Weapon Detection System Using Efficient Det

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AD18711 – MINI PROJECT
Viva Voce Examination

Batch No : AD12
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Date of Review : 22/11/2024
Domain : Deep Learning and Computer Vision

ABSTRACT

- A weapon detection system using the EfficientDet algorithm is proposed.
- The system is trained on a robust dataset for high-accuracy classification of various weapons.
- It enhances real-time detection capabilities for quicker and more reliable threat identification.
- The solution is scalable and integrates seamlessly into existing surveillance systems.
- This approach significantly improves public safety by addressing limitations in current weapon detection technologies.

INTRODUCTION TO BASIC CONCEPTS

Deep Learning:

- Neural Networks utilizes multi-layered neural networks to learn features from large datasets.
- Key Architectures includes CNNs, RNNs, and Transformers for tasks in computer vision, NLP, and speech recognition.

Computer Vision:

- Enables machines to interpret visual data like humans, recognizing objects and activities.
- Technique used on deep learning, especially CNNs, for feature extraction and pattern recognition.

EfficientDet:

- Design is balances accuracy and efficiency in object detection with a scalable architecture.
- Scaling Method uses compound scaling and BiFPN for enhanced feature fusion and representation.
- Versions available from D0 to D7, adaptable for various accuracy and efficiency requirements.

LITERATURE REVIEW (1/8)

Md. Ahsan Ahmed, Ikramul Haque, Mohammad Rifat Ahmed Rashid, Mahamudul Hasan, Maheen Islam, Mohammad Manzurul Islam, Taskeed Jabid, Md. Maiyaz Al Mahmud, Md. Muktadir Mukto, Md. Sawkat Ali, (2024), "Design of a real-time crime monitoring system using deep learning techniques", Intelligent Systems with Applications, Elsevier, Vol. 21, pp. 145-167.

- The proposed Crime Monitoring System (CMS) detects crimes in real-time using camera surveillance, combining CCTV cameras with deep learning methods and image processing techniques to counterbalance human weaknesses.

- The CMS operates in three stages: weapon detection (80%+ accuracy), violence detection (85% accuracy), and face recognition (97% accuracy), using models such as YOLOv5, MobileNetv2, and face recognition algorithms.

- The CMS's combined model was tested in real-world scenarios, demonstrating outstanding performance in detecting crime incidents and generating timely alarms, providing effective security and safety.

LITERATURE REVIEW (2/8)

Adriano Mancini, Alessandro Gandelli, Daniele Berardini, Emanuele Frontoni, Lucia Migliorelli, Sara Moccia, (2024), "A deep-learning framework running on edge devices for handgun and knife detection from indoor video-surveillance cameras," Multimedia Tools and Applications, SpringerLink Vol. 83, pp. 19109-19127.

- The proposed system addresses the challenges of detecting small weapons in surveillance videos in real-time using low-cost edge devices.

- A double-step Deep Learning approach is developed, using a CNN for people detection followed by a CNN for weapon identification, achieving near real-time performance on a NVIDIA Jetson Nano device.

- The system achieves accuracy (AP = 79.30) and speed (FPS = 5.10) on a custom indoor surveillance dataset, making it a promising solution for affordable and automated video surveillance systems.

LITERATURE REVIEW (3/8)

H. U. Ain Tahir. H. U, O. C. Edo, S. Khalid, A. Waqar, I. T. Tenebe, (2023), "Weapon detection system for surveillance and security", International Conference on IT Innovation and Knowledge Discovery (ITIKD), IEEE Conference, pp. 256-278.

- This study presents a robust object detection system that demonstrates resilience to affine, rotation, occlusion, and size variations using the YOLO V5 model.

- The system achieves a high F1-score of 95.43% and detection accuracy of 90.66% when combined with Mask-RCNN.

- The implementation of combined preprocessing methods significantly improves the overall system accuracy.

LITERATURE REVIEW (4/8)

Ansuman Bhattacharya, A. Sai Venkateshwar Rao, Shivam Kainth, Tarachand Amgoth, (2024), "An efficient weapon detection system using NSGCU-DCNN classifier in surveillance", Expert Systems with Applications, Elsevier, pp. 1079-1298.

