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Comprehensive Review of Computer Vision Analytics for Women's Safety

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Abstract: *The increasing rates of violence against women in public places have created a need for early intervention based systems for threat alert. This paper aims to present the state-of-art in implementing safety enhancements using AI solutions for object detection, gender classification, gesture recognition, and anomalies detection. Existing studies are reviewed and the latest research works are examined to find out about the capacity and constraints of surveillance systems leaning towards deep learning schemes such as YOLO, CNN, and LSTM to analyse real-time video. The review also outlines some limitations with the high achievable accuracy, low false positive rates, as well as the ethical dilemmas of privacy and security. Moreover, this paper reviews how alert mechanisms interrelate with law enforcement and looks at the possibility of employing large-scale cloud-based infrastructures for other purposes. This paper is the first step in building a viable, expansive, and moral use of AI technology to increase women's security in urban settings. The increasing rates of violence against women in public places have created a need for early intervention based systems for threat alert. This paper aims to present the state-of-art in implementing safety enhancements using AI solutions for object detection, gender classification, gesture recognition, and anomalies detection. Existing studies are reviewed and the latest research works are examined to find out about the capacity and constraints of surveillance systems leaning towards deep learning schemes such as YOLO, CNN, and LSTM to analyse real-time video. The review also outlines some limitations with the high achievable accuracy, low false positive rates, as well as the ethical dilemmas of privacy and security. Moreover, this paper reviews how alert mechanisms interrelate with law enforcement and looks at the possibility of employing large-scale cloud-based infrastructures for other purposes. This paper is the first step in building a viable, expansive, and moral use of AI technology to increase women's security in urban settings.*

Keywords: Computer Vision, Safety Detection, Deep Learning, Machine Learning

I. INTRODUCTION

This study assesses the efficacy of AI-based systems in identifying possible threats to women in public spaces through real-time monitoring. It looks into typical patterns of behavior or anomalies that point to a possible safety concern. Another critical challenge is whether gesture recognition and gender classification can reliably create real-time alerts that reduce false positives while ensuring a timely reaction to true threats. The study also looks into how identifying high-risk zones based on prior alerts can help with crime prevention and strategic planning in metropolitan areas. Lastly, it looks at the ethical and privacy protections that can be implemented to guarantee the proper application of surveillance technology while upholding an individual's right to privacy.

The main focuses of this research are gender classification, gesture recognition, voice analysis and anomaly detection in order to identify unsafe situations like a lone woman at night or odd behavior in public locations. It uses computer vision and machine learning algorithms to scan video streams in real time, detect anomalies, and deliver alarms. The project will ensure that all gathered data is anonymised and used solely for real-time threat detection.

The analytical boundaries will employ recorded data sets and live digital video streams to critically assess the credibility of threat recognition algorithms in simulation. Such cases are going to lie within the experimental boundaries: recognizing emergency notifications, and identifying females followed by suspicious persons. The project will be created methodologi- cally using Python, OpenCV, and the advanced and modern machine learning algorithms like TensorFlow. The testing will have to be performed with the purpose of raising identification rates and decreasing the number of false positive cases and biases.

A. Scope

The scope of the WatchGuard: Real-time Safety Detection Software project is described in the following manner:

- Uses technologies such as machine learning, computer vision and gesture recognition to increase women's safety in the streets.
- Builds on a live-camera stream-based system for monitoring for abnormalities or suspicious events or male to female ratios.
- Complements emergency gesture recognition and voices analysis to detect the distress signals and trigger alarms immediately.
- Uses open source libraries and pre-trained models to save cost and time of the development process.
- Protects privacy and ethical issues by removing identity information and only using it for near real-time threat identification.
- Used to identify high risk zones that can be applied for police work as well as urban planning in towns or cities.
- Uses design that can be used locally or integrated into the cloud depending on the owner's preference thus making it versatile.
- As to the future uses in smart city projects, the paper develops a conceptual model of AI-based solutions for urban security.

