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AI-Powered Military Border Surveillance System Using Face Recognition and Military Vehicle Detection

[1]Prof. P. P. Kulkarni , [2]Sale Tejashree , [3]Dhope Seema, [4]Devsarkar Nikita , [5]Bobade Sakshi

[1 2 3 4 5]*S. B. Patil College of Engineering, Indapur*

Email: pratikkulkarni019@gmail.com, saletejashree2003@gmail.com, seemadhope2004@gmail.com devsarkarnikita@gmail.com, bobadesakshi28@gmail.com

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Abstract

The Project presents an AI-powered surveillance system designed for military border security using two core modules. The first module uses Haar-Cascade-based facial recognition to detect and recognize trained military personnel faces. If an unauthorized face is detected, the system captures the image, determines the current location, and sends an alert email to concerd authorities [10]. The second module focuses on detecting military vehicles using a YOLOv8 deep learning model [4], [5]. The model is trained on a dataset of military vehicles and deployed to monitor the border area. On detecting a vehicle, it captures the image, calculates the distance from the camera using image-based estimation, logs the location, and sends an alert email. This dual-module system helps reduce human dependency, increases accuracy, and provides real-time responses to potential threats on the border.

Introduction

In mordern defense and surveillance systems, ensuring secure access and identifying po-tential threats at military bases and borders is of atmost importance. Traditional security methods like ID cards and manual checking are time consuming, prone to human error,and vulnerable to forgery or impersonation [3]. To enhance the efficiency and reliability of military Security, this project proposes an AI-powered Military Vehicle and Face Authentication System that combines automatic vehicle recognition with facial biometrics for a two-layered authentication process.By combining the face recognition and vehicle authentication, the system prevents unauthorized entry, reduces human error, and strengthens border and base security through real-time, automated verification [4],[10].

Literature Survey

S.No	Paper Title	Authors	Year	Problem Solved	Technique	Future Scope	Reference No
1	System-in-the-loop test system with Mixed Reality for AGV	Hyunsung Tae et al., Sae-dong Yeo, Sukhym Hwang	2025	Provides a mixed-reality system-in-the-loop platform for safe testing and validation of AGV sensors, controllers, and navigation in realistic scenarios	Mixed-reality Simulation, Virtual Test and Evaluation, Augmentaion Technologies, 3D Pose Estimation	Supports safe mixed-reality testing of AGVs and advances to real-time, high-fidelity, multi-AGV autonomous applications	[1]
2	Decision-Aid Framework for Face Authentication Using RestNext50 +BiLSTM	Ayat AbdMuti Alrawahneh etal, Siti Norul Huda Sheikh Abdullah, Tarik Abuain	2025	Uses ResNeXt50 with BiLSTM to build a decision-aid framework that enhances accuracy and reliability in face authentication.	ResNext50 + BiLSTM	Extend to real-time applications, larger datasets, multimodal biometrics, and improved robustness against spoofing	[2]
3	Enhanced Biometric Template Protection Schemes in IoT	Alamgir Sardar et al,Saiyed Umer, Ranjeet Kumar Rout	2024	Secures biometric data in IoT systems using advanced template protection schemes to prevent misuse	Template Protection + Face Recognition, Image Preprocessing	Improve with stronger encryption, blockchain integration, and scalable privacy preserving authentication for diverse IoT Applications	[3]

