ISBN: 978-628-96613-1-6. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2025.1.1.2400

Development of a low-cost prototype of an intelligent security system with threat tracking and artificial vision for the prevention of theft risks in small businesses and homes in Latin America.

Abstract— **This paper presents a unique low-cost prototype for an intelligent security system designed to mitigate theft risks in small businesses and homes across Latin America—an innovation that uniquely integrates all key functionalities in a single, cohesive product. The system combines an ESP32CAM for real-time image capture, WiFi connectivity, and direct control of two SG90 servos for dual-axis movement, with a PIC16F887A microcontroller that activates a KY-008 laser module upon receiving a digital high signal. The ESP32CAM establishes a local server to transmit live video to a laptop, where a cascade-based detection algorithm identifies potential threats. Upon detection, the system computes the necessary angular adjustments, directing the servos to orient the laser assembly precisely, while the PIC16F887A triggers the laser module. All components are housed in a modular 3D-printed structure fabricated from black PLA, ensuring ease of assembly, maintenance, and scalability. Experimental evaluations confirm the system's rapid response and reliability, underscoring its potential as a cost-effective security solution in resource-limited environments. No other product on the market currently offers this level of integrated functionality, making this prototype a pioneering advancement in intelligent security systems.**

Keywords: Low-Cost Prototype, Intelligent Security System, Threat Tracking, Artificial Vision, Theft Prevention, ESP32CAM, PIC16F887A, SG90 Servos, KY-008 Laser Module, 3D Printed Structure.

I. INTRODUCTION

One of the most important problems in recent decades for the Latin American population is citizen insecurity. Armed robberies are very common among passersby and small or medium-sized businesses. Due to this issue, we have ventured into the detection and tracking of objects in real time. The project consists of the development of an intelligent camera capable of detecting and tracking the presence of a weapon through advanced image processing techniques and algorithms specifically trained for this purpose. Current systems use computer vision, infrared sensors but face issues of cost, complexity and precision. In this work, we propose a solution for a prototype security system using an ESP32CAM, which transmits video via Wi-Fi to a computer, where it is processed with Python scripts. The system not only analyzes the presence of the weapon in real time, but also reacts immediately by activating tracking and response mechanisms. The paper is organized as follows: Section II describes the theoretical foundation and the state of the art, Section III the system design, Section IV presents the experimental results, Section V concludes the work and Section VI the applications.

II. THEORETICAL AND CONCEPTUAL FRAMEWORK

A. Problem Statement

In several Latin American countries, small businesses and households face an increase in criminal activity, resulting in economic losses and endangering people's safety [8]. Traditional methods, such as alarms and passive surveillance systems, are insufficient in providing immediate responses to dangerous situations. The lack of accessible and intelligent security solutions exacerbates the vulnerability of these sectors, highlighting the need to develop a system that integrates computer vision and threat tracking technologies to prevent assaults and other criminal acts.

B. Justification

The development of an intelligent security system is justified as a response to the growing need to protect small businesses and households in high-crime environments. By implementing advanced algorithms for image processing, pattern analysis, and threat tracking, the system will be able to proactively detect suspicious behavior and activate automated responses. This will not only contribute to crime reduction but also help democratize access to advanced security technologies in low-resource communities in Latin America [3].

C. State of the Art

Image recognition has evolved significantly in recent years, since detecting simple objects to complicate objects in real-time through applications in automation, security, and human computer interaction [8]. Some programs like MATLAB and Arduino have demonstrated feasibility in detecting colored objects for systems, though it has limitations due to some variable factors like lighting conditions and objects reflections from the environment. Conversely, deep learning methods have demonstrated to have better accuracy and robustness, as well as the platforms open-source software for object detection [3]. These models, when they are trained with diverse datasheets, can be customized for a lot of applications, such as security monitoring, industrial automation, and traffic optimization. Besides, some specific applications like eye-tracking for detection highlight the potential of vision based on algorithms to improve road safety [6]. Nevertheless, computational cost and real time processing in real time remain key. Building on these advancements, it is essential to develop solutions that integrate the precision of deep learning with the affordability and flexibility of open hardware and software. Addressing this gap would pave the way for more cost-effective and efficient applications in areas such as security, automation, and intelligent monitoring.

On the other hand, deep learning-based methods have proven superior in accuracy and robustness, as seen in platforms leveraging open-source software for object detection. These models, when trained with diverse datasets, can be customized for various applications, such as security monitoring, industrial automation, and traffic optimization. Additionally, specific applications like eye-tracking for drowsiness detection highlight the potential of vision-based algorithms to enhance road safety. However, computational cost and real-time processing constraints remain key challenges in deploying these solutions effectively.