II. LITERATURE SURVEY

A. Object Detection

The seminal work by Redmon et al.[1], presented at the IEEE Conference on Computer Vi- sion and Pattern Recognition (CVPR), introduces the YOLO (You Only Look Once) framework for real-time object detection. Unlike traditional detection systems that separate object classifi- cation and bounding box prediction into distinct steps, YOLO unifies these tasks into a single neural network, significantly improving speed and efficiency. The paper highlights YOLO's ability to process images at 45 frames per second while maintaining high accuracy, making it ideal for real-time applications. The authors also address challenges in detecting smaller objects and propose improvements for balancing precision and recall. The YOLO framework set a new benchmark in object detection and remains foundational in deep learning research. The paper titled "Detection of Crime Scene Objects Using Deep Learning Techniques"[2] by Kalpana, K., Maheshwaram, V., and Umarani, K. presented at the International Conference on Computer Science Engineering, explores the application of deep learning for detecting crime scene objects. The authors utilize convolutional neural networks (CNNs) to identify and classify objects critical to forensic investigations, such as weapons, bloodstains, and fingerprints. By leveraging large datasets and advanced image preprocessing techniques, the study demonstrates the potential of deep learning to enhance accuracy in crime scene analysis. The paper also highlights the importance of addressing challenges like occlusion and varying lighting conditions in real-world crime scenes. The research provides a valuable contribution to the integration of AI in law enforcement and forensic science. The paper titled "Gender and Age Detection Using Deep Learning"[3] by Kumbhar, U., and Shingare, A. S. presents a deep learning- based approach for the automated detection of gender and age from facial images. The authors utilize pre-trained convolutional neural networks (CNNs), fine-tuned on large datasets, to achieve robust performance in classifying gender and estimating age groups. The study highlights its applications in areas such as demographic analysis, personalized marketing, and security systems. Challenges such as diverse facial features, varying lighting conditions, and differences in age representation are discussed, alongside strategies to mitigate these limitations. This research underscores the capability of deep learning in solving real-world problems involving human attribute detection. The paper titled "Gender-Based Crowd Categorization and Counting Using YOLOv8" is authored by Harshavardhan G. Patil, Nikhil S. Mane, and Dr. Sandip M. Joshi. It discusses the implementation of the YOLOv8

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model for real-time crowd gender classification and counting, focusing on enhancing public safety and demographic analysis. The study leverages deep learning techniques to improve accuracy and efficiency in monitoring crowded environ- ments. The paper titled ”Real Time Multi-Class Object Detection and Recognition Using Vision Augmentation Algorithm”[4] by Al-Akhir Nayan, Joyeta Saha, Ahamad Nokib Mozumder, Khan Raqib Mahmud, and Abul Kalam Al Azad presents a novel approach to detecting small objects in real-time with improved accuracy. The proposed method utilizes upsampling and skip connections to enhance feature extraction at multiple convolution levels, achieving better performance compared to existing deep learning models. The study demonstrates its effectiveness in handling low-resolution images with noise.

B. Anomaly and Violence Detection

The paper titled ”Analysis of Community Outdoor Public Spaces Based on Computer Vision Behavior Detection Algorithm”[5] by Shouyun Xu, Chang Yu, and Yunfei Chen, discusses the application of computer vision algorithms to analyze behavioral patterns in outdoor public spaces. The study utilizes advanced detection techniques to evaluate pedestrian flow, social interactions, and spatial usage. The findings aim to inform urban design and policy-making for improved public space management and planning. The paper titled ”A Review of Abnormal Crowd Behavior Recognition Technology Based on Computer Vision”[6] provides a comprehensive analysis of existing methods and advancements in detecting abnormal crowd behavior using computer vision techniques. It discusses various deep learning-based approaches, challenges in real-time implementation, and potential applications in public safety and surveillance. The study highlights the importance of integrating AI with surveillance systems to enhance security and situational awareness in crowded environments. The paper titled ”Anomaly Detection in Videos for Video Surveillance Applications using Neural Networks”[7] presents a deep learning- based approach for real-time anomaly detection in video surveillance systems, focusing on identifying human intrusions and object anomalies. It employs Feature Pyramid Networks (FPN) for object detection and a classification model to analyze video frames and track movements. The system calculates anomaly scores to detect unusual activities, achieving high accuracy rates of 98.5% for object detection and 96.5% for human detection. Future improvements include continuous learning, optimization for GPUs/FPGA kits, and handling larger datasets for enhanced real-time performance. The paper titled ”Human Behavior Recognition of Video Surveillance System Based on Neural Network”[8] presents a behavior recognition system that utilizes the AAR-RNN algorithm to collect and analyze real-time data from wearable devices. The algorithm was transitioned from Python to Java, with accuracy validated by comparing results from both environments. The system effectively detects atomic and complex activities with an accuracy range of 88-90%. Future work includes refining the algorithm, improving data collection, and enhancing scalability for real-time applications. The paper titled ”Human Violence Detection Using Deep Learning Techniques”[9] explores real-time human violence detection in surveillance videos. It employs the Inception-v3 model with transfer learning and a custom neural network for classification. OpenCV is used to convert videos into frames, which are labeled for training and testing. The YOLOv5 model is integrated for object and face detection. The model achieved 74% accuracy, with performance evaluated using precision, recall, and F-score. Future enhancements include backend database integration and improved processing speed. The paper titled ”Violence Detection in Videos Using Deep Recurrent and Convolutional Neural Networks”[10] (2024) introduces a deep learning-based method for detecting violent actions in video sequences. It proposes ValdNet, a novel architecture that combines CNNs with RNNs (LSTM and GRU) to capture spatio-temporal features. The model processes RGB frames and optical flow to enhance motion detection. ValdNet achieves high accuracy across multiple datasets, outperforming existing methods. Future work aims to improve computational efficiency and enhance optical flow analysis for complex scenes.

