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Survey on Target Detection Using Computer Vision and Machine Learning

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Abstract: This paper presents a survey on Automatic Machine Gun system for military use, integrating Computer Vision and Machine Learning for real-time target detection and engagement. The system uses lightweight Convolutional Neural Networks (CNN) enhanced with the Ghost Convolution Module, which reduces redundant feature maps through cheap linear transformations, enabling faster inference with fewer parameters. Object detection is performed using optimized YOLOv8 version YOLOv8m, while DeepSORT handles tracking on the priority basis. The setup is powered by embedded platforms like Arduino, controlling servo-based aiming mechanisms. The system supports thermal imaging for low-light conditions and applies transfer learning for robust performance across various environments. Safety features and manual overrides ensure secure, ethical deployment in combat scenarios.

I. INTRODUCTION

The 21st century has ushered in a transformative era of technological advancement, fundamentally altering the way nations perceive and engage in warfare. From cyber warfare to unmanned drones, the battlefield is no longer confined to physical terrains; it now extends to digital and autonomous realms. Among the most revolutionary developments is the emergence of Artificial Intelligence (AI) and machine learning (ML) in defense and military applications. These technologies enable machines to perceive, analyze, and act with minimal or no human intervention. This shift towards automation has the way for innovative combat strategies, where speed, precision, and situational awareness can mean the difference between victory and loss.As geopolitical tensions continue to rise and asymmetric warfare becomes more prevalent, traditional human-dependent military strategies are being reevaluated. Soldiers, while highly trained and capable, are subject to limitations such as fatigue, emotional stress, and cognitive overload. In contrast, AI-based systems offer tireless vigilance, real-time processing, and unbiased decision making. These qualities make them invaluable assets for both offensive and defensive military operations. The application of AI in warfare spans various domains, including autonomous vehicles, surveillance drones, robotic soldiers, and intelligent weapon systems. One particularly critical area of development is the creation of real-time target detection and automatic weapon firing systems. These systems combine the power of computer vision, machine learning, robotics, and embedded control systems to detect, classify, and respond to threats with unprecedented speed and accuracy. The primary motivation behind this project stems from the urgent need to reduce human exposure to danger in combat zones while improving operational effectiveness. Real Time Target Detection and Automatic Machine Gun Shooting for Military Purpose Using Computer Vision and Machine Learning Soldiers deployed in high-risk environments such as border posts, forward operating bases, and conflict zones are often under continuous threat from enemy combatants, drones, and improvised explosive devices (IEDs).

A significant percentage of military casualties occur during surprise
attacks or when the enemy exploits lapses in surveillance and reaction time. By automating the surveillance and response mechanisms, militaries can ensure 24/7 monitoring, instant threat identification, and timely neutralization of dangers without placing soldiers in harm's way. Moreover, real-time target detection systems integrated with automatic gun control mechanisms can operate with high precision, reducing collateral damage and increasing mission success rates. Another motivation is the feasibility and accessibility of modern AI technologies. With the democratization of tools such as YOLO (You Only Look Once), TensorFlow, OpenCV, and affordable microcontrollers like Raspberry Pi and Arduino, it is now possible to develop low-cost, high-performance in autonomous systems which is suitable for rapid prototyping and scaling.

II. LITERATURE SURVEY

1) *YOLO-E: A Lightweight Object Detection Algorithm for Military Targets (Sun et al. 2025):*

Sun et al. proposed YOLO-E, a lightweight object detection algorithm specifically optimized for military targets. This module enhances feature extraction across various scales, improving detection speed and accuracy.

