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DEEP LEARNING–BASED AUTONOMOUS DEFENCE DRONE FOR UNAUTHORISED INTRUSION DETECTION AND RESPONSE

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ABSTRACT:

Securing and monitoring high-risk regions (military borders, restricted areas and government facilities) is challenging for today's Security Systems. Many traditional security methods depend on personnel observing certain areas (solid reliance on humans). Thus historically, this has resulted in many security operational delays due to human errors and injury, etc. A proposed Defence Drone System utilizing Deep Learning, has been developed to monitor sensitive areas in an intelligent and automated fashion, with advanced threat detection capabilities. The proposed Defence Drone System will utilize an unmanned aerial vehicle (UAV) with integrated cameras and sensors to collect visual data (real time) from an area being monitored. The collected UAV data will be configured utilizing Deep Learning and Computer Vision (or Image Processing) technologies to process visual data and detect the presence of unauthorized individuals, suspicious vehicles, unusual movements, etc. If a threat is identified during the collection of visual data, an alert will be sent to the security control center, and a record of the detected visual data will be provided to facilitate further investigation. This will allow security personnel to respond faster and make better informed decisions.The ultimate objectives of the project are to improve the efficiency of surveillance operations, reduce the potential for human risk, and enhance security operation by utilizing Drone technology integrated with AI technology. This proposal demonstrates the potential for intelligent drones to be utilized to support modern defense and monitoring applications reliably and effectively.

***Keywords*:** Defence Drone, Deep Learning, Computer Vision, Drone Technology, UAV Surveillance, Real Time Threat Detection, AI Security Systems, Intelligent Monitoring.

1. INTRODUCTION:

Today's society is concerned about security; therefore, security at military borders, restricted areas or government-controlled sites must always be actively monitored to detect intruders and their activities and to identify threats before they develop. Traditional methods of surveillance, such as humans or Closed-Circuit Television (CCTV), usually have drawbacks like slow response times, little coverage of the area, and greater risk to security personnel working in hazardous situations. The availability of new technologies has made it possible for new Intelligent Surveillance Systems (ISS), also known as Defence Drone Systems, to be developed using artificial intelligence (AI). Drones are able to scan large areas quickly, gaining visual data instantly from out-of-reach areas. When combined with advanced technologies like deep learning and computer vision, drones can also automatically analyze captured images and videos to determine whether they show any unusual or suspicious behaviour. The present study describes the development of an ISS for Defence Drones powered by Deep Learning which will be utilised by Australian Defence Forces (ADF) to monitor sensitive locations, and to provide the ADF with an early warning of possible threats. Each drone utilises cameras, sensors and an AI model to continuously and in real-time monitor the movements of unauthorised individuals on foot and suspected unauthorised vehicles in a monitored area. Drones increase the speed and efficiency of Surveillance by providing broader coverage of a monitored area and providing faster communications to Control Centres.

Figure 1 – Intelligent Drone Surveillance Concept

1.1 Background of the Study:

Security monitoring technology has rapidly advanced over recent years. Previously, most surveillance was completed using human guards; these individuals monitored national and international borders, restricted access areas, and other sensitive areas of government. While human monitoring is critical, there are limitations to it (such as fatigue, limited physical sight ability, delayed responses, and the chance of making an error as a result of these limitations). Due to an increase in the number and severity of security threats to both private and public sectors, there has been a need for more reliable and efficient means of monitoring security. To assist in improving security monitoring, closed-circuit television (CCTV) systems were designed to provide continuous video surveillance of predetermined locations. However, these types of systems have limitations as well. CCTV systems are fixed in place (they cannot be moved around to other areas), cover a limited area, and still utilize human operators to monitor and analyze the video footage from CCTV systems. In many large or remote areas, such as national borders or military zones, CCTV systems are unable to detect potential threats in a timely manner.Through the use of various artificial intelligence technologies, including computer vision and machine learning, today's security monitoring systems automatically analyze video footage, identify various items, and recognize patterns to find potentially problematic situations without human intervention. When combined with drones and deep learning technologies, real-time visual information is captured and analyzed, while providing the capability to automatically detect humans and/or vehicular (and other) activities that indicate suspicious movement, thereby increasing the overall efficiency of security monitoring and assisting agencies responsible for the protection of sensitive areas. Ref[1],[4]

Figure 1.1 – Evolution of Security Monitoring Systems

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1.2 **Problem statement:**Monitoring large and secure locations, such as military borders and government facilities, can be difficult because these locations require constant monitoring to ensure that there are no unauthorized individuals, suspicious vehicles, or suspicious activity that could put national security at risk. Traditional surveillance primarily uses personnel as well as fixed camera systems; however, these security measures do not effectively cover large geographical areas or remote locations. One major limitation of traditional surveillance systems is that they do not provide full coverage of an area. The cameras are fixed in one location, so they can record all sorts of activity in that location; however, they cannot easily identify moving objects over long distances. Therefore, in border areas or remote security zones, monitoring all activity is difficult using fixed camera systems only. Monitoring by personnel can also create delays in identifying potential threats because security personnel are not able to monitor all situations at all times.