C. Emergency Response

The paper titled ”AI-PaaS: Towards the Development of an AI-Powered Accident Alert System”[11] presents an AI-driven system that detects road accidents in real time using multiple sensors, such as acoustic, pulse oximeter, and optical heart rate sensors. The system processes motion and sound data using machine learning algorithms, including Hidden Markov Models, to detect accidents and promptly notify emergency responders and next of kin with location details. Future improvements include integrating Arduino UNO, refining detection algorithms, and expanding sensor capabilities for real-world deployment. The paper titled ”AI Enabled Accident Detection and Alert System Using IoT and Deep Learning for Smart Cities”[12] presents an AI-driven system that detects road accidents in real-time using vehicle and environ- mental sensors. The system employs supervised and unsupervised machine learning techniques, leveraging computer vision and anomaly detection to identify accidents quickly. It achieved 95% accuracy with a low false positive rate and reduced emergency response times by 20%. Future enhancements include predictive analytics and multi-vehicle collision detection. The paper titled ”LLM-Assisted Crisis Management: Building Advanced LLM Platforms for Effective Emergency Response and Public Collaboration”[13] focuses on enhancing satellite image detection for crisis management by addressing pseudo changes and class imbalance. It introduces DASNet, a dual-attentive fully convolutional Siamese network that incorporates a weighted double-margin contrastive (WDMC) loss with spatial and channel attention mechanisms. The model achieved high F1 scores on the CDD (91.9%) and BCDD (89.8%) datasets. Future improvements include applying DASNet to SAR images and integrating self-supervised learning. The paper titled ”Change Guiding Network: Incorporating Change Prior to Guide Change Detection in Remote Sensing Imagery”[14] introduces the Change Guiding Network (CGNet) to improve change detection accuracy in remote sensing imagery. CGNet enhances the U-Net model with a Change Guide Module (CGM) that refines multi-scale feature fusion using deep change features. It achieved the highest F1 score of 0.925 on the WHU-CD dataset. Future work includes expanding CGNet to SAR images and improving real-time satellite processing performance. The paper titled ”Real-Time Hand Gesture Recognition Based on Deep Learning YOLOv3 Model”[15] presents a system for recognizing hand gestures in real-time using YOLOv3 with DarkNet-53. It detects five gestures with high accuracy, achieving 97.68% in training and 96.2% in testing, outperforming models like VGG16 and SSD. Future enhancements include integrating YOLO-LITE for faster processing and improving gesture recognition with data fusion techniques.