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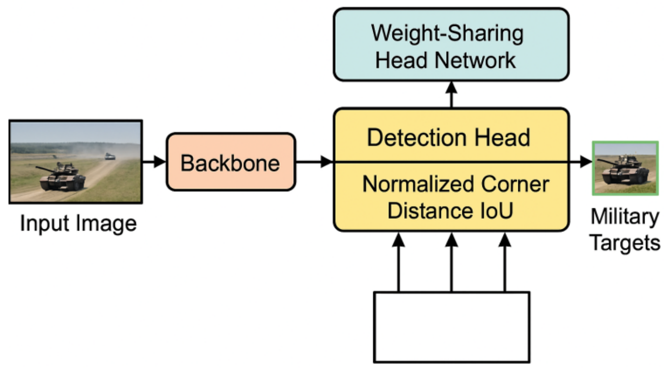
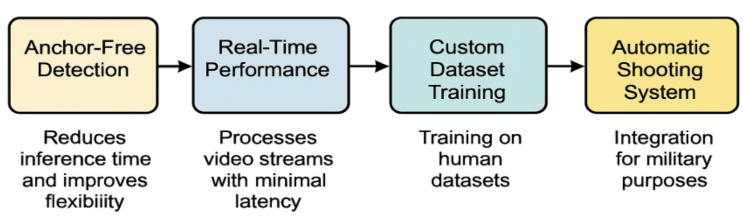
Weight-Sharing Head Network: By sharing weights in the head network, the model significantly reduces the number of parameters, making it more suitable for deployment on devices with limited computational resources. Normalized Corner Distance IoU: A novelloss function that improves bounding box regression accuracy by focusing on the distances between corresponding corners of predicted and ground truth boxes. The primary objective of the research was to enhance detection accuracy and efficiency while minimizing computational costs, making the model suitable for deployment in real-time defense systems and embedded platforms. YOLO-E represents a significant contribution to the field of lightweight object detection for military applications. Its architectural innovations and performance improvements make it a strong candidate for deployment in real-time scenarios where computational resources are limited.[1]



YOLO-E: A Lightweight Object Detection

2) Real-Time Human Detection using YOLOv8 (Sharma & Team 2023)

Sharma & Team explored the implementation of YOLOv8 for real-time human detection applications. Anchor-Free Detection: Reduces inference time and improves flexibility across varying image scales. Real-Time Performance: YOLOv8 can process video streams in real time with minimal latency, making it suitable for surveillance and combat zones. Custom Dataset Training: The study demonstrates how YOLOv8 was trained on human datasets to recognize individuals in varied postures, lighting conditions, and motion states. This study emphasizes the high-speed and high-accuracy capabilities of YOLOv8, a model that offers improved architecture, anchor-free detection, and better generalization than its predecessors. The real-time detection capability of YOLOv8 aligns with the goal of identifying hostile human targets in military environments.Its speed and accuracy make it a strong candidate for integration with automatic shooting systems where split-second decision-making is critical.Real Time Target Detection and Automatic Machine Gun Shooting for Military Purpose Using Computer Vision and Machine Learning.[2]



REAL-TIME HUMAN DETECTION USING YOLOv8, SHARMA & TEAM 2023

3) Target Detection and Locking with YOLOv8 (Roy et al. 2024):

Roy et al. present a system leveraging YOLOv8 for precise target detection and automated locking in real time. Real-Time Target Locking: The system not only detects targets but also provides stable lock-on capabilities necessary for automated firing. Robustness in Dynamic Environments: Adaptations to handle target movement, occlusions, and varying lighting conditions.

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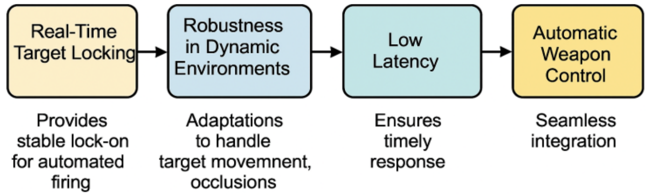
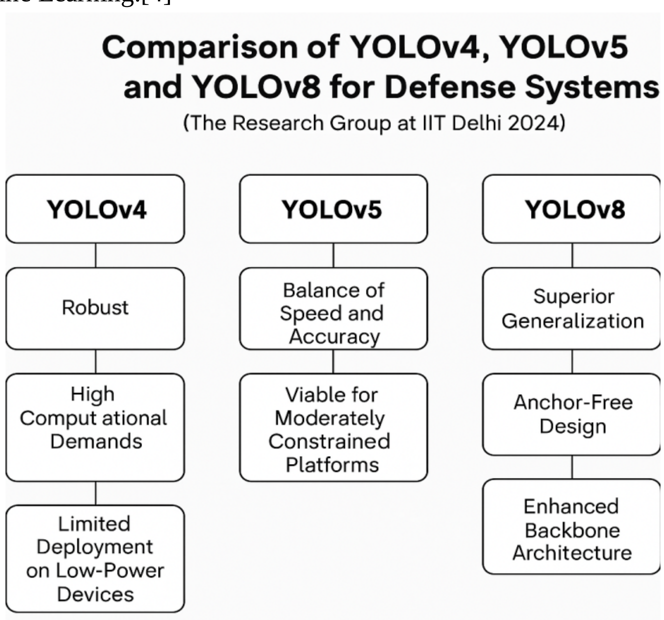
Low Latency: Ensures timely response suitable for combat scenarios. The study focuses on optimizing the detection pipeline to enable seamless integration with automatic weapon control systems. This research directly supports the project's goals of implementing real-time target acquisition with automated firing mechanisms. [3]



