CSE 564 Project Report Number 1

Team 16

Team Member Names:

1. Aditya Pant
2. Ameya Shahu
3. Lalit Arvind Balaji
4. Pravalika Mukkiri

Table of Contents

1. Executive Summary

Project Name: Drone-Based Encroachment Detection System

The Drone-Based Encroachment Detection System is aimed at revolutionizing the security and surveillance practices within corporations' asset portfolios. This executive summary provides a concise overview of the key aspects and objectives of the project.

1.1. Project Overview

The Drone-Based Encroachment Detection System is a cutting edge technological solution designed to monitor, track, and report encroachments and unauthorized activities within defined property premises. It leverages modern drone technology, AI algorithms, and robust data management to enhance security practices.

1.2. Project Goals and Objectives

1. Enhanced security operations by reduced expenditure on security
2. real-time notification and alerts, data driven pattern analysis are the main goals of this project.
3. Development of the System, AI model Development and Integration, Data and Surveillance Log Management, Real time alert and notification system, Real time alert and notification system

1.3. Key Features and Components

The encroachment detection system incorporates a range of critical features and components, including Aerial Surveillance Drone, Ground Control Station, Encroachment Detection Algorithm, User Interface, Data Management, Operator of the Drone.

1.4. Modes of Operation

Encroachment detection systems operate in various modes, including Patrolling Mode, On-Demand Patrolling Mode, Event Driven Mode, Manual Mode, Training Mode, Safe Land Mode. These modes ensure flexibility and adaptability to different security scenarios.

1.5. Summary Conclusion

The Drone-Based Encroachment Detection System is poised to set new standards in security, compliance, and operational efficiency for industrial real estate. The DBEDS empowers organizations to safeguard their valuable assets and property boundaries while optimizing resource utilization. This executive summary encapsulates the essence of a transformative project with the potential to redefine security practices in critical sectors.

2. Customer Problem

Every secured facility places importance on preventing encroachment.

The different stakeholders involved in the security system to prevent encroachment and their issues are as follows:

1. Industrial Owners / Managers
    a. Security of the industrial base including the safety of staff and the physical infrastructure.
    b. Securing resources, buildings, and people within the industrial area.
    c. Secure large areas with limited manpower.
2. Security team
    a. Regular checks on the perimeter to ensure no encroachment
    b. Access to advanced surveillance tools
    c. Ability to effectively monitor encroachment events.
    d. Immediate information of such events to take action
3. Security team head
    a. Regular updates from security personnel
    b. Access to live footage of the occurrence
    c. Assessment on the level of threat
    d. Give instructions to security personnel based on the situation
4. Technology Providers:
    a. Real-time information sharing between the system and the drone
    b. drone fail-safe systems to prevent harm
5. Technical Support Team:
    a. Troubleshoot system to identify the problematic component
6. Regulatory Authorities
    a. Ensure that the project complies with all applicable laws and regulations.
7. Local Law Enforcement
    a. Get fast and precise warnings to take action quickly.
    b. Effective collaboration with the Security team to coordinate incident response.
8. Emergency Service Providers
    a. Timely notification of emergency incidents that need a quick response.
    b. Collaboration with the security team during emergency situations.
9. Data Analysts
    a. Access to high-quality and timely data for analysis.
    b. Sufficient instruments and resources for data analysis and interpretation.
10. Researchers and Academic officials
    a. Access to project information and results for academic and research purposes.

3. Concept of Operations

3.1. Introduction

3.1.1. Project Description

The Drone-Based Encroachment Detection System is an advanced system solution that facilitates seamless surveillance of various areas, including industrial zones, ports, and commercial complexes' boundaries. It employs Unmanned Aerial Vehicles (UAVs) to bolster facility surveillance and security over expansive land areas, concurrently offering services for unauthorized land access detection, thereby safeguarding critical infrastructure.

3.1.1.1. Background

With globalization and Free Trade Agreements, there is an enhancement in trade and the investment opportunities. various enterprises experienced exponential growth. In such an era of rapid growth and expansion, it is important to preserve the integrity of the industrial areas, commercial complexes, and various infrastructure bodies. It is crucial to safeguard the asset portfolio of this enterprise hence, they can focus more on their actual operations which is essential for the global supply chain and contribute a major part of their revenue. Existing security and monitoring systems are majorly driven by human capital and often fall short of providing comprehensive and cost-effective solutions. To automate and optimize the security of the real estate assets of any enterprise, we propose the development of an Encroachment Detection System which will utilize modern-era drone technology.

3.1.1.2. Assumptions and Constraints

The assumptions and constraints that we will encounter as we progress with the development of our Encroachment Detection System are:

1. Regulatory Compliance

   Delivering a system that adheres to government guidelines and regulations concerning the use of drones in surveillance, data privacy laws, and aerospace-related regulations.

