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SMARTSHIELD: ADVANCED THREAT PERCEPTION AND PERSONALIZED ALERT SYSTEM

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Abstract : In a world where violence persists despite our strides towards civilization, the need for advanced surveillance systems to ensure public safety has become crucial . It introduces an intelligent surveillance framework specifically tailored to detect firearms, employing cutting-edge deep learning methodologies. With traditional firearm-related violence posing a significant threat to society, innovative approaches in law enforcement become imperative. This study centers on integrating DenseNet for firearm detection and Support Vector Machines (SVM) for face recognition within semi-urban and urban settings. The proposed system employs a stacked ensemble scheme, incorporating techniques like Non-Maximum Suppression, Non-Maximum Weighted, and Weighted Box Fusion for post-processing. This ensemble markedly enhances detection accuracy, especially concerning human faces and firearms. The system's adaptability extends beyond law enforcement to include the analysis of social media videos for detecting firearm-related content. Notably, the surveillance system triggers alerts exclusively upon detecting an unknown individual holding a gun, thus minimizing false alarms and ensuring a more precise response.

IndexTerms **- Computer vision, deep learning, ensemble, firearms, smart cities.**

I. INTRODUCTION

In today's world, the persistence of violence presents a considerable challenge to our civilized society. Firearms, among various tools of violence, pose a significant threat to public safety, demanding innovative methods for detection and prevention. This overview introduces our project, centered on creating an SmartShield: Advanced Threat Perception and Personalized Alert System using advanced deep learning techniques specifically for firearms detection. The widespread occurrence of firearm-related violence globally highlights the urgent need for robust surveillance systems. Conventional approaches often struggle to handle the scale and complexity of such incidents, prompting a shift toward intelligent, automated solutions. Our project is driven by the urgency to enhance existing surveillance structures with state-of-the-art technologies to mitigate the impact of firearm-related crimes.

This study explores the integration of deep learning techniques, notably DenseNet for firearm detection and Support Vector Machines (SVM) for face detection, in environments prone to firearm incidents, both semi-urban and urban. The goal is to develop a system that not only improves law enforcement efficiency but also mitigates challenges linked to human-based monitoring. The primary aim is to create an intelligent surveillance system adept at accurately detecting firearms, particularly guns, in real-world settings. By implementing automated smart surveillance techniques, our objective is to ease the workload of law enforcement personnel and deliver timely, actionable intelligence to prevent and address incidents promptly.

II. LITERATURE SURVEY

In the last few years, cities around the world are building smart city systems [1]. Roith Srivatsav, Gunjan Chhabra introduces a novel approach for detecting abnormal events in crowds. Their method involves estimating optical flows to cluster human crowds unsupervised using the AMC algorithm. Clusters are characterized by their orientation and position through a force field model, enabling the prediction of crowd behaviors and identification of anomalies in the scene. Utilizing the AMC Algorithm, this research contributes to anomaly detection and proves effective in detecting unusual events within uncontrolled surveillance video environments. However, a notable drawback is its documented poor performance.

Yuan Yuan, Yichang Feng and Xiaoqing Lu [2] introduces a novel approach for detecting abnormal events in crowds. Their method involves estimating optical flows to cluster human crowds unsupervised using the AMC algorithm. Clusters are characterized by their orientation and position through a force field model, enabling the prediction of crowd behaviors and identification of anomalies in the scene. Utilizing the AMC Algorithm, this research contributes to anomaly detection and proves effective in detecting unusual events within uncontrolled surveillance video environments. However, a notable drawback is its documented poor performance.

Qing-Ge Ji, Rui Chi, and Zhe-Ming Lu [3] introduces a method for anomaly detection utilizing a social force model based on blocks. This approach enables anomaly detection at both pixel and block levels. At the pixel level, anomalies are identified using a Gaussian Mixture Model (GMM), while at the block level, the crowd is segmented into blocks based on pedestrian detection, and anomalies are detected and localized employing a block-based social force model .The tools utilized in this research include OpenCV, Python language, scikit-learn, and GMM. Noteworthy advantages of this approach include its capability to detect anomalies at both pixel and block levels. However, the proposed system is reported to lack efficiency as a disadvantage.