Additionally, the security personnel who work in a threat filled environments can be at risk while they are monitoring. Finally, fixed camera systems, which do not have the capability to perform intelligent analysis of the footage, cannot detect suspicious behavior automatically; therefore, the process of identifying a potential threat is lengthy and inefficient.By utilizing drones with deep-learning technology, a new surveillance method will be based on real-time monitoring, automatic detection of threats, and rapid response to any incidents that may occur in high-security areas. Ref[9],[11].

1.3 **Objectives of the Study:**Aiming to produce an intelligent aerial defense drone-based surveillance system that autonomously detects suspicious activity through deep learning technology to enhance surveillance efficiency, real-time monitoring and facilitate Security Force personnel quickly and accurately identifying suspicion actions. To accomplish this goal, a few objectives are established; one objective is to design and engineer a drone-based Surveillance System for monitoring large, sensitive areas such as Military borders and restricted areas. Another objective is to implement a real-time Deep Learning and Computer Vision Model capable of detecting unauthorized individuals, suspicious motor vehicles, and unusual patterns of movements. The drone system will utilize live video images from the drone & use its analytical capabilities of the video footage to automatically process images and detect potential threats. In addition, an alert system that communicates the information of detected suspicious activity to the Security Control Center (SCC) shall be developed. The proposed system will also have the capability of being used to improve monitoring coverage and minimize risks to human Security Force personnel through the deployment of intelligent Aerial Surveillance.Ref[6],[18].

1.4 **Scope of the Study:**The aim of this research is to create an intelligent drone system that can monitor very secured areas using deep-learning technology and computer vision. The drone will be used in environments like military borders, restricted areas, and other sensitive areas requiring continuous surveillance. As part of the research project, the drone-based surveillance will collect video data from the physical environment using cameras and sensors. The video data that will be collected by the drone will then be processed by applying deep-learning algorithms to identify objects in the video such as people and vehicles. In addition to identifying objects in the video, the drone will also generate alerts for suspicious activity or unusual movements to the Command centre for Security control, and the events will be saved for later analysis.Another key component of the research involved creating an automatic surveillance system that leverages drone technology and integrates it with artificial intelligence. The project also describes the functionality of the system from data collection to image processing to object detection to alert generation. Additionally, the project demonstrates how modern technology improves efficiency and effectiveness of surveillance systems in the field.Though this project develops capacities to prototype drones, data, and algorithms, it is strictly an academic-research prototype that lacks an actual military deployment capability or capabilities as a defense system (i.e. weapon system).Ref[13],[5]

1.5 **Significance of the Study:**In this paper, we will demonstrate how modern methods can use advanced technologies to enhance security and surveillance. Security and surveillance are hot topics today, especially when it comes to preventing unauthorized access, illegal actions or events and minimizing the risk of crime through multiple forms of continuous observation within high-risk settings. Continuous monitoring is extremely important for most high-risk situations; security systems are compared to past systems, and improvements are made by automating the system in order to have an ongoing and more automated way of observing. In large or sparsely populated areas, traditional systems may become difficult and therefore not effective. The existence of intelligent and automated solutions are therefore necessary.

2. LITERATURE REVIEW:

Throughout my research, the literature review plays a key role in learning about existing technology, methodology, and systems that relate to drone surveillance as well as intelligent security monitoring. Several researchers have created cutting-edge surveillance devices using artificial intelligence, computer vision, and UAV technology, and examining these works can help to determine how well the current technologies are functioning and what areas could be improved on. There have been many different studies on the use of drones for monitoring larger, more restricted areas such as borders and forests as well as areas that cannot otherwise be accessed. The use of drones involves equipping them with cameras and/or sensors to collect real time data on the environment. Then algorithms from machine learning and deep learning can be used to automatically identify and classify objects, such as people and vehicles, which can help with quickly identifying potential threats.

Modern surveillance systems also utilize computer vision techniques to provide real time object detection and activity recognition with less human intervention; however; the technology is still facing issues, including but not limited to limited accuracy, delayed detection, and difficulty in monitoring the entirety of a location that is very large.This study will be using existing literature to stimulate insight that will help create a more robust and efficient drone defence system that will address the prior limitations of both the technologies and support the advancement of a more intelligent surveillance approach. Ref[2],[19].