- A weapon detection system is proposed to address the limitations of existing methods in detecting occluded and customized weapons in surveillance videos.

- The system employs a combination of techniques, including Gaussian Kernelized Double Plateau Histogram Equalization (GKDPHE) for contrast enhancement, Frobenius Norm-based Three Step Search (FN-TSS) for motion estimation, and Weibull Distributed Viola Jones (WDVJ) for object detection.

- The proposed system, based on a Non-linear and Scalar Growing Cosine Unit based Deep Convolutional Neural Network (NSGCU-DCNN), achieves high-accuracy rates in weapon detection, outperforming existing techniques.

LITERATURE REVIEW (5/8)

António Cunha, Hélder Oliveira, Tomás Santos, (2024), "Systematic review on weapon detection in surveillance footage through deep learning," Computer Science Review, Elsevier, Vol. 51, pp. 66-78.

- The growing number of crimes with weapons worldwide necessitates the development of effective solutions for early detection and prompt action by law enforcement agencies.

- A systematic review of deep learning-based weapon detection methods reveals that Faster R-CNN and YOLO architectures are commonly used, and that realistic images and synthetic data can improve performance.

- However, challenges persist, particularly in detecting small weapons, and future research directions should focus on addressing these limitations to enhance the accuracy and effectiveness of automatic weapon detection systems.

LITERATURE REVIEW (6/8)

L. Elluri, V. Mandalapu, N. Roy, P. Vyas, (2023), "Crime Prediction Using Machine Learning and Deep Learning: A Systematic Review and Future Directions," IEEE Access, pp. 168-178.

- In this paper Deep learning models like Random Forest Regressor model ,Spatio-Temporal Graph Convolutional Networks (ST-GCN), and Convolutional Neural Networks (CNN) were applied.
- Random Forest Regressor model achieved 89% accuracy in predicting crimes, specifically focusing on urban attributes affecting homicides.
- The availability of high-quality, reliable, and up-to-date crime data remains a significant challenge

LITERATURE REVIEW (7/8)

Hongwei Ding, Mingliang Duan, Haiyan Li, Yuanyuan Pu, Zhijun Yang, Guanbo Wang, (2023), "Fighting against terrorism: A real-time CCTV autonomous weapons detection based on improved YOLO v4", Digital Signal Processing, Elsevier, Vol. 132, pp. 178-190.

- This paper proposes a real-time weapon detection approach for CCTV footage using YOLO v4, with a customized backbone (SCSP-ResNet) and modules (receptive field enhancement and Fusion-PANet) to improve accuracy and speed.

- The approach is evaluated on a merged synthetic and real-world dataset, achieving a 7.37% increase in mAP and a 4.2% reduction in inference time, while reducing the model's parameter by 0.349 BFLOP/s.

- The proposed detector outperforms the baseline model in terms of accuracy, real-time performance, and robustness, making it a promising solution for security and counter-terrorism applications.

LITERATURE REVIEW (8/8)

Nidhi Gupta, Pawan Kumar Sharma, Pavinder Yadav, (2023), "A comprehensive study towards high-level approaches for weapon detection using classical machine learning and deep learning methods.", Expert Systems with Applications, Vol. 212, Elsevier, pp. 65-77.

- There is a need for technology that can automatically detect criminal activities, such as armed robbery, from CCTV footage without human intervention, and existing algorithms have limitations in terms of specific conditions..

- The study identifies gaps in existing weapon detection technologies, including the challenging task of intra-class detection, which involves identifying the specific type of firearm used in an attack.

- The paper compares and analyzes the performance of various machine learning and deep learning approaches for weapon detection, concluding that deep learning techniques outperform traditional machine learning techniques in terms of speed and accuracy.

ISSUES & CHALLENGES

- Time complexity, interconnectivity, interdependency, and hierarchy of the problems are some of the challenges that are faced while developing the system.
- The weapon detection accuracy is only 80%+ while using YoloV5 model.
- Small objects, such as handguns, are challenging to detect because they have less pixel information and semantic detail.
- Weapons can be partially or fully obscured in images, which makes detection difficult. For example, pistols held with two hands or concealed by clothing can be hard to detect accurately.
- Mask R-CNN achieved a detection accuracy of 90.66% and a mean Intersection over Union (mIoU) of 88.74% .
- Misclassification remains a problem, especially in dynamic backgrounds or with overlapping objects.