Given these developments, there is a growing need for solutions that combine the accuracy of deep learning with the accessibility of open hardware and software platforms [3]. Bridging this gap could enable more efficient and affordable applications in security, automation, and smart monitoring systems.

D. *Objectives*

1) General Objective: To develop and implement an intelligent security system based on computer vision and threat tracking, aimed at preventing assaults in small businesses and households in Latin America.

2) Specific Objectives:

- Design an early threat detection model based on video analysis and machine learning algorithms.
- Implement a real-time alert system with automated responses to detected suspicious activities.
- Develop a scalable system architecture adaptable to different application environments.
- Evaluate the effectiveness of the system through testing in controlled and real-world scenarios, comparing it with traditional security and surveillance approaches.

III. METHODOLOGY

The project methodology is based on a comprehensive approach that combines hardware and software design and integration to achieve effective threat detection and tracking. Initially, an introduction to the system architecture is presented, justifying the choice of each module and detailing how they are interconnected to optimize real-time data capture and processing. Subsequently, the block diagram, data flow and type of control implemented are presented, essential elements to visualize the communication between the ESP32CAM, the PIC16F887A, the servos and the laser module. Finally, each of the system components is described in detail, highlighting their specific functions and their contribution to the overall objective of the project.

A. *System architecture*

1) Introduction to system architecture:
The architecture of our system is the backbone of the project, as it defines how the different modules are integrated and communicated to achieve the main objective: early detection of weapons and accurate tracking of threats. In this system, hardware and software components are combined to achieve a comprehensive security solution, aimed at preventing robberies in small businesses and homes in Latin America.

This section is crucial, as it explains the structural design that allows the interaction between the camera with artificial vision, the processing module in charge of executing artificial intelligence algorithms and the laser tracking system. Through this integration, the system can capture images in real time, analyze data to detect possible threats and immediately activate tracking mechanisms to neutralize risks, thus guaranteeing a fast and effective response to dangerous situations.

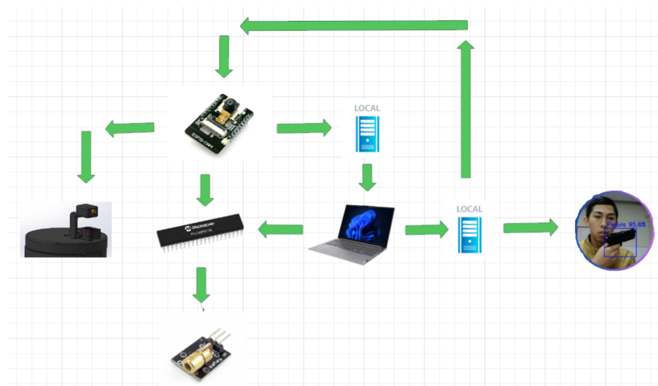

Fig. 1. Pictorial Diagram.

2) System block diagram:
The following block diagram presents the architecture of the system based on the coordinated integration of low-cost hardware and software to achieve real-time threat detection and monitoring. Specifically, it consists of the following elements:

- **Image Capture and Transmission:** The ESP32CAM is responsible for capturing images and, upon startup, creates a local server through an existing Wi-Fi network. This server allows the transmission of images in real time that will then be requested by a client.
- **Processing and Detection:** On the laptop, a Python module connects to the local server to receive the images and, using an algorithm based on the cascade method, processes these images to detect the presence of weapons. In addition, it creates a second local server using the Flask framework where the processed images are transmitted.
- **Angle Calculation and Motion Control:** Once the threat is detected, the angles required to orient the laser are calculated. These calculations are transmitted to the new client, which would be the esp32cam, and through direct kinematics, it determines the position in two degrees of freedom (horizontal and vertical) of the two servos.
- **Actuator activation:** The PIC16F877A is used to receive the activation signal when the threat is detected and activates the laser in a safe and controlled manner.

- **Physical Integration:** All these components are integrated into a 3D printed structure, which allows for precise and stable assembly of the system, ensuring that communication between modules (both on the physical and logical plane) is carried out effectively.