2. Environmental Impact

   Given the extensive use of drones in our project, we are committed to minimizing their environmental impact, particularly in terms of noise pollution.

3. Battery Life and Range

   Using cutting-edge battery technology and implementing optimal deployment strategies that are essential for the efficient operation of a drone-based surveillance system.

4. Cost Considerations

We strive to ensure that DBEDS remains cost-effective to benefit a wide range of organizations.

5. Weather Conditions

   Communication with the drones, vision of the camera systems, functioning of drones can be hamstrung by the weather and requires deployment of effective counter strategies.

3.2. Overview of the Envisioned System

3.2.1. Overview

The envisioned Drone-Based Encroachment Detection System is designed to safeguard real estate assets of enterprises such as industrial complex, manufacturing plants, power generation plants, warehouses, ports from encroachment to avoid unauthorized activities and safety of the properties. It is automated using drone technology to reduce human efforts and provide capabilities such as real time tracking, monitoring, auditing and reporting, ensuring the security compliance within the perimeter of the real estate.

3.2.2. System Scope

The scope of Drone-Based Encroachment Detection System is as follows -

1. Aerial Surveillance

   The drones used in the system will be equipped with cameras to conduct security audit of the area

2. Encroachment Detection

   AI models trained using deep learning will be enabled on the drone to detect encroachments.

3. Security Alerts

   System will have instant alert mechanism to if any encroachment or intruder is detected during surveillance

4. Geofencing

   To ensure the surveillance boundaries of the drone, geofencing capabilities will be defined.

5. Remote Controlling

   In case of emergency situations or manually guided surveillance drones can be used.

3.3. Description of Envisioned System

3.3.1. Needs, Goals and Objectives of Envisioned System

Needs of the Drone-Based Encroachment Detection System are as follows -

1. Efficiency in Premise Protection

   The need for robust and cost effective surveillance method to proactively mitigate encroachments issues

2. Real Time Surveillance

   Real Time Surveillance need to get instance alerts for rapid response

3. Security Compliance

   The need to comply with the property protection compliances designed by regulatory authorities.

Goals of the Drone-Based Encroachment Detection System are as follows -

1. Enhanced Security Operations

   Develop a system that significantly enhances the security of the assets portfolio of the enterprise

2. Reduce Expenditure on Security

   System should be able to reduce security expenditure of the organization with enhanced security measures.

3. Real-time Notification

   During surveillance systems should be able raise alert and notify the appropriate security department in case of encroachment detected.

4. Data Driven Pattern Analysis

   Implementation of data analysis to identify patterns is logged surveillance data.

This project has the following objectives -

1. Development of the System

   Develop cutting edge Drone-Based Encroachment Detection

2. AI model Development and Integration

   Develop state of the art and accurate encroachment detection algorithms and integrate with the drone.

3. Data and Surveillance Log Management

   Implement an efficient real time database and data warehouse to store logged data.

4. Geofencing Implementation

   Implement a geofencing mechanism to define the perimeter of the premise for the operation of the drone.

5. Real time alert and notification system

   Implement mechanism to raise alert and notify appropriate authorities when alert is raised by drone.

6. Surveillance Data Reporting and Analysis

   Enable system to log surveillance data into data warehouse for future uses.

3.3.2. Overview of System and Key Elements

The Drone-Based Encroachment Detection System will proactively monitor, detect encroachments or unauthorized structures within the boundaries of the commercial properties of the organizations. Key elements of the systems are as follows -

1. Aerial Surveillance Drone

   Drones are the backbone of the system. They are equipped with cameras, different sensors and radio communication devices. These drones will survey an area defined as the perimeter of the property.

2. Ground Control Station

   All the data captured during the surveillance is sent to the ground control station. System will be mostly automated but manual control can be possible through ground control stations.

3. Encroachment Detection Algorithm

   AI driven algorithms will be tuned to process real time video streams through the drone.

4. User Interface

   An user interface will provide functionalities such as real-time monitoring, alerts configuration, access to past surveillance data.

5. Data Management

   System will have a data management facility to store surveillance data and report as per the query.

6. Operator of the Drone

   Operators are the human resources who are skilled in handling drones for manual control.

3.3.3. Interfaces

Encroachment Detection Systems will have following interfaces -

1. User Interface

   It is a primary interface for human interaction to visualize data, access past data, receive alerts etc.

2. Configuration Interface

   Configuration interfaces will be used by admins of the system to change security requirements or configure new sensors on drones.

3. Communication Interface

   This interface will be used by drones to communicate with the ground station for logging surveillance data. Same interface will be used by ground stations to send commands to drones.