Thittaporn Ganokratanaa ,Supavadee Aramvith , Nicu Sebe [4] introduces an innovative unsupervised learning method for video anomaly detection using deep learning architectures. Their proposed method, the Appearance and Motion DeepNet (AMDN), employs multiple Stacked Denoising Autoencoders (SDAEs) to learn representations of both appearance and motion in video activities.Utilizing tools such as SDAEs, TensorFlow, and ADMN, this approach offers advantages by not relying on prior knowledge for feature design and circumvents the necessity for object-level analysis like object detection or tracking. However, a notable disadvantage highlighted in the paper is the reported lack of cost efficiency in the proposed system.

Shuyao Zhang , Renke Liu ,Hideyuki Sawada Donald [5] provides an overview of AMDN, an unsupervised anomaly detection method leveraging deep learning, particularly Stacked Denoising Autoencoders (SDAEs), to learn appearance and motion representations within video scenes. Although specific tools are not explicitly mentioned, common frameworks such as TensorFlow or PyTorch are presumed. Notably, the advantages highlighted encompass knowledge-free feature design, while potential drawbacks include concerns regarding cost efficiency. Utilizing tools like the Python programming language, PCA, and CNN, this review emphasizes the efficiency and accuracy benefits of AMDN. However, it points out a vulnerability to environmental factors as a potential disadvantage of the system.

Safa Alfattama , Priyadarshi Kanungo , Sukant Kishoro Bisoy Harby [6] provides a comprehensive overview of recent developments in human face recognition research, encompassing applications, techniques, and limitations. This review extensively explores insights from the Face Recognition Vendor Test (FRVT) 2002, offering a detailed examination of automatic face recognition technology. The tools highlighted in this paper primarily focus on the utilization of FRVT. It emphasizes the advantage of providing a comprehensive literature review, yet notes a disadvantage related to the limited specifics concerning the project's algorithm.

Soumitra Chowdhury , Sudipta Nath , Ashim Dey, Das [7] assesses various detection and recognition methods, emphasizing the Viola-Jones (Haar Cascade) for consistent detection and the Fisher Face (LDA algorithm) for faster recognition. Despite attempts to adapt these algorithms for multiple faces, limitations persist, prompting a need for Deep Learning, particularly convolutional neural networks, to address both detection and recognition requirements. This review identifies tools such as VIOLA-JONES, Haar cascade, and the LDA algorithm. It highlights the advantages of automation and efficiency in face recognition systems but raises concerns regarding security as a notable disadvantage.

Rajdeep Chatterjee, Manas ranjan Pradhan , Ankita Chatterjee , Tanupriya Choudhury [8] demonstrates the efficacy of a deep learning-based framework in detecting faces and guns, emphasizing the superiority of the WBF-based ensemble object detection scheme. Exploring different architectures, the study highlights the trade-offs between model size and performance, favoring the smaller-sized EffDet-B0 models over FRCNN due to their reduced file size and potential for improving ensemble efficiency. Addressing concerns about FPS values, the paper suggests employing a primary detection architecture with a faster frame rate to mitigate the impact on ensemble speed. It emphasizes the collective strength of ensemble models, leveraging their diversity for superior performance despite individual weaknesses. The ultimate goal is to enhance CCTV-based monitoring, elevating it into an intelligent surveillance system with the primary aim of ensuring societal safety.

Muhammad Tahir Bhatti, Muhammad Gufran Khan, Masood Aslam ,Muhammad Junaid [9] introduces an innovative automatic weapon detection system for real-time implementation, targeting improved security and law enforcement, particularly in regions affected by violent incidents. The system's deployment aims to positively impact the economy by bolstering security measures, attracting investors, and fostering a safer environment for tourists. The study focuses on live CCTV-based weapon detection, emphasizing minimized false positives and negatives while achieving high precision and recall rates. Leveraging a newly constructed training database tailored for real-time scenarios, the research evaluates diverse deep learning models using sliding window/classification and region proposal/object detection approaches. Results highlight the superiority of object detection algorithms with Region of Interest (ROI), especially the Yolov4 model trained on the new database, exhibiting minimal false readings and achieving exceptional mean average precision (91.73% mAP) and F1-score (91%) with nearly 99% confidence across various image and video types, establishing its credibility as an automatic real-time weapon detector. The paper outlines future work focused on further reducing false readings while potentially expanding the scope of detected objects, emphasizing precision and recall enhancements.