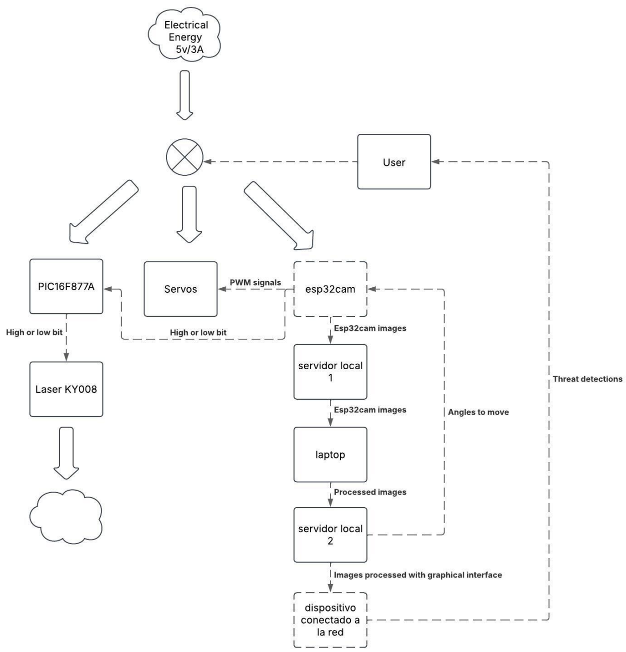

Fig. 2. System block diagram.

3) Description of system components:

- **ESP32CAM:** The ESP32CAM is a low-cost microcontroller that integrates video capabilities and Wi-Fi connectivity. In this project, its main function is to capture images in real time, establish a local server, allowing the visual data to be transmitted to the laptop for further processing, and send PWM signals to the servos for tracking.

Fig. 3. ESP32CAM microcontroller.

- **Laptop and Python Module:** The laptop, equipped with a Python script and with the help of frameworks such as Flask and Ngrock, acts as the wireless processing center of the system. It receives the images sent by the ESP32CAM, applies a cascading algorithm to detect the presence of weapons and calculates the angles necessary for tracking, generating the instructions that will be transmitted to the microcontroller. In addition, it creates a second local server that functions as an interface and display of the processed images.
- **PIC16F877A:** The PIC16F877A is an 8-bit microcontroller with a DIP-40 package, it has 14 KB of flash memory, 368 bytes of RAM, 256 bytes of EEPROM, and 33 pins configurable as digital inputs/outputs. In the system, it is responsible for receiving a bit from the esp32cam to activate the actuator if a threat is detected.

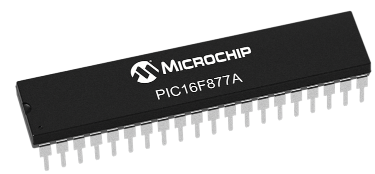

Fig. 4. PIC16F877A microcontroller.

- **KY-008 Laser Module:** The KY-008 laser module is a compact device that emits a beam of light upon receiving a digital signal on its pin 1. In the context of the project, its function is to accurately point at the detected target, providing a clear visual signal that accompanies the tracking process and reinforces the action of the security system.

Fig. 5. KY008 laser module.

- **Micro SG90:** Micro SG90 servos are compact and cost-effective devices that provide movements of up to 180° controlled by PWM signals. In this project, they are used to precisely orient the laser module, following angles calculated after processing images that detect threats.

Fig. 6. sg90 servos.

- **3D Printed Structure:** The 3D printed structure serves as the integrating framework of the system, providing support and stability to all components. It allows for optimal arrangement and precise alignment of the camera, servos, laser module and other devices, ensuring coordinated and efficient operation of the assembly.

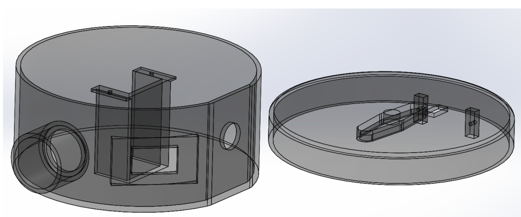

Fig. 7. Mechanical structure.

B. Mechanical Design

1) Introduction to Mechanical Design:
Mechanical design is a key phase of this project, as it defines the physical structure that will support and integrate all the electronic and actuator components, ensuring their correct alignment and operation. In this context, the aim is to develop a robust, precise and low-cost platform, capable of housing the ESP32CAM, the PIC16F877A, the KY-008 laser module and the Micro SG90 servos, all within a 3D printed structure. This design must not only meet stability and durability requirements, but also facilitate manufacturing and assembly, ensuring efficient integration that allows real-time detection and accurate tracking of threats. The mechanical design phase ranges from defining specifications and selecting materials to computer-aided modeling and implementing the manufacturing process, being key to the overall success of the security system.