3. PROPOSED SYSTEM / METHODOLOGY:

3.1 System Overview:

This is an intelligent defence drone system, which will provide the ability to monitor secured sites while using Deep Learning Technology & Computer Vision Technology to detect threats to secured areas. The use of both AI and Drone Technology will create a smart surveillance solution capable of covering very large monitored areas while detecting suspicious activity in real time.Drones equipped with cameras and sensors will be flying over secured areas, including Borders, Restricted Areas, and Sensitive Government Areas, and will capture live video feed(s). The captured video's individual frames will be processed via a trained AI Model against the detected object(s) (ie. humans and vehicles) in the captured video(s) to confirm that the detected object is either "Normal" or "Suspicious" based on predefined conditions.

In the event of an identified Unauthorised Person, Unusual or Suspicious Movement, or Suspicious Vehicle(s), the system will automatically create an alert immediately and will generate a report to be sent directly to the appropriate Security Control Centres for required action. All recorded or stored video footage and results from the detection will be uploaded to a relational database for subsequent review & analysis.Overall, this proposed Defence Drone System will improve security operations by providing a real-time monitoring capability, Automated Threat Detection, reducing human workload, and improving surveillance capability & efficiency.Ref[7],[14].

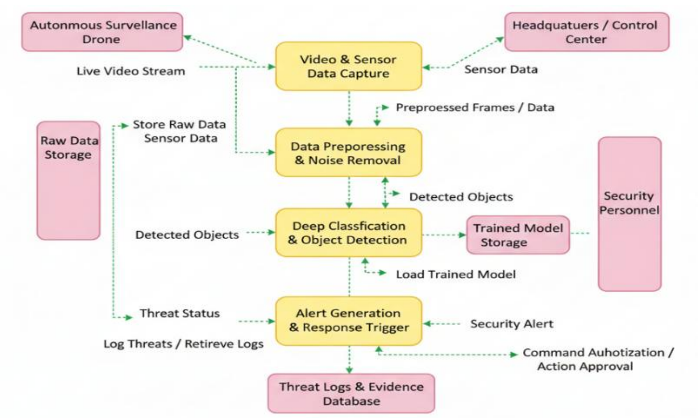

Figure 3.1 – Complete Defence Drone System Overview

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3.2 System Architecture: The architecture of the system gives details about each element of the new defence drone system in relation to its elements and how they integrate to provide intelligent surveillance. The components of the system include drone platforms, data processing units (DPUs), artificial intelligence models (AIMs), communication systems and data storage technologies that create an effective monitoring system.The first component of the defence drone system is the drone platform. This platform contains a flight controller, camera, GPS module and sensors, all of which enable the platform to fly over pre-defined, secure areas, and record real-time video and environmental data. The data acquisition module provides for the recording of live video, and converting live video into frames for analysis.

The next component of the defence drone system is the processing and analysis module. The processing and analysis module uses deep learning algorithms that are part of the overall AI model, and computer vision algorithms, to detect and evaluate the image content in each video frame and identify objects, such as humans and vehicles. In the case of detecting an object, the AIM will determine if there are any patterns related to its movement (based on the amount of video captured) indicating whether the activity appears to be normal or suspicious.If an activity is determined to be suspicious, the third component of the defence drone system is the threat detection and alert module that generates an alert that goes back to the security control centre, along with still images or video clips of the activity being captured. The fourth module of the defence drone system is the database module. The database module stores all data (i.e. recorded video, detections and logs) that can be used for future analysis.The last of the modules is the control centre module, which provides the monitoring of alerts, makes decisions on the course of action for each alert and may send commands back to the drone. Ref[7],[10].