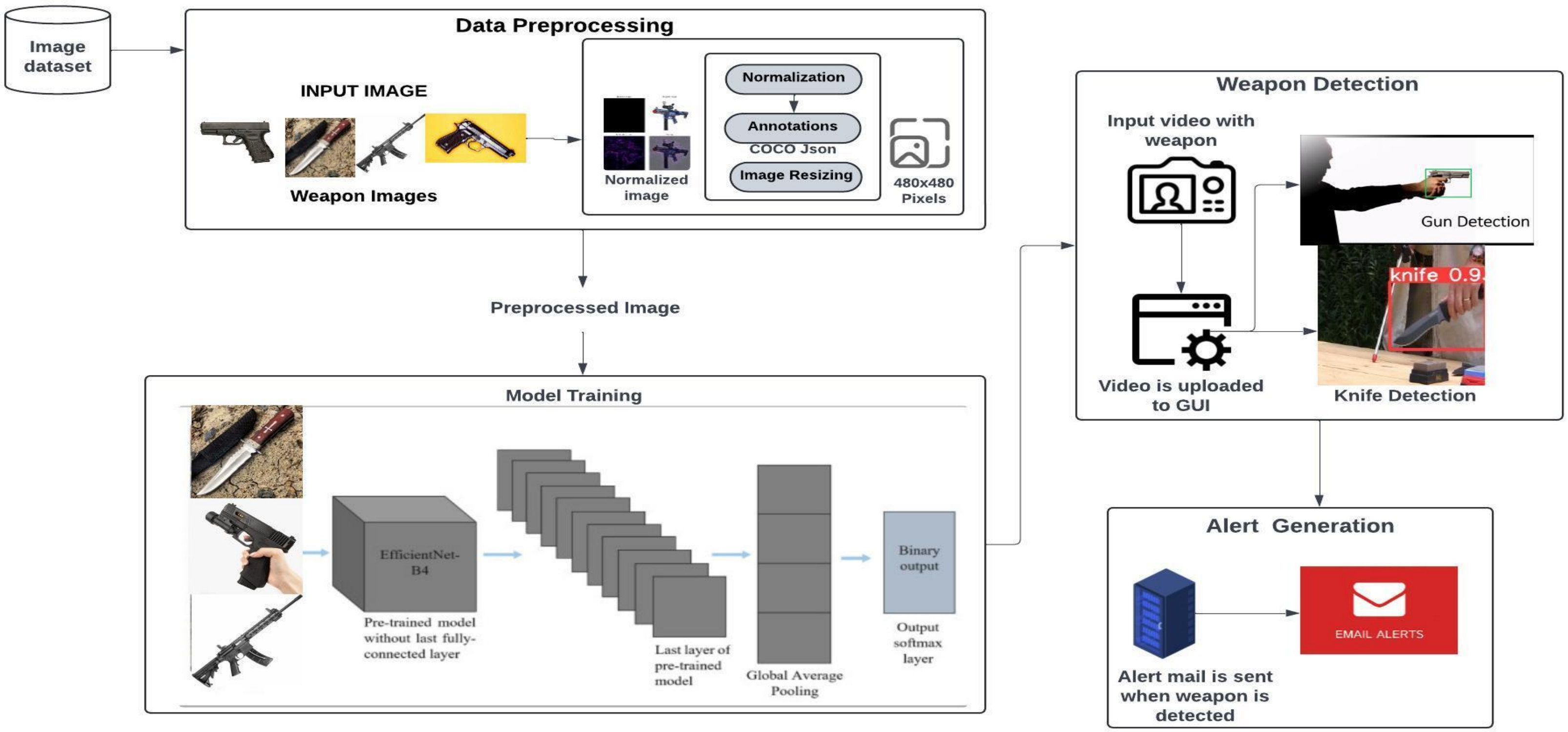
PROBLEM STATEMENT

- Weapons in public spaces pose a serious security threat.
- Current detection systems are inefficient and unreliable.
- EfficientDet, a state-of-the-art object detection model, can be used for accurate weapon detection.
- Model training on a large dataset and techniques like fine-tuning and non-maximum suppression improve accuracy.
- Integration with existing monitoring infrastructure enhances public safety.

