined time frame to prevent damage.

1.2.8 Ethical and Privacy Constraints

- Data Privacy: If the camera footage includes private spaces, the system must ensure data privacy and comply with relevant data protection laws.
- Ethical Use: The technology should be used ethically, and safeguards should be in place to prevent misuse.

1.3. Professional and Ethical Issues

The primary ethical responsibility of our fire detection system is to contribute to society and human welfare. The system shall quickly identify potential fire outbreak areas and provide necessary and accurate information. Thus, it contributes to public and property security. Since the system will use camera data in public areas, specifically factories and ports, the confidentiality of unused data shall be ensured. Particular attention should be paid to individuals' privacy rights. As with all computer systems, transparent and accurate reporting shall be made. The system should execute without any bias, for example without discriminating against any demographic group. It shall provide equal protection to all individuals in the areas monitored by the camera. While the fire detection algorithm of the system is being developed, existing patent and intellectual property rights shall be respected.

Professionally, our main priority is to always keep quality at the highest level. It is necessary to provide high accuracy and reliability without missed cases of fire or false alarms. It should be a timely response from emergency services. In addition, Fire and Safety Standards published by the Turkish Standards Institute and upon the letter of the Ministry of Public Works and Settlement dated 1/11/2007 and numbered 5098, in accordance with the additional article 9 of the Civil Defense Law numbered 7126, compliance with the "Regulation on Fire Protection of Buildings" decided by the Council of Ministers on 27/11/2007 will be ensured.

2. Requirements

- **Data Collection and Annotation**

  A diverse dataset of images and videos that include various fire scenarios, from sparks to full-blown fires shall be collected. The number and variety of the dataset is very important to be able to detect the fire while it is a spark, before it spreads, and to ensure that it works in both indoor and outdoor environments. After the dataset is created, we annotate the data to label fire, sparks, and non-fire instances for model training. The label variety can be increased depending on the results of the model.

- **Model Development**

  A deep learning architecture shall be selected and implemented for fire detection. According to our preliminary research, we consider using the YOLO (You Only Look Once) algorithm for fire detection. To achieve high accuracy and real-time processing capabilities, the model will be trained on YOLO with the dataset we have created. Depending on the results, different artificial intelligence models can be used.

- **Hardware Integration**

  For hardware requirements for camera integration, we should ensure compatibility and optimize so that the system shall be efficient for real-time processing.

- **Alarm and Notification System**

  A notification system shall be implemented to generate alerts upon fire detection. Alert preferences should be customizable to meet customer needs, such as a phone notification, activating sirens, or notifying the nearest fire department. Our primary alarm system will be a warning system that notifies a fire brigade directly.

- **Calibration and Customization**

  A calibration process should be adopted to adapt the system to various environments and to allow customers to fine-tune the model.

- **Scalability**

  The system shall be designed to accommodate varying numbers of cameras and multiple locations or environments.

- **Security and Privacy**

  Data privacy and security should be ensured in handling camera feeds to comply with relevant data protection regulations.

- **Maintenance and Updates**

  In order to address emerging threats and changing conditions, a maintenance plan should be established for regular model updates and system adaptation.

- **User Interface**

  A convenient and user-friendly interface shall be created for system configuration and monitoring.

- **Documentation**

  Comprehensive documentation for installation, configuration, and troubleshooting should be provided.

- **Testing and Validation**

  Rigorous testing, including field tests, to ensure system reliability and effectiveness shall be conducted.

- **Compliance and Regulations**

  Compliance with local regulations and safety standards related to fire detection should be ensured.

- **Cost Estimation**

  A long-term budget should be developed that includes costs for hardware, software development, data acquisition, and ongoing maintenance.

- **Customer Support**

  A support system should be established to address customer queries, issues, and maintenance requests.

3. References

ACM Code of Ethics and Professional Conduct

- URL: https://www.acm.org/code-of-ethics

Stanford Encyclopedia of Philosophy - Ethics of Computer and Information Science

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