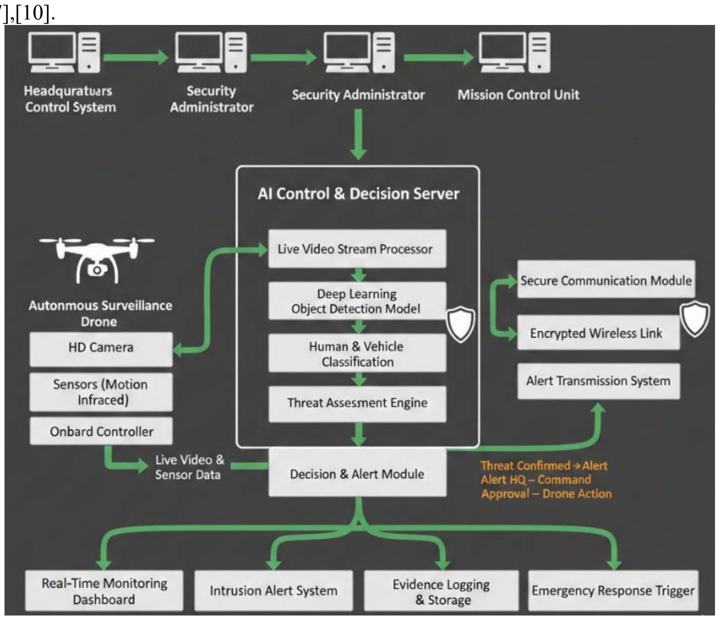

Figure 3.2 – System Architecture Diagram

3.3 Hardware Components: Integration of the hardware components will form the physical, or structural, foundation of the proposed defence drone system; will enable the drone to: fly; capture visual data; collect environmental data; support the surveillance process. Choosing the most appropriate hardware components and integrating them into the drone as quickly as possible will result in stable flight; accurate monitoring; continued performance. The frame is the primary structural support for the drone, with supporting structure, such as motors; the flight controller; the camera; and the battery, attached to the frame. An improved design for the frame, to make it more lightweight and stable, will provide balance and efficiency during flight. The flight controller is the drone's "brain", which controls the drone's movement and stability. The flight controller receives data from sensors, such as the gyroscope and accelerometer, and provides the motor with a signal to adjust the speed of each motor based on this data.The camera module is designed to capture live video and images of monitored areas. The deep learning model will use this visual information to identify objects and detect suspicious behaviour. Generally, large, high-quality cameras will allow data to be detected with greater accuracy. The GPS module will provide real-time tracking of the drone's location. The GPS module will also record the location of each detected event for use as evidence in an investigation or to provide information during a security analysis. The motors of the drone will all be brushless; electronic speed controllers will control the speed of the brushless motors. The battery will provide power for all electronic components of the drone. Integration of these hardware components will provide stable flight, allow for real-time data collection, and allow for effective surveillance activities.Ref[8],[9]

3.4 Software and AI Model: In the defence drone system being suggested, the AI software and model are critical parts as they will use the data captured by the drone to help find potential threats. The drone collects visual data by flying, but its AI software will process what it collected and turn the data into information that can be used to help secure operations. By using programmatic frameworks and software tools to process the video captured by the drone camera, the images of the video stream can be isolated into independent frames and then identified through the use of computer vision.

The centre of the overall system is a deep-learning model that was built using images of human beings, vehicles, and other relevant objects in its sets of data. During the training phase, the model would learn to identify certain characteristics and patterns in the data, and then be able to recognize the same objects through real-time video captured by the drone. Once the model has been created, the software will send each frame of the video to the model for analyses. The software will label the identified objects and identify potential suspicious activities based on a set of pre-defined conditional standards. The system also contains four different modules that will handle data processing, data visualization, and data communication so that the results of the analysis will include bounding boxes, labels, and degrees of confidence of the identified subjects, while also storing the associated events and forwarding alerts back to the control centre.Ref[17],[20]

4. RESULTS AND ANALYSIS:

4.1 Experimental Results and Analysis: The results of the experiments conducted to test the AI-based Defence drone surveillance system are presented in this chapter. The analysis of these results is intended to determine how effectively the system can detect and track various objects through aerial images of drones using deep learning technologies. The results provided evidence that the system can successfully track and classify military personnel, military vehicles and other types of objects within a surveillance environment, thereby providing support to missions in high-risk, restricted areas. To complete the research necessary to validate the AI based defence drone surveillance system, a number of experiments utilizing aerial surveillance images captured by simulated drones. Each aerial surveillance image was processed by deep learning technology to perform real-time object detection and classification. After processing an individual frame of a captured drone image, the system generated bounding boxes and a confidence score associated with each object detected in each frame, allowing the system to categorize and label the detected object as either a soldier, military vehicle, or another type of object.The system's performance was evaluated through experimentation performed under varying degrees of conditions, including an investigation into the single object detection versus multiple object detection capabilities of the system, as well as environmental conditions. The results of each of the individual tests were evaluated by means of both visual inspection and metric evaluation, which allowed for greater accuracy in determining the success of the object detection by the AI based defence drone surveillance system, compared to how effective the system operated during daylight hours compared to low-light conditions.The results of this series of tests affirmed the effectiveness of the AI based defence drone surveillance system in terms of providing an automated method of conducting surveillance, as well as enhancing security operations within sensitive environments.

4.2 Dataset Used for Testing: The quality and variety of the dataset utilized in training and testing are most essential in determining the performance of any deep-learning-based detection system. This study used a database comprised of aerial surveillance images to evaluate the proposed defence drone monitoring system. The database contains actual surveillance events in which members of the military and their associated vehicles are viewed in many different locations; these images were

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captured by drone at the aerial level and include things such as soldiers and military vehicles as well as background materials, including terrain, roads, buildings, and vegetation. The wide variety of background items within the image will help the model learn how to separate out those items that are important targets from those items that are not and, thus, increase the accuracy of detection when performing surveillance.