D. Crime Hotspot Prediction

The paper titled ”Crime Forecasting: A Machine Learning and Computer Vision Approach to Crime Prediction and Prevention”[16]explores the application of machine learning and computer vision in crime detection and prevention. It demonstrates how these technologies can enhance law enforcement strategies by improving speed and accuracy in solving crimes. The study shows significant advancements through statistical observations and suggests future work on integrating predictive models and addressing ethical concerns in surveillance. The paper titled ”Empirical Analysis for Crime Prediction and Forecasting Using Machine Learning and Deep Learning Techniques” [17] explores various machine learning algorithms, including logistic regression, SVM, Na¨ıve Bayes, and deep learning models like LSTM and ARIMA, to predict and analyze crime trends. The study finds that random forest achieved 77% accuracy on the Chicago dataset, while Na¨ıve Bayes performed best on the Los Angeles dataset. Future work aims to integrate visual mapping for improved police patrolling. The paper titled ”Crime Prediction Using Machine Learning and Deep Learning: A Systematic Review and Future Directions” [18] reviews ML and DL techniques for crime prediction, focusing on regression and classification models. Techniques like CNNs and RNNs are used to analyze diverse data sources, achieving notable accuracy im- provements. Future directions include reinforcement learning for neighborhood crime detection and transfer learning for limited datasets while addressing ethical concerns. The paper titled ”Comparison of Machine Learning Algorithms for Predicting Crime Hotspots” [19] evaluates machine learning models such as LSTM, KNN, SVM, and CNN for crime prediction using historical data and built environment covariates like points of interest (POIs) and road network density. LSTM achieved the highest accuracy, with improved performance when environmental factors were included. Future work suggests incorporating socioeconomic factors and ensemble models for better predictions across diverse regions. The paper titled ”Crime Prediction Using Spatio-Temporal Data”[20] addresses crime prediction challenges by tackling data imbalance issues. Using the San Francisco crime dataset, the study applied resampling techniques like SMOTE and random undersampling to improve classification accuracy. The random forest model achieved an accuracy of 99.16% with random undersampling. Future research aims to incorporate deep learning techniques and expand the study to include cybercrime prediction. The paper titled ”Comparative Study of Approaches for Detecting Crime Hotspots with Considering Concentration and Shape Characteristics” [21](PubMed, 2022) evaluates various spatial hotspot detection methods by analyzing both concentration and shape characteristics. It introduces an evaluation framework with new indicators to assess detection techniques. The study highlights the AMOEBA method for its superior accuracy in capturing hotspot intensity and morphology. Future work aims to extend the framework to spatio-temporal analysis and explore additional datasets for validation.

III. OVERVIEW OF PROPOSED SYSTEM

The proposed Women Safety Analytics system leverages AI to enhance public safety by detecting threats in high-risk areas. It consists of several modules: an Input Module for video pre-processing, an AI Processing Module for object detection, gender classification, and gesture recognition, and a Threat Detection Module that assesses risk levels. Alerts are sent in real-time via multiple channels. Data storage enables trend analysis and visualization for proactive safety measures. A dashboard provides monitoring and control, while privacy measures ensure ethical use. Future expansions may include audio detection and predictive analytics.

IV. CONCLUSION

The Women Safety Analytics system offers a comprehensive AI-driven solution to enhance public safety by integrating advanced technologies such as object detection, gender classification, gesture recognition, and anomaly detection. By leveraging real-time video surveillance, machine learning algorithms, and a robust alerting mechanism, the system ensures swift responses to potential threats in public spaces. The architecture is structured into several key modules, including an Input Module that preprocesses live video feeds to eliminate noise and standardize frames, ensuring optimal data quality for AI processing. The AI Processing Module employs state-of-the-art deep learning techniques, such as YOLO and CNN, to detect individuals, classify genders, and recognize gestures that may indicate distress, such as waving hands. Additionally, the system's anomaly detection capabilities identify abnormal crowd behaviors and situational risks like lone women in isolated areas. Once threats are identified, the Threat Detection and Alerting Module assesses the severity of the situation based on factors such as time, location, and predefined risk thresholds. When an alert is triggered, the Notification System ensures real-time communication with law enforcement and emergency responders via SMS, email, or mobile app notifications. The Data Storage and Analysis Module securely stores all collected data—video footage, metadata, and alerts—facilitating trend analysis, resource planning, and high-risk zone identification through visualizations such as heat maps and charts. A user-friendly dashboard and interface module enables authorized personnel to monitor real-time feeds, configure system settings, and analyze safety patterns. The Privacy and Security Module ensures compliance with ethical guidelines by anonymizing personal data and restricting unauthorized access to sensitive information. The system is designed to be adaptable and scalable, offering potential future enhancements such as audio distress signal detection, predictive analytics, and integration with smart city infrastructures. The project also addresses crucial challenges such as minimizing false positives, improving detection accuracy, and balancing surveillance capabilities with ethical concerns regarding privacy. In conclusion, the Women Safety Analytics system provides a holistic and effective strategy for enhancing women's security in urban environments. It enables law enforcement agencies to act proactively, making public spaces safer through AI-powered real- time monitoring and data-driven insights. As the system continues to evolve, it holds great promise for broader applications in crime prevention and public safety initiatives across smart cities worldwide.

DECLARATIONS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

This survey paper does not generate or analyze new datasets. It provides a comprehensive review of existing literature and publicly available datasets relevant to the topic. The data supporting this study have been cited within the manuscript and can be accessed through the respective references. For any additional queries regarding data availability, the corresponding author may be contacted.

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