4	Military Vehicle Object Detection Based on Hierarchi- cal Feature Represen- tation and Refined Locatiza- tion.	Yan Ouyang et al, Xinqing Wang, Ruizhe Hu, Honghui Xu, Fam- ing Shao.	2022	Accurate multi- scale military vehicle detection with refined locatization using hi- erarchical features.	Hierarchical Feature + YOLO, Object detection, Military Object De- tection, Re- inforcement technology	Real-time deployment,multimo dal/ 3D data integration, robustness to camou- flage, and autonomous defense appli- cations.	[4]
5	Visitor Authen- tication Based on Face Recogni- tion using CCTV	Hyung-Jin Munetal, Min- Hye Lee	2022	Provides automated visitor au- thentication through CCTV- based face recognition for enhanced security.	CCTV + Face Recogni- tion,YOLO, Object Detection technology, Security service with face recognition technology	Expand to real-time large-scale deployment with AI-driven accuracy, antispoofing, and cloud integration.	[5]
6	Robust Facial Authenti- cation for Low-Power Edge-AI Devices.	Wangyao et,nViktor Varkarakis, Gabriel Costache, and Joseph Lemley	2022	Provides efficient and secure facial au- thentication optimized for low- poweredge- AI devices.	Edge-AI + Face Recog- nition,Face re- lighting method, FR evalua- tion, IOT, Portrait relight- ing, Face recognition	Enhance with advanced lightweight models, multimodal biometrics, and broader deployment in IoT and mobile systems.	[6]
7	Steganograp Secret Sharing with GAN- Based Face Synthesis.	,Sicisheng Chenetal, Ching- chun chang3, And Isaoechizen3	2021	Uses steganography and GAN-based face syn- thesis to securely hide and share secret information.	GAN + Steganog- raphy + Morphing,	Stronger GAN models, real-time sharing, and broader use insecure communi- cation and forensics.	[7]

8	Efficient Android Based Multi- modal Biometric Authenti- cation.	Xinman Zhang etal	2020	Uses an an- droid based platform combining multiple biometrics (e.g., finger- print, face, voice) for secure user authentica- tion.	Multimodal biometric authenti- cation , Android- based smart terminal, improved LBP, im- proved VAD, Adaptive Fusion Strategy	Enhance with AI-driven liveness detection, cross plat- form support, cloud integration ,and stronger protection aganist spoof- ing attacks.	[9]
9	3D face Authen- tication Software Test Au- tomation	Debdeep Banerjee et al,Kevin YU	2020	Automates testing of 3D face au- thentication software for accuracy, reliability, and per- formance vaildation.	3D Face Recognition ,Test Au- tomation,	Advance toward AI- driven adaptive testing, cross platform support, and large scale real time deployment.	[10]
10	Privacy Preserving Edge Com- putation Based Face Verifica- tion	Xiang Wang, Heyu Xue, Xuefeng liu and Qingqi Pei	2019	Secures face verifi- cation by processing biometric data locally on edge devices to preserve privacy.	Face Recog- nition, Edge computing , Privacy pro- tection,	Enhance with federated learning, stronger encryption, and scalable deployment across IoT and cloud edge systems.	[11]

Research Gap

AI-powered military border surveillance systems using face recognition and military vehicle detection show , but many several gaps remain as it is. Current models lack robustness against real-world challenges such as poor lighting ,occlusion, long-rang low-resolution imagery, and adversarial spoofing.Face recognition suffers from the demographic ,dataset bias, while detecting small or distant vehicles remain difficult to detect reliably, especially at night remains difficult. Multi-sensor fusion and cross modal tracking are still in under development process, leading to high false alarm rates in real deployments.Moreover, most solutions are resources heavy and unsuitable for the real time tracking edge deployment in remote areas, and they contain lack explanation , makes the operator ,tracker
trust difficult. Finally the lack of standardized datasets and benchmarks for border surveillance scenarios limits progress, as most publicly available datasets are collected in controlled .Adversary-informed design, legal and ethical safeguards, and standardized border-specific datasets are still limited, restricting the reliability and safe deployment of such systems.

Problem Statement

Securing national borders is a top priority for any

country. Human-based surveillance systems are prone to fatigue, limited coverage, and delays in response. Intrusions by unauthorized personnel or unidentified vehicles along military borders pose a critical threat. There is a pressing need for an automated, intelligent surveillance system that can authenticate military vehicles using object detection models. Unauthorized presence or movement should trigger real-time alerts with visual evidence and location for immediate action.

Conclusion

The developed AI-based surveillance system successfully enhances border security by integrating face recognition and military vehicle detection. By recognizing authorized personnel and identifying unauthorized entries, it minimizes the chances of intrusions. The system also effectively detects military vehicles using YOLOv8 and provides valuable spatial information including distance and location. Automated email alerts ensure real-time response and situational awareness. This system demonstrates the potential of combining computer vision with location services to modernize military security infrastructures and reduce reliance on manual surveillance.

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