This dataset has two components: a training dataset and a test (or evaluation) dataset. The training dataset is used to teach the model to identify various types of objects; the test dataset allows the investigators to assess and measure how well the trained model performs with new images. The images within the dataset include captures of objects and scenes taken under numerous environmental parameters including: different lighting conditions (all day and low-light), various object sizes, wide range of camera angles, and varying levels of difficulty with respect to background complexity, as well as daytime and nighttime scenes. All images within the database contain information identifying as well as enclosing, in a bounding box, every object in the scene, which assists the model in learning the classification of the objects as well as how to detect them spatially.

Dataset Attribute	Details
Dataset Name	Aerial Military Surveillance Dataset (AMSD)
Source	Simulated drone aerial images (border & restricted areas)
Total Images	12,500 annotated frames
Training Set	8,750 images (70%)
Validation Set	1,875 images (15%)
Test Set	1,875 images (15%)
Object Classes	Military Personnel, Military Vehicle, Civilian, Background
Image Resolution	640×640 pixels (resized for model input)
Annotation Format	Bounding boxes with class labels (YOLO format)
Lighting Conditions	Daytime, Low-light, Nighttime (thermal-aided)
Altitude Range	30 m – 150 m AGL (Above Ground Level)
Background Variety	Terrain, Roads, Buildings, Vegetation, Mixed Urban
Augmentation Applied	Horizontal flip, rotation (±15°), brightness variation, mosaic

Table 4.2 Summary of the Object Detection Dataset

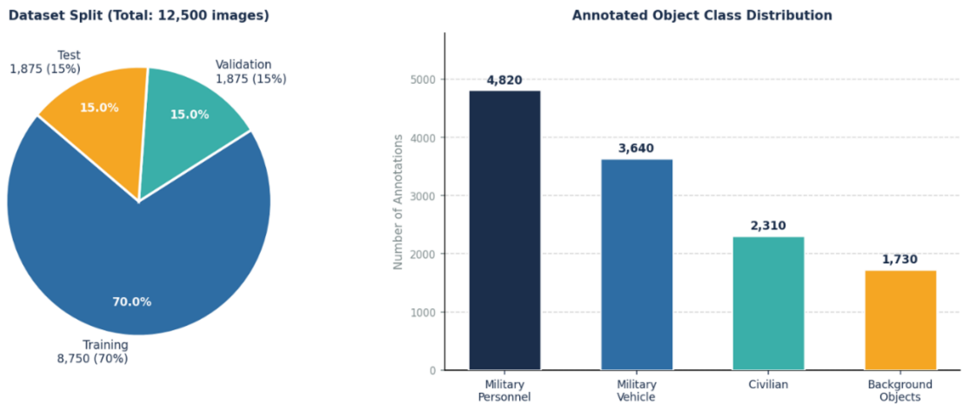

Figure 4.2 : Dataset split into Training (70%), Validation (15%), and Test (15%) subsets.

4.3 Threat Detection Using Artificial Intelligence: Detecting threats is one of the primary objectives of any proposed defence drone surveillance will be through automatic means of identifying potentially suspicious or dangerous objects based upon the video captured by the camera mounted on the drone. Rather than relying solely on human operated monitoring, the system will utilise Artificial Intelligence to assess the visual data and to automatically determine if any potential threat exists at the time of processing. The drone will be continuously capturing live video feed of the surveyed area it has flown over and transmitting it back to the processing unit. The video will be processed by receiving each frame of the video and analysing these frames individually for the first stage of processing: Image Preprocessing.

4.4 Alert Generation and Notification System:A vital part of the proposed drone defense surveillance system is the alert generation and notification system. This system will automatically generate an alert whenever suspicious activity or dangerous objects such as weapons, unauthorized vehicles, or suspicious human movement are detected by the artificial intelligence threat detection module in a restricted area via drone surveillance monitoring (which is not continuously monitored by human operators).Once detected, the user will receive an alert that provides details about the object type detected (for example, weapon, unauthorized vehicle, etc.), the date and time when it was detected, and the location where it was detected, as well as the captured image frame of the object as evidence.

Alerts are delivered in many different ways; for example, visual alerts on the monitoring dashboard, email notifications, mobile alerts via text messages or SMS, and/or voice alerts. The alert system will also have a priority-based system in that each object detected has an associated risk level assigned, and that if any object detected reaches a specific risk level, the alert system will activate an alarm(s) at the monitoring station.All alerts will be retained by the alert system in a database, which includes sufficient detail for further investigation and analysis. Confidence scores will be assigned to reduce false alerts and improve the reliability of the alerts to provide a quicker response time for security personnel and to provide an improved level of security monitoring of sensitive areas.