PROPOSED WORK

- The aim of this project is to develop a robust deep learning model for real-time weapon detection using the EfficientDet architecture.
- The system will process video input from a webcam or video file to identify and highlight moving weapons through contour detection and bounding boxes.
- A unique visualization effect will simulate neural activations with randomly colored circles, providing an intuitive output that indicates the presence and movement of detected objects.
- By emphasizing modularity and real-time performance, the project seeks to create a scalable detection framework applicable to surveillance, anomaly detection, and behavior analysis in complex environments.
- Ultimately, the goal is to enhance the interpretability of object detection by incorporating visually engaging elements that simulate neural processing outputs, innovatively tracking and visualizing dynamic activity in real-time video feeds.

ARCHITECTURE DIAGRAM



SYSTEM REQUIREMENTS AND TOOLS

Hardware Requirements:

- CPU: Intel i5iI7
- GPU:Intel iRISxe
- RAM : 2GB
- Storage : 250 GB

Software Requirements :

- Windows, MacOS or Linux.
- VS Code, Colab, PyCharm

MODULES DESCRIPTION

1. Data Preprocessing
2. Weapon Detection
3. Alert Generation

MODULES DESCRIPTION (1/3)

1. DATA PREPROCESSING

- Collect image or videos with various weapons (e.g., guns, knives) and non-weapon objects.
- Remove corrupted, incomplete, or irrelevant samples.
- Impute or remove samples with missing data.
- Ensure a balanced dataset with diverse classes to prevent model bias.
- Resize all images to 480x480 pixels.
- Apply min-max normalization to standardize pixel values.

MODULES DESCRIPTION (2/3)

2. WEAPON DETECTION

- The EfficientDet algorithm will be used as the backbone of the system, chosen for its ability to balance detection accuracy and computational efficiency. It uses a bidirectional feature pyramid network (BiFPN) to better detect objects at different scales.
- The weapon detection module processes an input video, uploaded by the user.
- The video frames are analyzed in real-time using a object detection model, EfficientDet.
- The model scans each frame to detect weapons, such as guns or knives.
- When a weapon is detected, a bounding box is drawn around it with a confidence score displayed on the video frame.
- The system continues to analyze subsequent frames, providing continuous detection and alerting based on weapon presence in the video.

MODULES DESCRIPTION (3/3)

3. ALERT GENERATION

- Sends immediate email notifications when a weapon is detected in the video feed.
- Triggered automatically when the detection model identifies a weapon with confidence above the threshold.
- Email contains key information such as weapon type, detection time, and can optionally include a screenshot of the detected frame.
- Utilizes SMTP protocol for sending emails, and can be configured with Gmail.
- Delivers fast, automated, and reliable alerts to multiple recipients, ensuring timely responses to potential threats.

IMPLEMENTATION SCREENSHOTS (1/3)

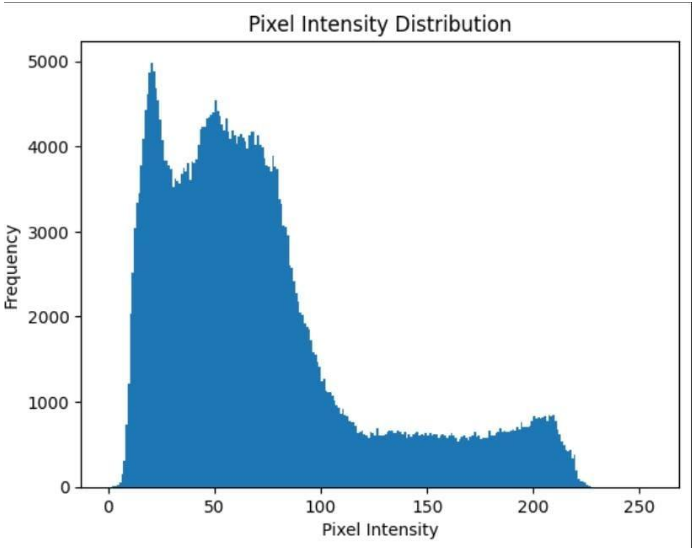


Fig: 1 Pre-processing

IMPLEMENTATION SCREENSHOTS (2/3)