Rajib Debnath [10] introduces an efficient firearm detection algorithm characterized by low time complexity and high performance, combining a simple template matching algorithm with an object detection approach that reduces the search space. The employed object detection algorithm demonstrates superior qualitative and quantitative results, particularly in varying illumination conditions, effectively managing challenges posed by changes in firearm color due to differing illumination. However, while successful in detecting firearms with varying rotations and scaling, the proposed method faces limitations in efficiently detecting partially occluded firearms and struggles in dynamic backgrounds with rapid changes. The paper highlights future work aimed at improving detection accuracy for partially occluded firearms and addressing challenges posed by swiftly changing backgrounds.

III. System Architecture

System design encompasses the intricate process of outlining a system's architecture, including its components, modules, interfaces, and data, to meet specific requirements. It stands as a pivotal phase within software development, aiming to strategically plan solutions for problems outlined in requirement documentation. This initial design phase lays the groundwork for the project's solution. The quality of the software heavily relies on the system's design, making it a critical determinant. The primary objective of this phase is to craft an overall requirement. It involves identifying necessary modules, their interactions, and the expected outputs to ensure an optimized system configuration.

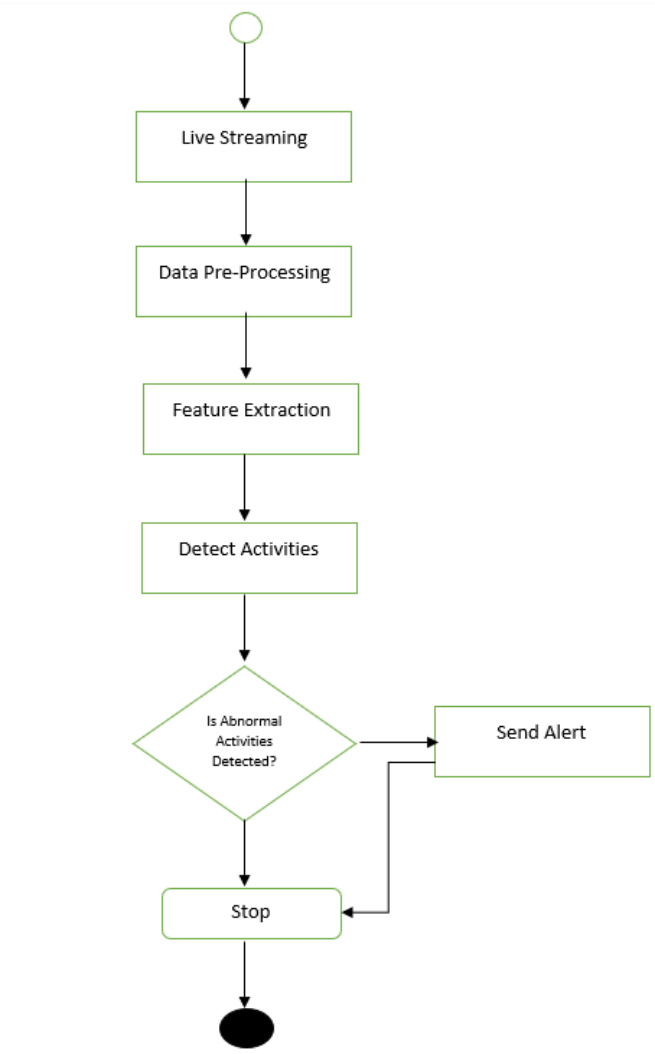

Fig 3.1 : System Architecture

IV. RESEARCH METHODOLOGY

Methodology refers to the systematic approach and set of procedures used to conduct research or carry out a project. It outlines the steps, tools, and techniques employed to achieve the objectives of the study or project.

4.1 Feature Extraction

This phase involves extracting dataset features by scanning and mapping data using NLP to define unusual activities within the dataset.