4.5 Object Detection Results: In this segment you will find information on the type of data processed by the AI assisted drone surveillance system as part of the object detection protocol. The purpose of the experiment was to analyze the ability of the trained deep learning model to effectively detect and distinguish between different types of objects that are visually present within the drone camera's field of view during drone operated surveillance. Testing was completed using the drone's ability to send back aerial photos and videos to create the simulated physical environment of being on the border surveillance environment. The image and video frames that were collected and transmitted back. The prototype system operates by detecting each object with a bounding box indicating the class of object such as Military Personnel or Military Vehicle and includes an indicator of the maximum probability of it being an accurate detection score. Test results indicate the trained deep learning model is capable of detecting the presence of both single and multiple object types that have been identified as part of the overall physical area of interest, as well as the specific location of each detected object within the image frame.

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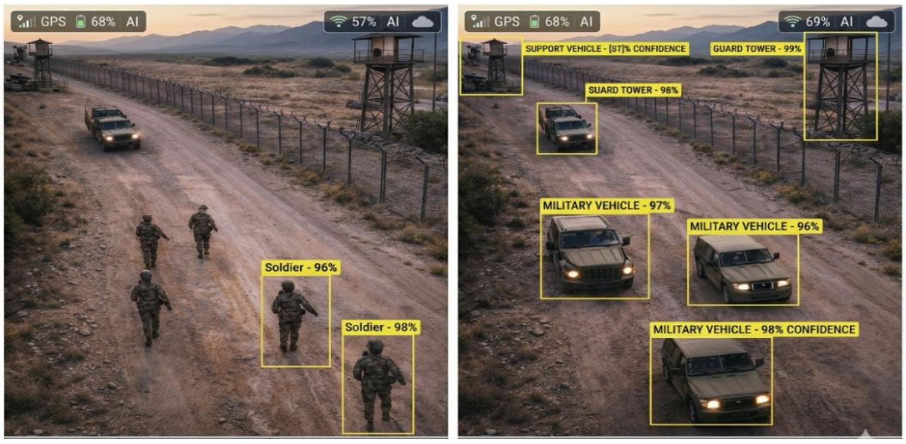

Figure 4.5.1 – Object Detection Results

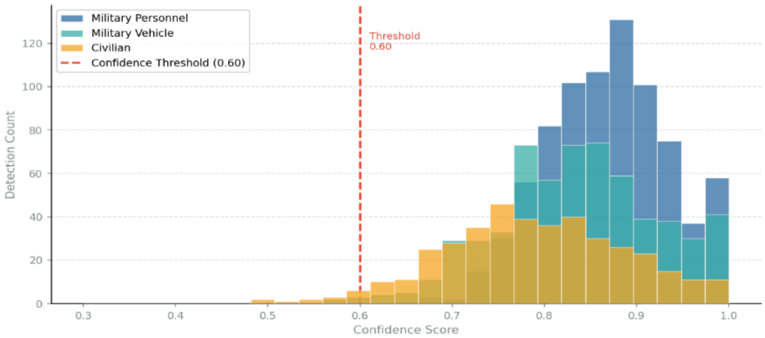

Figure 4.5.2 – Confidence score distribution for each object class

4.6 Night Surveillance Detection Results: In this section of the report we will explore how well the proposed AI based defense drone surveillance system functions when operating in low light situations (at night or in other low light environments). Many security threats happen in the dark so there needs to be a way for surveillance systems to function well under limited light conditions. For the analysis phase of the experiment, the drone captured images of the experiment site as if it were conducting nighttime surveillance. The lighting conditions were such that the light levels were low and the visibility would also be low. Once captured, the images were then processed by the ML model to see if it could still detect objects (such as people, military vehicles, etc.) in this lighting condition.

The analysis results show that although poor light conditions can negatively affect the detection accuracy of the ML model, the drone does detect objects (i.e., clearly defined, illuminated by security lights or vehicle headlights) when operating under poor light conditions.Target objects have been surrounded with bounding boxes, labelled and assigned a confidence score by the AI model based on their shape, pattern and learned feature characteristics.