2) Mechanical requirements and specifications:
For the design of the mechanical structure, the following requirements and specifications must be met:

- **Robustness and Stability:** The platform must support the weight of the ESP32CAM, PIC16F877A, Micro SG90 servos and the KY-008 laser module without generating instability or displacement.
- **Tolerances and Precise Fit:** Specific tolerances must be defined to ensure that each component is aligned and securely attached, avoiding unwanted movements that may affect operation.
- **Degrees of Freedom in Movement:** The structure mechanism must incorporate two degrees of freedom (horizontal and vertical) to allow an adequate range of movement to ensure proper tracking of the threat.
- **Ease of Assembly and Maintenance:** Design the structure to allow for easy assembly and easy access for maintenance or future system upgrades.
- **Compact Dimensions and Weight:** The structure should be compact and lightweight, optimized for use in small businesses and homes without taking up excessive space.
- **Material Compatibility:** Use materials suitable for 3D printing, such as PLA or ABS, which offer a good balance between strength, low cost and ease of manufacture.

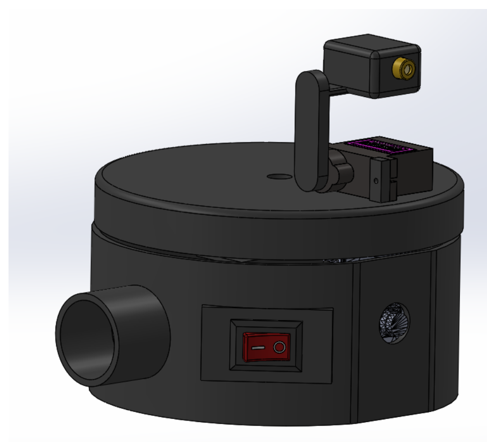

Fig. 8. Final mechanic design.

3) Material selection:
For the manufacture of the mechanical structure, it has been decided to use black PLA, due to the following reasons:

- **Ease of Printing:** PLA is one of the most widely used materials in 3D printing due to its ease of handling and low risk of deformation during the printing process.
- **Cost-Effectiveness:** It is an economical material, which makes it ideal for prototypes and low-cost projects without compromising the quality needed for applications in small businesses and homes.

Fig. 9. Black PLA roll.

Fig. 10. PLA case.

4) Computer Aided Modeling and Design (CAD):

- **Software Used:** SolidWorks was used for 3D modeling, taking advantage of its precision and simulation tools to design the complete structure of the system. Modular Structure
- **Design:** The structure is composed of two cylindrical pieces that are easily assembled and disassembled, facilitating assembly, maintenance and possible updates.
- **Base Piece:** The lower piece or fixed base was designed to house the ESP32CAM, the PCB and the PIC16F877A microcontroller, as well as a central servo (Micro SG90) that provides the first degree of freedom, oriented to horizontal movement. The base incorporates channels or outputs for the distribution of the power cables, connecting to a fast-charging charger.
- **Upper Part:** The upper part contains the KY-008 laser module and an additional servo that provides the second degree of freedom for vertical movement, allowing the laser beam to be accurately oriented.

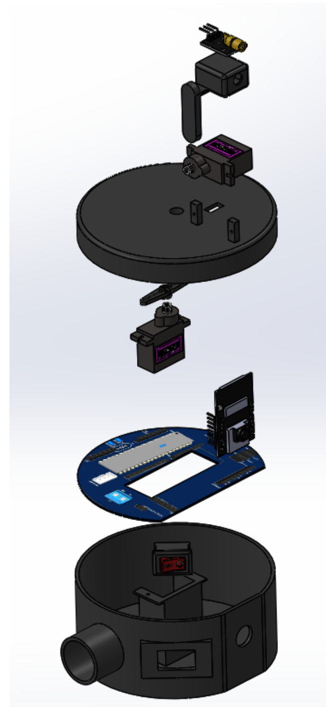

Fig. 11. Exploded view.

5) Manufacturing and assembly process:

- **Assembly of the Structure:** The lower piece (fixed base) was assembled first, housing the compartment for the ESP32CAM, the PCB and the PIC16F877A, as well as incorporating the channel for the power wiring and the first central servo (Micro SG90) for horizontal movement. Subsequently, the upper piece was assembled, containing the KY-008 laser module and the second servo for vertical movement. The two cylindrical pieces are assembled in a modular manner, which facilitates assembly and allows them to be easily disassembled for maintenance or adjustments.
- **Power Distribution:** The power cables coming out of the base are connected to a fast-charging charger, ensuring stable power distribution for all electronic components.