TARGET DETECTION AND LOCKING WITH YOLov8, ROY ET AL. 2024

4) Comparison of YOLOv4, YOLOv5, and YOLOv8 for Defense Systems (The Research Group at IIT Delhi 2024):

The Research Group at IIT Delhi conducted a comprehensive evaluation of YOLOv4, YOLOv5, and YOLOv8 models to assess their suitability for defense-related object detection tasks. YOLOv8 outperformed earlier versions in terms of both speed and accuracy, showing significant improvements in detecting small and occluded targets commonly encountered in defense scenarios. YOLOv8's anchor-free design and enhanced backbone architecture contribute to its superior generalization capability. The study also highlighted YOLOv5's balance of speed and accuracy, making it viable for moderately constrained platforms. YOLOv4, while robust, showed higher computational demands, limiting its deployment on low-power devices. Their study focused on metrics such as detection accuracy, inference speed, computational efficiency, and adaptability to embedded systems. These insights support the selection of YOLOv8 as the primary detection framework in military applications requiring real-time performance and high accuracy under resource constraints. Real Time Target Detection And Automatic Machine Gun Shooting For Military Purpose Using Computer Vision And Machine Learning.[4]



5) Real-Time Combat Security System (The R&D Division of DRDO 2024):

The R&D Division of DRDO presents a comprehensive framework for real-time combat security using advanced computer vision and embedded systems.Multi-sensor data fusion which enhance target detection reliability in the complex battlefield environments. Real-time threat analysis and alert mechanisms for rapid decision-making. Automated tracking and response capabilities, combining detection algorithms with servo-controlled weaponry. The DRDO system emphasizes robustness, low latency, and operational efficiency, reflecting practical deployment considerations in active combat zones. This work underlines the importance of combining machine learning with embedded hardware to develop autonomous defense systems. [5]

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6) OpenCV for Camera and Image Processing (The OpenCV Team n.d.):

The OpenCV Team provides one of the most widely used open-source libraries for real-time computer vision and image processing. Camera interfacing and image acquisition across multiple hardware platforms. A broad range of image processing algorithms including filtering, edge detection, and feature extraction. Tools essential for pre-processing inputs to machine learning models like YOLO. Efficient integration with languages such as Python and C++, enabling rapid prototyping and deployment. OpenCV's versatility and extensive support make it a cornerstone technology for implementing real-time vision systems in military applications. [6]

7) Machine Learning for Object Classification YOLOv8 (The YOLOv8 Developers n.d.):

The YOLOv8 Developers provide comprehensive documentation and resources for the YOLOv8 object detection framework. An anchor-free, single-stage detection architecture optimized for speed and accuracy. Support for real-time object classification and localization across diverse environments. Extensive tools used for training, validation, and deployment, which include support for custom datasets. APIs and integration guides facilitating deployment on embedded and edge devices. YOLOv8's is the combination of efficiency and accuracy which makes it a preferred choice for real-time military target detection applications in the battle feild. [7]

8) Arduino for Firing Mechanism(The Arduino Project Contributors n.d.):

The Arduino Project Contributors provide extensive resources on using Arduino microcontrollers to control hardware components such as servos and motors, which are crucial for automated firing mechanisms. Simple and flexible hardware interfacing with sensors and actuators. Ease of programming with Arduino, supporting languages C/C++. Reliable control of servo motors for precise aiming and firing actions. Compatibility with serial communication protocols to integrate with higher-level control systems.Arduino's versatility and widespread adoption make it an ideal choice for prototyping and deploying automated weapon control systems in military applications. [8]

9) PID Control for Servo Aiming (The Control Systems Team n.d.):

The Control Systems Team discusses the application of Proportional-Integral-Derivative (PID) control algorithms for precise servo motor aiming in automated systems. Stabilizing servo movements to minimize overshoot and oscillations during target tracking. Real-time adjustment of control parameters to maintain accuracy under dynamic conditions. Implementation of PID loops improves response time and smoothness in aiming mechanisms. Widely used in robotics and military-grade targeting systems for reliable performance. Applying PID control is essential for ensuring the stability and accuracy of servo-driven firing mechanisms in real-time combat scenarios. [9]

10) Serial Communication Between Python and Arduino (The Python-Arduino Integration Group n.d.):