4.2 Preprocessing

Extracted features undergo preprocessing to identify those suitable for event detection, forming clusters based on their characteristics.

4.3 Behavior Detection

Cluster formations and object detections from video devices are mapped, enabling the detection of unusual levels in images by comparing with trained data.

4.4 Video to Frame Extraction

Using raster-scan order, videos are extracted from devices and frames are extracted utilizing a specific algorithm.

$$\sum v \frac{lv}{pf} \quad \text{(Eq. 1)}$$

Where lv= video length

pf = total fps in the video length

v = video frames

4.5 SIFT (Scale-Invariant Feature Transform)

SIFT is a computer vision algorithm detecting and describing local features in images. It identifies key points in reference images, compares them with new images, and filters matches based on their feature vectors' Euclidean distance. Consistent clusters agreeing on an object's location, scale, and orientation in the new image are then determined using an efficient hash table implementation of the Hough transform. These clusters undergo detailed model verification and outlier removal, computing the probability of features indicating an object's presence with high confidence.

V. SOFTWARE REQUIREMENT

The System Requirement Specification (SRS) serves as a pivotal document shaping the software development process, capturing system requirements and delineating its key features. It represents an organization's understanding of a client's system needs before the commencement of actual design or development work. This bilateral approach ensures mutual comprehension between the client and the organization regarding each other's requirements at a given point in time. The meticulous crafting of software requirement details minimizes development effort, facilitating the early detection and rectification of errors, misunderstandings, and inconsistencies. While focusing on the product and not the project, the SRS acts as a foundational guide for subsequent product development, albeit subject to potential revisions that continue through production evaluation. Essentially, the software requirement specification stands as the inception of software development, translating client ideas into a formal document that becomes the cornerstone of the requirement phase output, emphasizing completeness and coherence in delineating specified requirements.

VI. APPLICATIONS

The SmartShield: Advanced Threat Perception and Personalized Alert System for Firearm Detection finds crucial applications across diverse scenarios, with one key use being in enhancing public safety in urban areas. Deployed in city centers and crowded public spaces, the system serves as a proactive measure against firearm-related incidents. By employing advanced deep learning techniques, the technology aids law enforcement in swiftly detecting and preventing potential threats, thereby contributing to the overall security of residents and visitors.Additionally, the system's adaptability allows it to be seamlessly integrated into transportation security protocols, particularly at airports. In this context, it strengthens aviation security by identifying individuals carrying firearms, providing an additional layer of screening to ensure the safety of passengers.

Furthermore, the technology is instrumental in protecting critical infrastructure, such as power plants and government facilities, by effectively detecting potential threats and unauthorized access. Its versatility extends to large-scale events, concerts, and sports gatherings, where it augments event security efforts by identifying individuals with firearms, mitigating potential risks and ensuring the safety of attendees. Lastly, the application of this intelligent surveillance system in educational institutions contributes significantly to campus security, offering a proactive approach to detect firearms and enabling rapid responses to potential threats, thereby fostering a safer learning environment for students and staff.

VII. CONCLUSION

The SmartShield: Advanced Threat Perception and Personalized Alert System designed for firearm detection serves as a critical asset across various scenarios, prominently enhancing safety in urban settings. Strategically deployed in city centers and bustling public areas, it acts proactively against firearm-related incidents by utilizing advanced deep learning techniques. This technology aids law enforcement in swiftly detecting and preempting potential threats, significantly bolstering the security of both residents and visitors. Moreover, its adaptable nature seamlessly integrates into transportation security, notably at airports, reinforcing aviation safety by pinpointing individuals carrying firearms and adding an extra layer of screening for passenger safety. Additionally, it plays a vital role in safeguarding crucial infrastructure like power plants and government facilities, effectively identifying threats and preventing unauthorized access. Its versatility extends to enhancing security measures at large events, concerts, and sports gatherings, identifying individuals with firearms to mitigate risks and ensure attendee safety. Lastly, its implementation in educational institutions significantly enhances campus security, proactively identifying firearms and enabling rapid responses to potential threats, fostering a safer learning environment for students and faculty.

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