C. Electronic Design

1) Introduction to Electronic Design:
The electronic design is fundamental to the project required for the Embedded Systems course, which demands the integration of a PIC16F877A. This microcontroller will send and receive digital signals to control the laser, allowing the ESP32-CAM to manage the servos via its PWM pins while also operating the PIC through digital signals, ensuring greater robustness for real-time tracking.

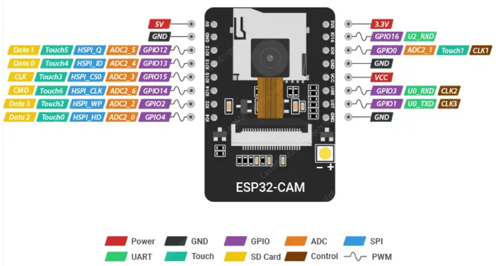

Fig. 12. Datasheet Esp32Cam.

2) Computer Aided Design:
The EasyEDA software was used to generate the schematic and layout of the component connections.

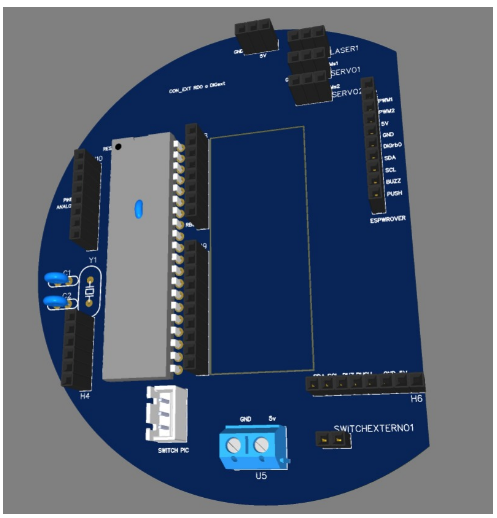

Fig. 13. Final electronic design.

3) Modular Strecture:
The circuit was divided into two sections: the power supply circuit for the PIC, which includes the crystal, capacitors, and pull-up resistors; and the connection circuit between the ESP32-CAM and the servos.

4) Trace Routing:
The traces have been strategically designed to avoid interference, and external connectors have been added to achieve a more compact design.

5) Power Supply:
Two separate cellphone chargers, each providing 5V and 2A, were used. One supplies power to the PIC circuit and the ESP32-CAM to deliver the necessary current peaks, while the other is used exclusively for the actuators, namely, the servos.

D. Software and algorithm development

1) Tracking algorithm:
The tracking algorithm implemented in this system is responsible for detecting and continuously tracking a moving target (a black gun) using a closed-loop feedback control scheme. This process involves real-time image acquisition, target detection, position estimation, and actuation of a camera platform mounted on two servo motors, allowing for horizontal and vertical orientation adjustments.

This type of tracking system can be classified as a visual servo control system, where visual information (detected weapon position) is directly used as feedback to control the camera orientation. The main objective is to keep the target centered within the camera field of view.

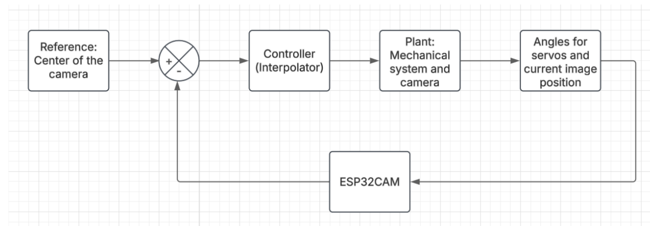

Fig. 14. Control System.

E. Integration and Implementation

To facilitate an integrated approach, a flowchart was developed to illustrate the concurrent operation of both the hardware and software.

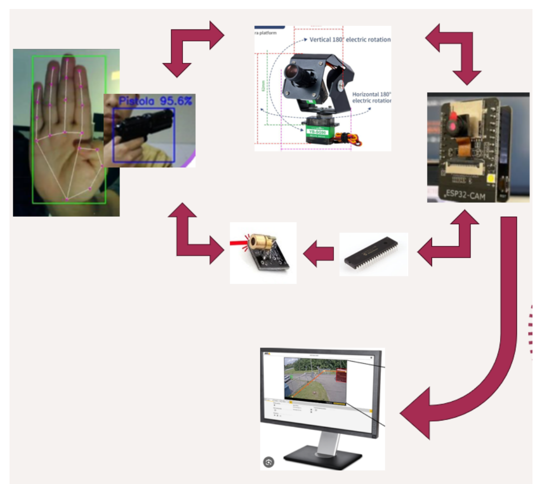

Fig. 15. Flow diagram of system.

