SECURITY APPLICATION BASED ON ARTIFICIAL VISION

INDEX OF CONTENTS

DICTIONARY

- **IoT**: The Internet of Things (IoT) refers to a network of physical devices, vehicles, appliances, and other physical objects that are embedded with sensors, software, and network connectivity, allowing them to collect and share data, *IBM. (n.d.)*.

- **ESP8266**: Low-cost chip that supports WiFi connection with TCP/IP stack.

- **RTSP**: Real Time Streaming Protocol (RTSP) is an application-level network communication system that transfers real-time data from multimedia to an endpoint device by communicating directly with the server streaming the data, *Definition from TechTarget. (n.d.)*.

- **IP**: An **Internet Protocol (IP) address** is the unique identifying number assigned to every device connected to the internet. An IP address definition is a numeric label assigned to devices that use the internet to communicate, *Fortinet. (n.d.)*.

- **HTTP**: The Hypertext Transfer Protocol (HTTP) is the foundation of the World Wide Web and is used to load webpages using hypertext links. HTTP is an application layer

protocol designed to transfer information between networked devices and runs on top of other layers of the network protocol stack, *Cloudflare. (n.d.)*.

- **Telegram**: Telegram is a messagin application that have a lot of features for free, included features focused for development.

- **YOLOV8**: YOLOv8 is the newest model in the YOLO algorithm series – the most well-known family of object detection and classification models in the Computer Vision (CV) field. With the latest version, the YOLO legacy lives on by providing state-of-the-art results for image or video analytics, with an easy-to-implement framework, *viso.ai. (n.d.)*.

- **Computer vision**: field of artificial intelligence (AI) that uses machine learning and neural networks to teach computers and systems to derive meaningful information from digital images, videos and other visual inputs—and to make recommendations or take actions when they see defects or issues, *IBM. (n.d.)*.

- **Algorithm**: In programming is basically, a serie of actions or procedure that describe how to do or solve something.

- **Accuracy**: Accuracy is a metric that measures how often a machine learning model correctly predicts the outcome, *Accuracy - machine learning. (n.d.)*.

ABSTRACT

The following project aims to provide a security solution based on the implementation of IoT technologies and the use of an artificial vision model for real-time detection of the flow of people in a given space through a security camera that works under the RTSP protocol and an infrared motion sensor. The approach of this solution involves the integration of technologies that will allow the user to interact with a real-time monitoring system through a web application with three main modules, the first one related to the real-time video of the camera processed with artificial intelligence, the second one corresponds to records associated with

the same camera and the third one with events from the infrared sensor. In addition, the application will have real-time alert notifications via telegram.

INTRODUCTION

Security is a very important issue that concerns us as individuals in a society. Under this premise, a number of technologies arise to provide solutions in this area, from the implementation of IoT systems for user access to certain private establishments to security camera monitoring applications that provide intrusion alerts and real-time detection.

It is at this point where the idea of creating the application in question was born, an intelligent IoT system, equipped with a web application for real-time monitoring and detection of people through the implementation of a camera that works under two protocols, IP and RSTP, and on the other hand an infrared motion sensor, the latter communicates with the application through an ESP8266 module, capable of providing WiFi support to send information via HTTP protocol. It also has real-time event alerts via telegram.

The objective of this product is to facilitate and simplify the management of the security of a certain establishment by means of detection and monitoring devices for the end user.

PROBLEM

Often countless establishments face security challenges in terms of accurate intrusion detection and notification, which usually leads to security breaches that generate economic losses, harm to individuals, among others.

Having a physical surveillance system cannot be enough; ideally, a video processing system and real-time alerts should be in place to prevent and avoid disastrous situations that end in losses.

JUSTIFICATION

Frequently, businesses, companies of any kind and even residences choose to implement surveillance systems and equipment such as cameras, proximity sensors, among others. They do it to keep a real-time flow of events occurring in their facilities. The idea in itself is fine, the flaw comes in what is done with the material captured by the acquired devices. It usually depends entirely on the work of the human operator in front of the screen or in some cases there is not even staff that is responsible for monitoring cameras and events in real time.

This project aims to provide an extra in terms of security to mitigate shortcomings in monitoring processes of events related to hardware devices inside or outside establishments, both public and private, this through the detection and notification in real time of people through the implementation of a pre-trained algorithm of artificial vision, as well as the incorporation of a web application for surveillance or administrative staff to perform the effective management of the events that occur in their facilities.