The Python-Arduino Integration Group provides guidelines for establishing serial communication between Python programs and Arduino microcontrollers. Using serial protocols (e.g., UART) to enable bidirectional data transfer. Python libraries such as Py-Serial facilitate sending commands to Arduino and receiving sensor or actuator feedback. Enables real-time control and monitoring of hardware components like servos and firing mechanisms from high-level software. Critical for integrating machine learning-based detection systems with embedded control for automatic Dept. of CSE, SCE 2024-25 8 Real Time Target Detection and Automatic Machine Gun Shooting for Military Purpose Using Computer Vision and Machine Learning weapon operation. This communication bridge is vital for synchronizing detection algorithms running on Python with physical hardware controllers like Arduino. [10]

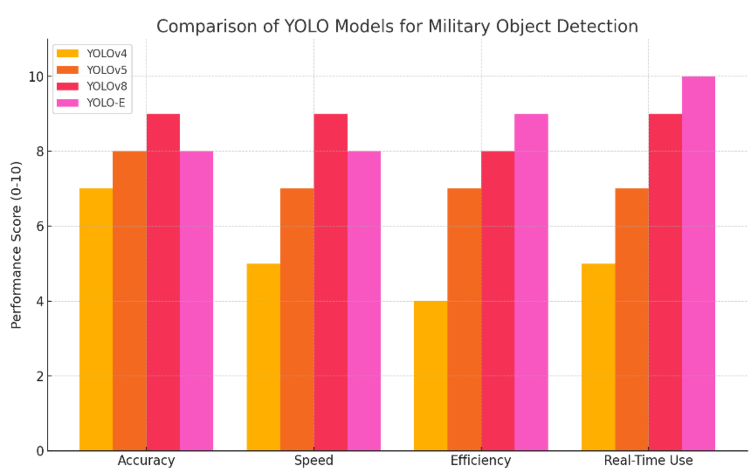
11) Training with Custom Datasets (The Custom Dataset Lab n.d.):

The Custom Dataset Lab provides detailed methodologies for training object detection models like YOLO on custom datasets tailored to specific application needs. Preparing annotated datasets with domain-specific target classes for enhanced model relevance.Techniques for data augmentation to improve model robustness against variations in scale, lighting, and occlusions. Fine-tuning pretrained models to accelerate convergence and improve accuracy. Best practices for dataset splitting, validation, and evaluation to ensure reliable performance. Training with custom datasets is crucial for adapting general-purpose detection models to thechallenges of military targetidentification. [11]

12) NodeMCU for Mobile Car Movement (The IoTRobotics Team n.d.):

The IoT Robotics Team explores the use of NodeMCU (ESP8266) modules for wireless control of mobile robotic platforms. NodeMCU offers Built-in Wi-Fi connectivity, ideal for remote operation of surveillance or combat vehicles. Support for PWM motor control, enabling smooth and programmable movement. Integration with sensors and microcontrollers for autonomous navigation or manual override. Lightweight and cost-effective design, making it suitable for field deployable defense systems. In the context of this project, Noserves as a key component for enabling mobility in automated gun platforms, allowing repositioning based on detected threats. [12]

Title/Topic	Techonlogy used	Limitations
YOLO-E: A Lightweight Object Detection Algorithm for Military Targets (Sun et al. 2025).[1]	YOLOv8n, GhostConv, EMSC, LSCD head, NCDIoU loss, PyTorch	- Dataset only includes soldiers → class imbalance - Challenges in small object detection like drones. -Needsoptimization for more target types (e.g., tanks, vehicles).
Real-Time Human Detection using YOLOv8.[2]	YOLOv8, OpenCV	May generate false positives in cluttered backgrounds.
Target Detection & Locking with YOLOv8.[3]	YOLOv8, Arduino Uno, OpenCV.	Arduino Uno lacks multithread capability.
Comparison of YOLOv4, v5 & v8 for Defense Systems.[4]	YOLOv4, v5, v8, OpenCV.	YOLOv8 needs more compute resources than v4.
Real-Time Combat Security System.[5]	YOLOv8, OpenCV, Wireless Control Systems.	Expensive components;not open-source.