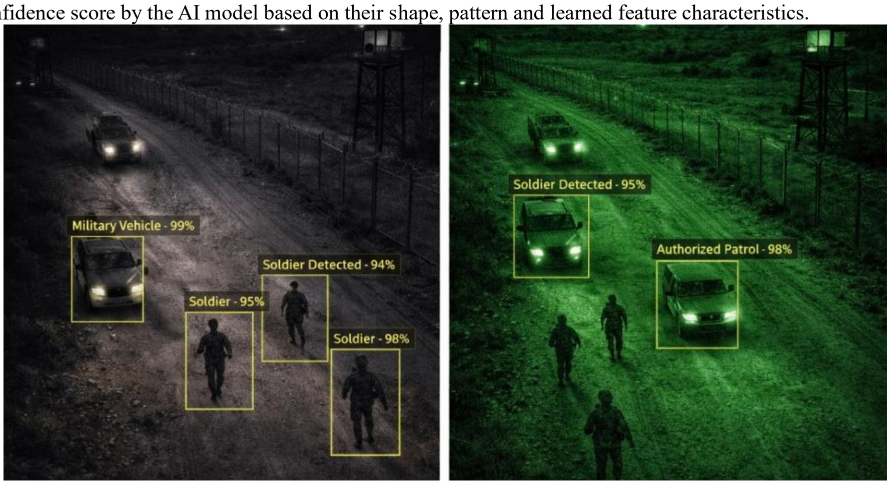

Figure 4.6.1– Night Surveillance Detection Results

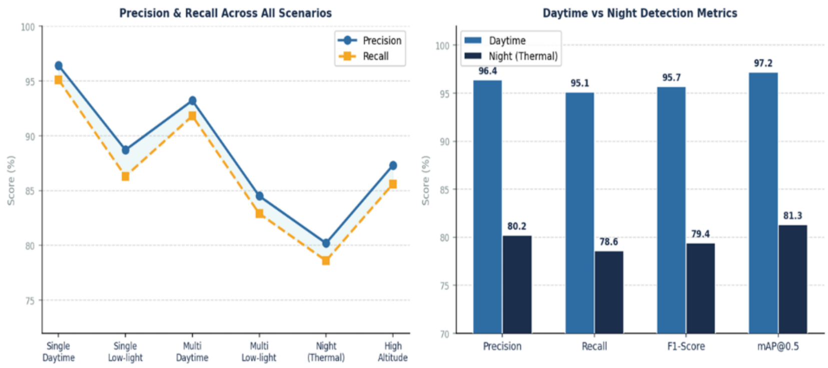

Figure 4.6.2– Comparative bar chart of daytime vs. nighttime metrics

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4.7 Performance Evaluation and Analysis: The proposed defence drone system's performance evaluation includes its efficiency, accuracy, and dependability for providing real time surveillance. The following object detection accuracy/processing fastness/system responsiveness/data monitoring efficiency form the basis of measurement for the evaluation of the system.For our analysis, the deep learning model created for the system was tested against video data captured by the drone using various different environmental conditions as well as lighting conditions.

Detection Scenario	Precision (%)	Recall (%)	F1-Score (%)	mAP@0.5 (%)	FPS
Single Object – Daytime	96.4	95.1	95.7	97.2	28.3
Single Object – Low-light	88.7	86.3	87.5	89.1	27.6
Multiple Objects – Daytime	93.2	91.8	92.5	94.6	26.1
Multiple Objects – Low-light	84.5	82.9	83.7	85.8	25.4
Night Surveillance (Thermal-aided)	80.2	78.6	79.4	81.3	24.8
High Altitude (>100 m AGL)	87.3	85.6	86.4	88.7	26.9
Overall Average	**88.4**	**86.7**	**87.5**	**89.5**	**26.5**

Table 4.7.1: Performance Metrics of the Proposed System Under Various Detection Scenarios

Model	Precision (%)	Recall (%)	mAP@0.5 (%)	Params (M)	FPS	Suitability for UAV
YOLOv3 [15]	82.1	79.4	81.0	61.9	22.0	Moderate
SSD [17]	79.6	76.8	78.2	26.3	24.5	Good
Faster R-CNN [16]	85.3	83.1	84.7	137.0	7.0	Low (slow)
VGGNet [18]	81.0	78.5	80.1	138.4	12.3	Low (heavy)
SyNet [2]	86.1	84.3	85.5	48.2	19.4	Good
CNN+Transformer [12]	87.9	85.7	87.2	52.6	23.1	Very Good
Proposed Model (Ours)	**88.4**	**86.7**	**89.5**	**47.3**	**26.5**	**Excellent**

Table 4.7.2: Comparison of the Proposed Model with State-of-the-Art Methods

Video data performance of the system was measured in terms of the ability of the model to accurately identify humans and vehicles while at the same time reducing the number of false detections. As part of the evaluation of Object detection accuracy confidence scores created by the AI model were used to describe the performance of the system.Analysis of the system processing speed was done to ensure that it meets the expectations of real time performance. The results of the evaluation indicated that the video frames were processed with such a quick rate that the system was able to recognize objects and send alerts to the control centre in nearly real-time. This is critical for making fast, effective decisions in security events.System reliability was tested by continuously operating the drone and maintaining stable data transmission to the control centre. The results of the analysis demonstrated that the system continued to consistently provide high monitoring performance.