Ultimately, the security system designed and built for the project will allow end users to manage the security of their establishments by detecting and segmenting humans in real time, as well as storing and alerting about intrusion events in parallel.

OBJECTIVES

General

- Create an IoT application that allows the user to manage the security of an establishment through a real-time event monitoring system based on artificial vision.

Specific

- Articulate effectively hardware components to synchronize events accurately.

- Implement a cloud component to streamline the flow of information captured by the HW-201 sensor.

- Provide the user with an intuitive and secure web interface for real-time event monitoring.

- Build a modular application to facilitate scalability and maintenance.

- Integrate a system of alerts via telegram to notify the user about events associated with the surveillance camera and infrared motion sensor.

THEORICAL FRAMEWORK

Antecendents

Object traking with camera

Object tracking camera Modern object-tracking methods can be applied to real-time video streams of basically any camera. Therefore, the video feed of a USB camera or an IP camera can be used to perform object tracking, by feeding the individual frames to a tracking algorithm. Frame skipping or parallelized processing are common methods to improve performance with real-time video feeds of one or multiple cameras, *viso.ai. (n.d.).*

The future of AI surveillance cameras – Integration with remote video monitoring

These cameras prove their worth when instant actions follow up on all detections. The real benefit appears when you combine these AI cameras with remote video monitoring. The remote video monitoring center receives an alarm signal as soon as the camera AI spots suspicious activity, such as smoke, fire, or an intruder. The remote operator uses real-time video monitoring feeds to evaluate the circumstances and take the necessary action in compliance with each client's SOPs, Chris Cullen. This could involve voice interventions,

getting in touch with the site's owner, or calling law enforcement, *Chris Cullen (May 10, 2024).*

Surveillance cameras with artificial intelligence

The incorporation of morphology-based detection in CCTV cameras with artificial intelligence is crucial for minimizing false alarms triggered by irrelevant objects like animals loitering in the area or natural environmental elements. This technology ensures that alerts are exclusively generated for detections of interest, such as humans and vehicles, *Surveillance Cameras with Artificial Intelligence. (n.d.).*

Figure 1

Surveillance cameras with artificial vision
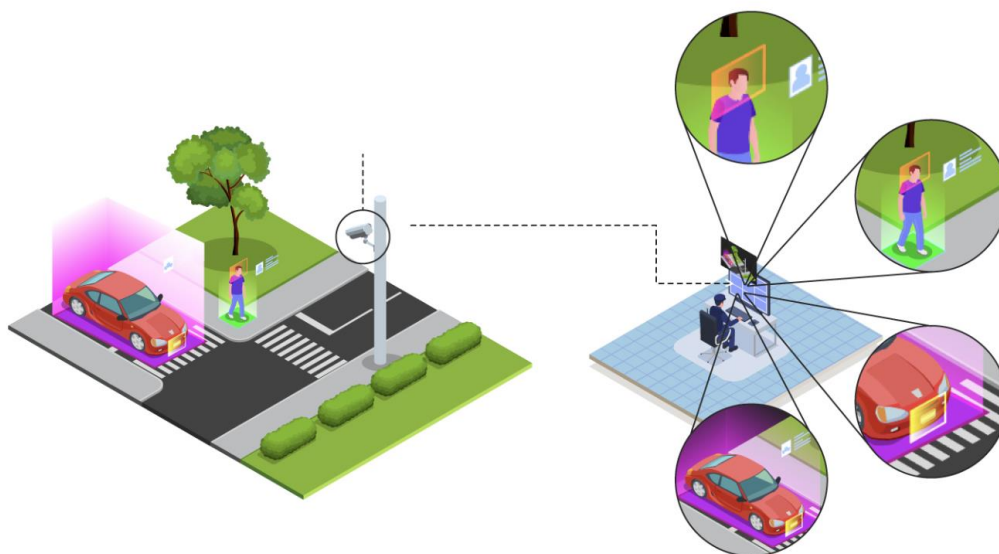
Theoretical bases

¿What's object tracking?

Object tracking is an application of deep learning where the program takes an initial set of object detections develops a unique identification for each of the initial detections and then tracks the detected objects as they move around frames in a video, *viso.ai (n.d.).*

Figure 2

People and object tracking

¿What's an IP camera?