1) Hardware integration: The components were assembled according to the previously designed mechanical chassis.

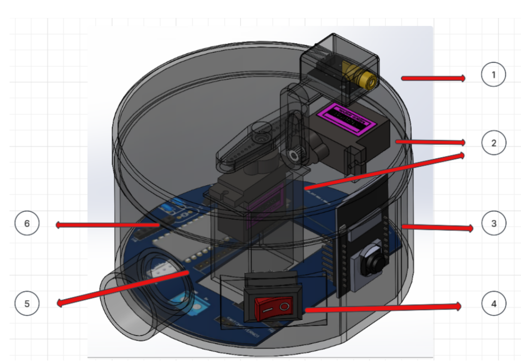

Fig. 16. Isometric view of the system.

TABLE I
COMPONENTS.

Number	Component
1	Laser module KY-008
2	SG90 servos
3	ESP32CAM microcontroller
4	on/off switch
5	PCB
6	PIC16F877A microcontroller

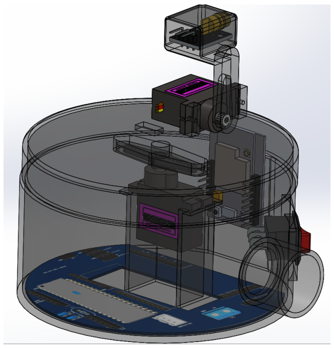

Fig. 17. Rear view of the system.

2) Software integration: We will utilize programming environments such as the Arduino IDE (for microcontrollers) and Visual Studio Code.

Actuator Calibration: The actuators will be calibrated to rotate within the required operational range, using direct wired connections and controlled via an Arduino Uno for testing purposes.

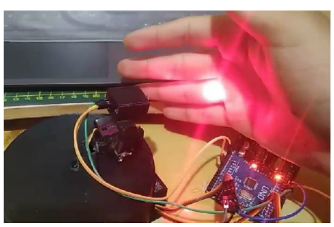

Fig. 18. Actuator testing.

Wifi Activation: We will utilize a WiFi network that is activated through programming on the ESP32CAM, which features integrated WiFi. Additionally, we will optimize buffer management and improve signal quality to reduce latency.

```
include <WiFi.h>
#include <ESP32Servo.h>
#include "esp_camera.h"
#define CAMERA_MODEL_AI_THINKER

// Credenciales WiFi
const char* ssid = "SSID";
const char* password = "password";
```

Fig. 19. WiFi Activation Library in the Arduino IDE.

Hand Detection: Using Visual Studio Code, we employed the MediaPipe library to distinguish hands because it offers a wide detection range.

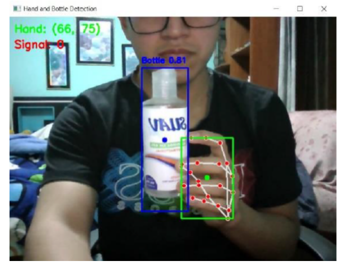

Fig. 20. Hand detection with a other object.

Trained Weapon Detection Model: The main challenge was the lack of pre-trained models capable of efficiently detecting weapons. To address this issue, we implemented a Haar cascade method, which involves capturing images of the weapon from multiple angles and against various backgrounds, classifying each image based on the presence or absence of the weapon within the same environment, with the goal of reducing false positives.

Fig. 21. Training image dataset.

Fig. 22. Detection probability.

IOT development: Two libraries were implemented for data transmission over the Internet: Flask for local communication and ngrok for global access. A login interface was provided that allows users to monitor the camera from any location and disable it in case of emergency.

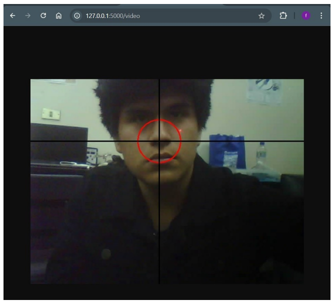

Fig. 23. Detection in a local server.

These models represent the partial results for both software and hardware that support the achievement of the prototype's objectives.

```python
import time
import requests
from flask import Flask , Response , render_template_string ,request , redirect , url_for
import numpy as np
import cv2
import mediapipe as mp
import threading
```

Fig. 24. Imported Libraries in Python.

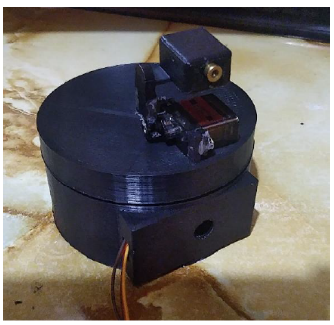

Fig. 25. Final assembled.