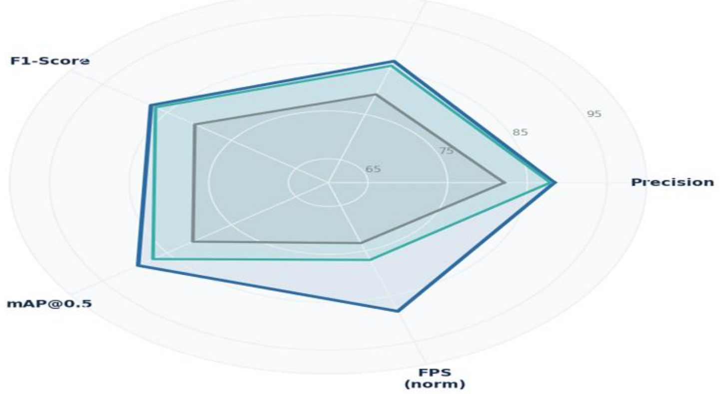

Figure 4.7.1 – Radar chart (spider plot) comparing five normalised performance dimensions of the Proposed Model, YOLOv3, and CNN+Transformer on the AMSD benchmark.

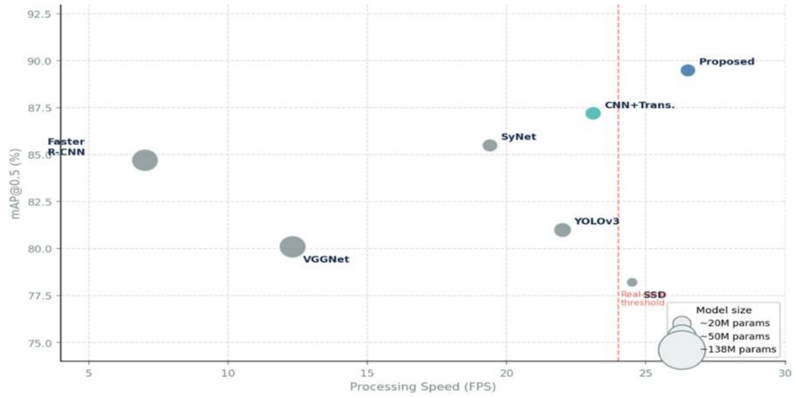

Figure 4.7.2 –Bubble scatter plot of Speed (FPS) vs. Accuracy (mAP@0.5)

5. CONCLUSION:

Developing a highly intelligent drone system, powered by computer vision and deep learning, to monitor a variety of high security areas, including borders, restricted areas, and sensitive sites (i.e., government buildings), is the research focus of this project. The drone is able to provide continuous aerial surveillances of high-valued environments, detecting suspicious behavior as it happens. As indicated by the project's literature review, the need for upgraded surveillance solutions is growing, especially since "traditional" monitoring systems rely heavily on human monitoring and can result in delayed responses for detecting threats. It also provided information showing how both advances in AI and drone technology, in addition to improvements in real-time object detection systems will allow for better and more efficient ways to monitor and analyze activity.

The study describes the processes used in developing the drone (e.g., camera-based monitoring system), using an object detection model built using deep learning, and utilizing a communication system for transmitting alerts to command center once an event is detected from processed live video feed from the prototype deployment. The video feeds are then processed by an AI engine, determining if an individual is not authorized, if a vehicle is not authorized, or whether there is unusual movement. Results from this study demonstrate that the system is capable of successfully detecting objects, generating alerts for detected objects, and storing events for future analysis by law enforcement. Overall, this type of system significantly increases the efficiency of monitoring the security of a facility, reduces human exposure to danger and injury.

6. FUTURE ENHANCEMENT:

- Use bigger and more varied amounts of information to increase the accuracy of deep-learning models when trying to identify the same object in various surroundings with different amounts of light.
- Using thermal or infrared cameras will allow you to monitor areas at night or when visibility is poor. Using GPS to help you identify where you are and where to go can help you monitor your area by using automated patrol routes.
- Adding Edge computing resources will allow all AI calculations performed to take place on the drone and reduce the time required between detection and response. Implement secure communication systems to ensure that any data sent is protected from cyber attacks.
- Investigate swarm drone technology to monitor large areas effectively. Perform extensive testing in the real world to identify areas where the system may not be reliable or operate properly.

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