IP stands for Internet Protocol and IP cameras record footage digitally, sending information via the internet. Instead of using an in-house storage device, the files transmitted from IP camera systems are stored in the cloud. Apart from recording video, some IP cameras can also record audio, *Advantex. (n.d.).*

¿What's ESP8266 module?

An ESP8266 Wi-Fi module is a SOC microchip mainly used for the development of endpoint IoT (Internet of things) applications. It is referred to as a standalone wireless transceiver, available at a very low price. It is used to enable the internet connection to various applications of embedded systems, *ESP8266 Wi-Fi Module Datasheet : Working & Its Applications. (n.d.).*

¿What's HW-201 module?

A sensor module adaptable to ambient light, which has a pair of infrared transmitting and receiving tubes, the transmitting tubes emit infrared at a certain frequency, when the direction of the obstacle (reflective surface) is detected, the infrared reflected is received by the receiving tube, After the processing comparator circuit, the green light is on, but the output output interface signal digital signal (low level signal), you can adjust the detection distance potentiometer, effective distance range 2 ~ 30cm, working voltage 3.3V - 5V, *PIR Sensor. (n.d.).*

Ultralytics YOLO model

The latest version of the acclaimed real-time object detection and image segmentation model. YOLOv8 is built on cutting-edge advancements in deep learning and computer vision, offering unparalleled performance in terms of speed and accuracy. Its streamlined design makes it suitable for various applications and easily adaptable to different hardware platforms, from edge devices to cloud APIs, *Ultralytics Yolo Docs. (n.d.).*

For the current project, two pre trained models by Ultralytics solutions were tested, one for detection and another one for capturing and tracking human posing, nevertheless the final choice was to use the last one, since the project didn't have a different intention to identifying human tracking and posing:
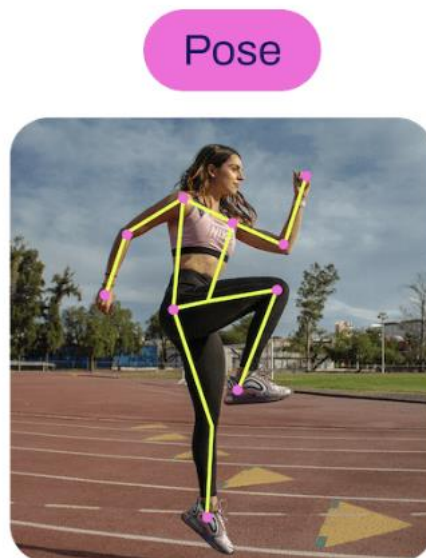
Figure 3
Detection model by Ultralytics
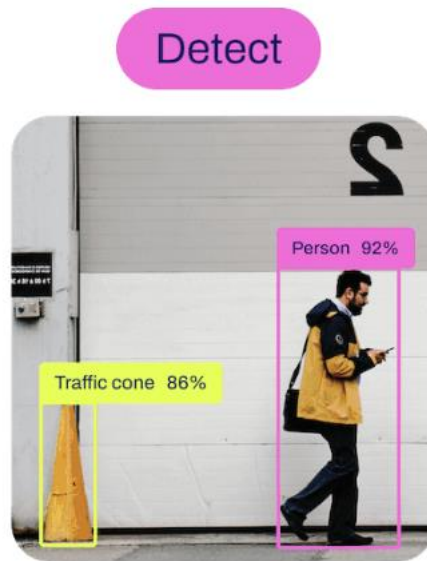
Figure 4

Pose model by Ultralytics

HARDWARE AND SOFTWARE

Implemented hardware

- Camera Tapo C200

- Laptop camera

- ESP8266 WiFi module

- HW-201 infrared sensor

Implemented software

Backend

- Spring Boot (Java)