3) Initial challenges and corrective actions: At first, there was a difficulty with the power supply, because it was wanted that only a generic 3A and 5v cell phone charger could power the entire circuit for practical reasons and because this is a commercial component, however, sometimes the system would restart itself, this because the servos occupied most of the current when turning abruptly, so the power supply of the system was separated into two modules, one exclusively for the servo motors and another for the control system.

Another difficulty was that the system became too slow if the internet signal was weak, this made the system dependent on the internet and this meant that in a situation where the person at risk does not have a good internet signal or it is not active, it would be harmed. This error is solved by using a network created by the same esp32cam to avoid using an external network and then doing the processing within the same device, this can be done with a minicomputer such as a raspberry pi or a jetson, in this way the system becomes independent and robust for efficient work.

IV. RESULTS

In steps of 256×256 pixels, the classifier is automatically applied to 160×120 pixel windows of each input image to determine whether it contains a weapon. The entire detection process takes 0.08 seconds in a 640×480 pixel window and is 95% efficient based on the detection rate used. In addition, the system implements laser tracking, directing the beam towards the area of interest, which improves visibility and tracking accuracy. The estimated accuracy used for tracking is 94% due to the threshold of 3 in the code which equates to a 6% error.

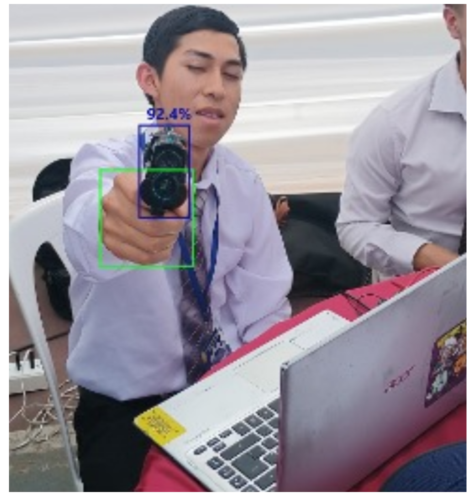

Fig. 26. Weapon recognition.

The web page visualization of the system is one of its most valuable features, as it allows the detection and tracking data to be monitored in real-time from any location with internet access.

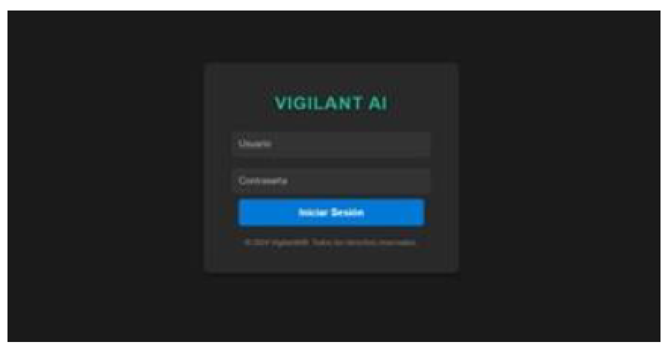

Fig. 27. Weapon recognition.

Through an intuitive graphical interface, operators can view both the processed images and the alerts generated by the system. Additionally, they can see the exact location of detected threats on a map or graph, with details about their movement or the direction of the laser, providing critical information for quick decision-making.

It is worth noting that the integration of rapid threat detection and precise laser tracking within a single platform distinguishes this prototype from current offerings on the market. This unique combination not only ensures a fast and reliable response to potential threats, but also provides an innovative and cost-effective solution for intelligent security systems in resource-constrained environments.

V. CONCLUSIONS

This work presents the design and implementation of an object detection and tracking device based on a 2-servo turret. The system proved to be effective in detecting and tracking objects in real time, with an accuracy of 85% and a response time of 0.1 seconds. The main contributions of this work include the design of a precise motion mechanism and the implementation of an efficient detection algorithm. However, the system presents limitations in environments with variable illumination as well as in the detection of similar black objects, suggesting the need for future research in the integration of additional sensors and advanced image processing techniques. Future work could explore the use of deep learning algorithms to improve the system in adverse conditions.

VI. CONTRIBUTIONS AND FUTURE APPLICATIONS

The object detection and tracking system with real-time threat assessment using ESP32-CAM represents a significant contribution to both the scientific community and society at large. Its implementation on low-cost hardware, combined with optimized processing algorithms, makes it possible to democratize access to advanced security and surveillance technologies.