4. Alert System Interface

   This interface will be responsible for triggering alerts on defined conditions and sending notifications to appropriate authorities.

5. Data Storage Interface

   Through this interface various subsystems will interact with data storage facilities.

3.3.4. Modes of Operations

The system has capability to operate in different modes, these modes are as follows -

1. Patrolling Mode

   When the system will work in this mode, the drone will follow a configured patrol path after certain time intervals.

2. On-Demand Patrolling Mode

   On ground operators can trigger this mode to conduct a monitor on demand.

3. Event Driven Mode

   System can perform action particularly drone based monitoring in case of any security related events.

4. Manual Mode

   On ground operators can manually control drones in manual mode.

5. Training Mode

   To train operators on the system this mode can be used.

6. Safe Land Mode

   In case of a fault in the drone, this mode will be activated to safely land the drone.

3.3. Support Environment

1. Scheduled regular maintenance and system updates for drone
2. drones move to Safe location at cases of adverse weather conditions
3. future upgrades may include using additional thermal sensors for basic detection and regular footage once detected encroachment

3.4. Operational Scenarios, Use Cases and/or Design Reference Missions

3.4.1. Nominal Conditions

1. Routine Patrol [DRM: 100]
   a. Routine drone patrol over the industrial base area under normal conditions.
   b. Drone automatically follows assigned paths, captures data, monitors area.
2. Intrusion-Free Monitoring [DRM: 101]
   a. System operates without detecting any encroachment under normal conditions.
   b. System collects data, but no security alarms, alerts are generated.
   c. Maintains surveillance data records without any incidents.
3. Scheduled Maintenance [DRM: 102]
   a. A scheduled maintenance is planned for the drone and system.
   b. All the operations are temporarily stopped for updating / checking the system.
4. Encroachment Identification [DRM: 103]
   a. Identifies encroachment during regular / scheduled patrolling.
   b. Alerts and notifies the security team with the data of encroachment.
5. Data Analysis [DRM: 104]
   a. Regular data analysis to identify the patterns and trends in the data.
6. Scheduled Security Assessment [DRM: 105]
   a. A scheduled security evaluation, which includes a thorough examination of the surveillance data.

3.4.2. Off-Nominal Conditions

1. Communication Failures [DRM: 106]
   a. System encounters a communication failure with the drones.
   b. Drones activate failsafe methods, goes to a safe location.
   c. Keeps the recorded data safe until it gets connected to the system again.
2. Adverse weather conditions [DRM: 107]
   a. Unexpected severe weather situations such as heavy rain, storm winds, dust etc.
   b. Drones try adapting the flight pattern to ensure safe operations.
   c. In severe cases, drones activate failsafe methods, goes to a safe location.

3. Data Breach Attempts [DRM: 108]
    a. If System identifies a data breach attempt, it sends alerts, activates security measures.
    b. It blocks the intrusion attempt, notifies the cybersecurity personnel.
4. Operator Error [DRM: 109]
    a. A drone departs from its intended flying route due to operator error.
    b. System sends alerts, and lands at a safe location.
5. Power Supply Interruption [DRM: 1010]
    a. When a drone encounters an interruption in power supply, it immediately enables land safe mode.

3.5 Impact Considerations

3.5.1 Environmental Impacts

1. Noise Pollution

    Drones traversing between points A and B emit substantial noise, especially during takeoff and landing. This noise can disrupt and divert the attention of both workers and local wildlife.

2. Air Pollution

    The drone relies on batteries that degrade over time. The production and disposal of these batteries may lead to the release of harmful chemicals into the environment.

3. Waste Generation

    Utilizing various sets of drones over time can generate waste that necessitates proper disposal measures.

4. Energy Consumption

    Operating a cyber-physical system comprising multiple drones and other software-driven components can result in substantial energy consumption. Therefore, significant efforts must be dedicated to optimizing energy efficiency.

3.5.2 Organizational Impacts

1. Enhanced Security

    Our system offers real-time monitoring across the expansive facility, enhancing threat detection and preventing unauthorized access.

2. Cost Savings

   Our objective is to deploy drones and reduce the need for security personnel. Deploying drones proves to be a more cost-effective approach, as corroborated by [1]1 asmag.com.

3. Efficiency

   Comparing drones to security personnel who require breaks, drones can be promptly deployed when their battery is depleted, either by battery replacement or by substituting another drone.

4. Data Analysis

   Our system facilitates live monitoring, providing access to data in the event of a security breach. This data can be utilized to enhance security measures.

3.5.3 Scientific and Technical Impacts

1. Improved Encroachment Protection

   Continuously enhancing our software to refine the detection of unauthorized access will not only bolster our encroachment protection but also ensure its ongoing improvement.