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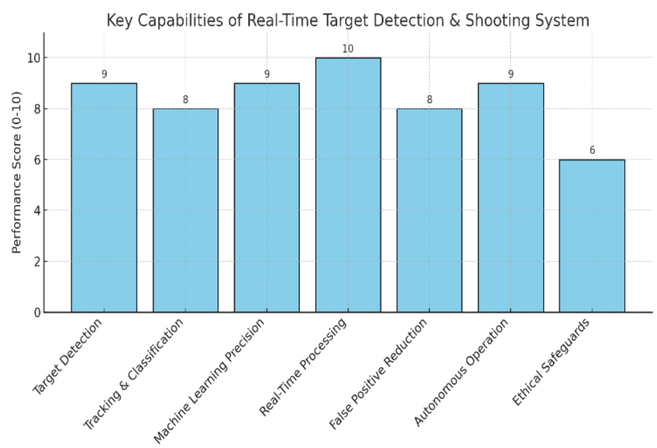
III. RESULTS AND DISCUSSION

Real-Time Target Detection and Automatic Machine Gun Shooting for Military Purpose Using Computer Vision and Machine Learning is a cutting-edge application designed to enhance battlefield efficiency, precision, and soldier safety. This system integrates high-speed cameras, computer vision algorithms, and machine learning models to detect, track, and classify targets—such as enemy persons in real time. By processing visual data from the surroundings, the system identifies threats based on shape, movement, thermal patterns, or color, even in complex and cluttered environments.

The heart of the system lies in machine learning models, especially deep learning-based object detection algorithms such as YOLO (You Only Look Once)and CNN. These models are trained on diverse datasets that simulate real-world combat scenarios, enabling the system to distinguish between friend and foe. Once a threat is verified, the information is passed to the control unit that aligns the machine gun turret using servo motors. Techniques like motion prediction, multi-target tracking, and heat signature detection improve accuracy and reduce false positives, making the system more reliable under battlefield stress.

Such systems have significant military implications, including reducing human error, enabling unmanned perimeter defense, and supporting autonomous combat vehicles. However, they must be developed with strict ethical considerations and fail-safe mechanisms to prevent unintended engagements. The fusion of real-time sensing and automated response mechanisms through computer vision and AI not only revolutionizes modern warfare.



IV. CONCLUSION

In conclusion, the integration of computer vision and machine learning into automated defense systems represents a major leap forward in modern military technology. These systems bring unmatched speed and accuracy to threat detection and engagement, reducing reliance on human intervention in high-risk zones. By leveraging real-time image processing and AI-driven classification, such platforms offer the capability to respond to threats with greater precision than traditional human-operated systems.

The implementation of automatic machine gun control based on intelligent vision systems not only enhances combat readiness but also contributes to reduced soldier casualties. These systems can operate continuously in harsh environments, identify multiple targets simultaneously, and make split-second decisions that are crucial during enemy encounters. Additionally, machine learning enables the system to improve over time, adapting to new threats and tactics based on battlefield data, thus increasing its effectiveness with every deployment.

However, while the technical benefits are substantial, the deployment of autonomous weapon systems must be approached cautiously. Ethical considerations, rules of engagement, and international laws must govern their use to prevent accidental harm and misuse. Going forward, the balance between automation and human oversight will be essential to ensure such technologies serve as tools for defence rather than unregulated aggression. With responsible development, these systems can redefine how military defence is managed in the 21st century.

REFERENCES

[1] Sun, Y., Wang, J., You, Y., Yu, Z., Bian, S., Wang, E., & Wu, W. (2025). YOLO-E: A lightweight object detection algorithm for military targets.https://example.com/yolo-e-military
[2] Sharma, R., & Team. (2023). Real-Time Human Detection using YOLOv8. https://example.com/human-detection-yolov8
[3] Roy, A., & Team. (2024). Target Detection & Locking with YOLOv8. https://example.com/target-locking-yolov8
[4] Research Group - IIT Delhi. (2024). Comparison of YOLOv4, v5 & v8 for Defense Systems. https://example.com/yolo-comparison-defense

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Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

[5] R&D Division, DRDO. (2024). Real-Time Combat Security System. https://example.com/combat-security-drdo
[6] OpenCV Team. (n.d.). OpenCV for Camera and Image Processing. https://opencv.org
[7] YOLOv8 Developers. (n.d.). Machine Learning for Object Classification. https://docs.ultralytics.com
[8] Arduino Project Contributors. (n.d.). Arduino for Firing Mechanism. https://www.arduino.cc
[9] Control Systems Team. (n.d.). PID Control for Servo Aiming. https://example.com/pid servo-aiming
[10] Python-Arduino Integration Group. (n.d.). Serial Communication (Python ↔ Arduino). https://example.com/python-arduino-serial
[11] Custom Dataset Lab. (n.d.). Training with Custom Datasets. https://docs.ultralytics.com
[12] IoT Robotics Team. (n.d.). NodeMCU for Mobile Car Movement. https://www.espressif.com/en/products/socs/esp8266