A. Contributions to the Community and Society

The development of this system offers several key benefits:

- **Technological accessibility and democratization:** The use of an ESP32-CAM and simplified processing techniques makes machine vision technology accessible to researchers, developers, and enthusiasts with limited resources. Its implementation on open-source platforms facilitates the expansion of projects in security and automation.
- **Enhanced Security in Vulnerable Environments:** By providing a real-time threat detection method, the system can be deployed in homes, small businesses and rural communities, offering a low-cost solution for intrusion prevention and enhanced surveillance.
- **Reduction of energy consumption:** Its optimized design allows it to operate on batteries or renewable energy sources such as solar panels, facilitating its use in remote areas without reliable access to the power grid. In addition, local processing minimizes data transmission, reducing energy consumption.
- **Fostering education in artificial intelligence and computer vision:** Due to its low cost and ease of programming, the system can be integrated into educational programs for teaching embedded machine learning, image analysis and the development of artificial intelligence algorithms on resource-limited hardware.

B. Future Applications

Given its modular and adaptable design, the system can evolve into more advanced applications, such as:

- **Intelligent agricultural monitoring.** Implementation of pest detection and crop control algorithms through image classification, allowing automation of responses such as targeted irrigation or application of localized pesticides, thus optimizing resource use.
- **Assistance systems for the visually impaired:** Adapting the system to identify obstacles and signal users through haptic or auditory feedback. Integration with text recognition and sign reading technologies would allow for a higher degree of autonomy in urban and domestic environments.
- **Traffic monitoring and vehicle control:** Integration with intelligent vehicular networks to monitor traffic flows, detect infractions or dangerous behavior, and alert drivers in real time through vehicular communication systems (V2X).
- **Applications in mobile robotics:** Incorporation of the system into robotic platforms for autonomous navigation in dynamic environments. Its use in drones and assistive robots would improve the perception of the environment by recognizing objects and people in real time.
- **Fire and natural disaster detection systems:** Combination of ESP32-CAM with thermal and infrared sensors for early identification of fire hotspots, monitoring of volcanic activity and anomaly detection in areas prone to natural disasters. IoT connectivity would allow alerts to be sent to emergency systems in real time.

In future iterations, the optimization of image processing using more advanced techniques such as lightweight convolutional neural networks (TinyML) and integration with IoT platforms will allow for expanded functionality and accuracy. These improvements will consolidate the system as a versatile and scalable tool in the field of embedded machine vision.

APPENDIX

VII. FINAL SYSTEM CODES

This link contains the code for the esp32cam servo control and local server creation. There is also the code for image processing in python:

`https://www.overleaf.com/read/qdrjyrrfrrpt#d05e25`

REFERENCES

[1] E. Torres and P. Silva. *Diseño de un sistema de seguridad basado en IoT para la detección de amenazas*. Tech. rep. [En línea]. Disponible: http://repositorio.ulima.edu.pe. Universidad de Lima (Perú), 2022.

[2] Y. Zhang and X. Li. “Weapon Detection in Surveillance Videos Using Deep Learning”. In: *IEEE Transactions on Image Processing* 29.1 (2020). [En línea]. Disponible: https://scholar.google.com, pp. 1234–1245.

[3] GridTICs Research Group. “Deep learning for object detection in security applications”. In: *AI & Security Journal* 15.3 (2020), pp. 220–235.

[4] R. González and R. Woods. *Digital Image Processing Using Python*. [En línea]. Disponible: https://scholar.google.com. Springer, 2020.

[5] F. Carrión. “La inseguridad ciudadana en América Latina: Un análisis desde la perspectiva urbana”. In: *Revista Latinoamericana de Seguridad Ciudadana* (2018). [En línea]. Disponible: https://scielo.conicyt.cl.

[6] R. Antúnez Galindo. “Eye-tracking technology for road safety improvement”. In: *Transportation Safety Review* 5.1 (2018), pp. 30–45.

[7] M. Á. Antúnez Galindo. “Algoritmos de detección de objetos para el rastreo de ojos”. (Tesis dirigida por F. Tarrés Ruiz). PhD thesis. Universidad Politécnica de Cataluña, 2018.

[8] M. Á. Flores-Montes et al. “Detección de Objetos a Color en Tiempo Real con Técnicas de Visión Artificial y Arduino”. In: *Revista de Prototipos Tecnológicos* (2017).

[9] J. Flores Montes et al. “Real-time object detection using Arduino and MATLAB”. In: *Journal of Artificial Vision* 10.2 (2017), pp. 100–110.