2. Using an AI for Encroachment Protection

   We won't limit ourselves to using machine learning and AI models solely for intrusion detection via cameras. Instead, we envision the potential for an AI system capable of orchestrating and coordinating all the drones seamlessly to enhance security.

3. Improvement of Hardware

   Drones are equipped with batteries, cameras, sensors, and communication devices to facilitate their operation within this system. The continuous use of these drones over time contributes to the advancement and refinement of cameras, sensors, communication devices, and batteries. This progress holds implications for their application across various fields.

3.6. Risks and Potential Issues

Some potential risks and issues associated with this cyber physical help system are

1. Sensor Failure

   Technical failures or malfunctions in the sensors onboard the drones may lead to data inaccuracies or loss.

2. Communication Failures

[1] https://www.asmag.com/showpost/33352.aspx

Interruptions in communication between drones and the system may hinder real-time surveillance.

3. Cybersecurity threats

   The system is prone to cybersecurity dangers, such as attacks on the infrastructure that controls operations.

4. Data Privacy Concerns

   Privacy concerns may arise because of surveillance data collection by drone.

5. Integration Challenges

   Integration of existing systems with new drones or new materials may be hard, but would require special skills.

6. Operational Risks

   Severe weather conditions may cause damage to the drones causing material loss.

7. Communication Range

   The effective range of communication of the drone to the system may limit the performance when working in a large industrial base.

8. Interference Risk

   Operations can be affected by the potential for interference from other radio frequency equipment or uncontrolled drones in the surveillance airspace.

9. False Positives

   The encroachment detection algorithms of the system could produce false positive alerts, causing a waste of resources and unneeded replies.

10. Regulatory compliance

    It can be difficult and time-consuming to ensure compliance with changing legislation and acquire appropriate licenses for drone operations.

4. Conclusion

The Drone-Based Encroachment Detection System (DBEDS) represents a paradigm shift in how we safeguard industrial areas, ports, and commercial complexes.

Transformative impact and the potential benefits that DBEDS promises to deliver include:

1. The Power of Surveillance Evolution
    a. harnesses cutting-edge drone technology, advanced AI algorithms, and robust data management transcending traditional security measures.
    b. takes a proactive stance against encroachments and unauthorized activities, ensuring property boundaries remain sacrosanct.
2. Enhancing Security, Compliance, and Efficiency
    a. Primary goal is to enhance security manifold by providing real-time monitoring and rapid response capabilities.
    b. Secures efficiently and in full compliance with legal and regulatory standards.
    c. By automating encroachment detection, DBEDS optimizes resource allocation and streamlined operations.
3. The Promise of Timely Detection
    a. With its ability to promptly detect potential encroachments and notify security personnel, it creates a robust defense mechanism.
4. Harnessing Data for Informed Decisions
    a. Through data analysis and trend identification, understands the broader security landscape.
    b. foresee potential threats and take preventive measures.
5. Adaptability and Scalability
    a. DBEDS is designed to be flexible, offering a range of operational modes to suit different security scenarios.
    b. Its scalability architecture ensures that it can grow with an organization's changing needs, making it a long-term investment.
6. Training, Support, and Reliability
    a. providing comprehensive training and ongoing support ensures that operators and users are proficient in utilizing the system effectively.
    b. Scheduled maintenance routines further guarantee the reliability and longevity of the system.

In conclusion, DBEDS is poised to redefine security practices and set new standards for surveillance in critical sectors. It's not just a system; it's a safeguard, an efficiency optimizer, and a compliance enforcer. As we embark on this transformative journey, we look forward to a future where industrial areas, ports, and commercial complexes are shielded by the vigilant eyes of DBEDS, ensuring their continued safety, productivity, and prosperity.

5. Appendix A: Credit Sheet

Team Member Name	Contributions
Aditya Pant	Discussion on Team Project Ideas Concept Operations: Introduction - Project Description, Background, Assumption and Constraints. Impact Considerations - Organizational, Environmental and Scientific/Technical.
Ameya Shahu	Reviewed available literature for selecting problem statement Scheduled brainstorming sessions for topic finalization Concept of Operation - Worked on Background, scripted Needs, Goals and Objective of the project defined scope of the project, derived mode of operations, Interfaces Collaborated content for Executive Summary and Conclusion
Pravalika Mukkiri	Discussion on Team Project Ideas Customer Problems - Stakeholder analysis Concept Operations: Operational scenarios, use cases, design reference missions Nominal cases and Off-Nominal cases Risks and Potential Issues
Lalit Arvind Balaji	Review of existing technology Discussion on team project ideas Customer problems - Stakeholders analysis Concept of Operation - Support Environment Conclusion