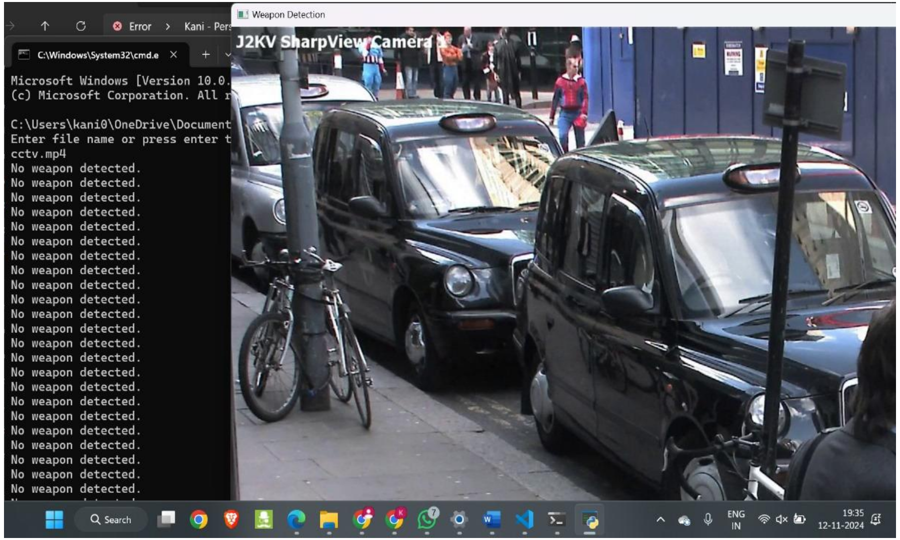


Fig: 2.1 No weapon detected

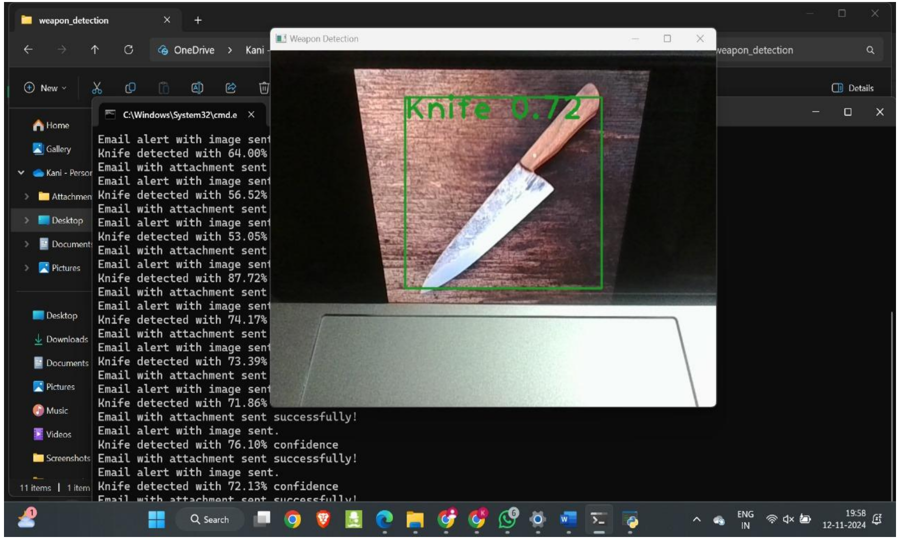


Fig: 2.2 Weapon Detection – Knife

IMPLEMENTATION SCREENSHOTS (3/3)

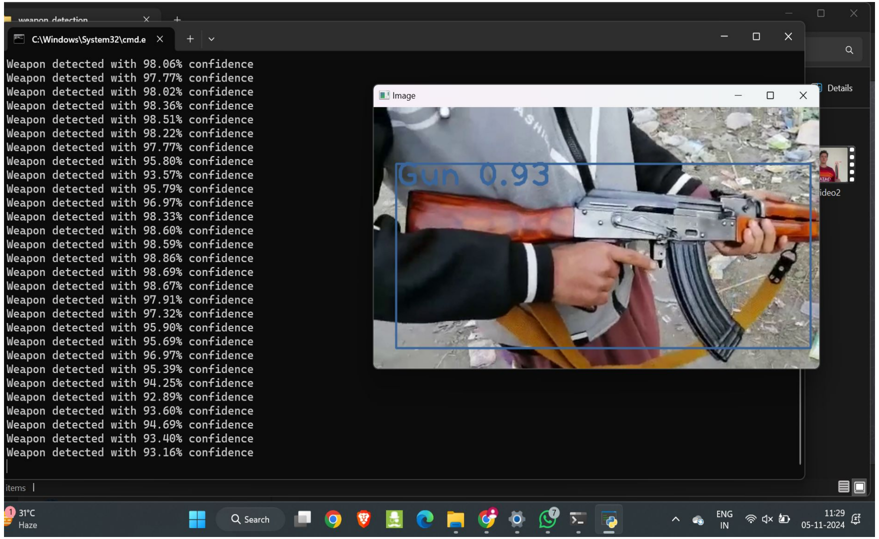


Fig:2.3 Weapon Detection – Rifle

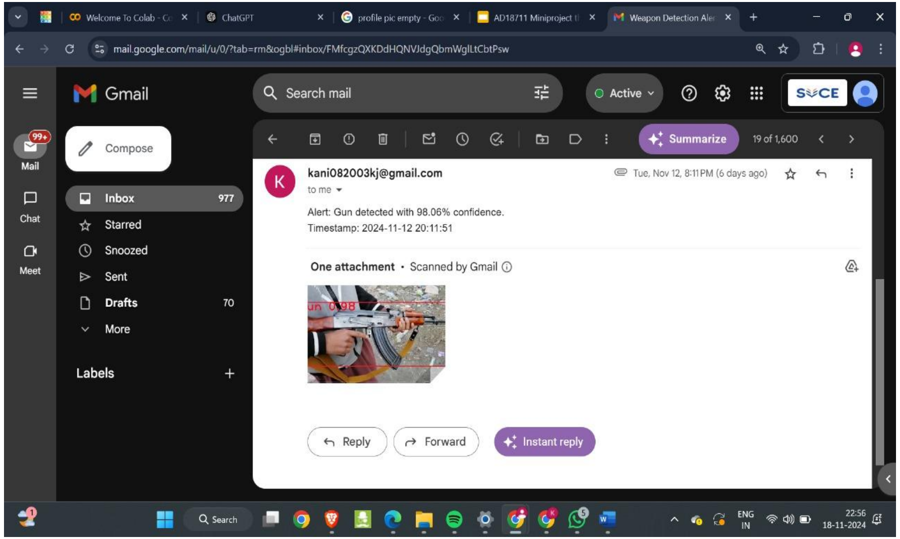


Fig: 2.4 Email Alert for Weapon Detection

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3. H. U. Ain Tahir, O. C. Edo, S. Khalid, A. Waqar, I. T. Tenebe, (2023), “Weapon detection system for surveillance and security”, International Conference on IT Innovation and Knowledge Discovery (ITIKD), vol. pp. 256-278.
4. Ansuman Bhattacharya, A. Sai Venkateshwar Rao, Shivam Kainth, Tarachand Amgoth, (2024), “An efficient weapon detection system using NSGCU-DCNN classifier in surveillance”, Expert Systems with Applications, pp. 1079-1298.

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5. António Cunha, Hélder Oliveira, Tomás Santos, (2024), “Systematic review on weapon detection in surveillance footage through deep learning,” Computer Science Review, Vol. 51, pp. 66-78.
6. L. Elluri, V. Mandalapu, N. Roy, P. Vyas, (2023), “Crime Prediction Using Machine Learning and Deep Learning: A Systematic Review and Future Directions,” pp. 168-178.
7. Hongwei Ding, Mingliang Duan, Haiyan Li, Yuanyuan Pu, Zhijun Yang, Guanbo Wang, (2023), “Fighting against terrorism: A real-time CCTV autonomous weapons detection based on improved YOLO v4,” Digital Signal Processing, Vol. 132, pp. 178-190.
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