- Python

- C++

Frontend

- React – Vite

- Tailwind CSS

- Material UI components

Database

- MongoDB Atlas

Cloud

- AWS IoT Core

Libraries and technologies

- FileGrid

- Web sockets
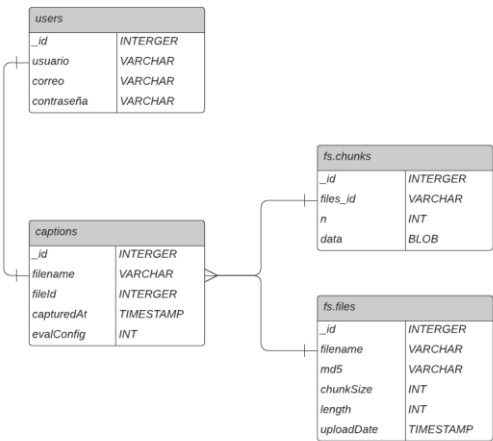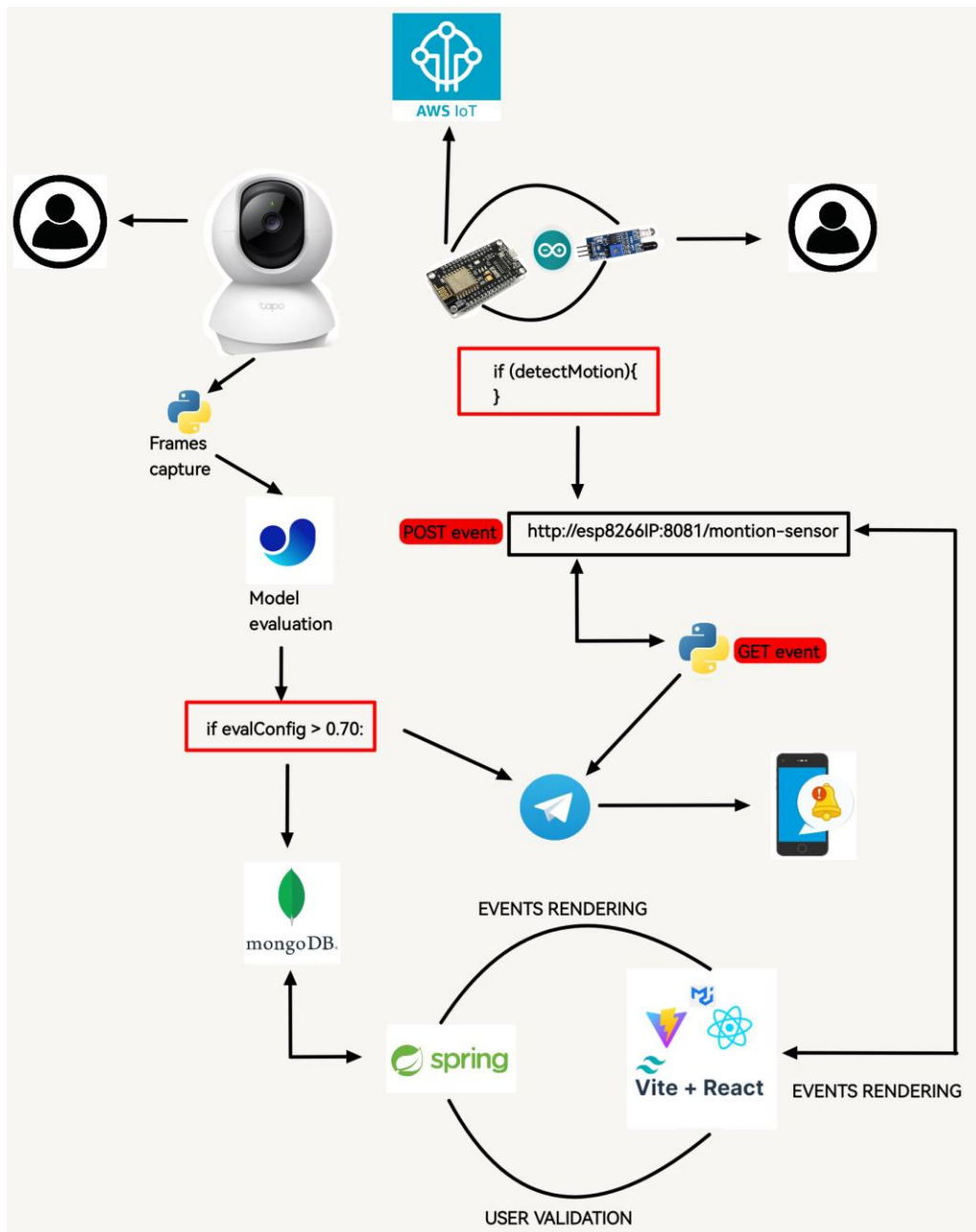
- JSON objects

- Encoding

- Hashing

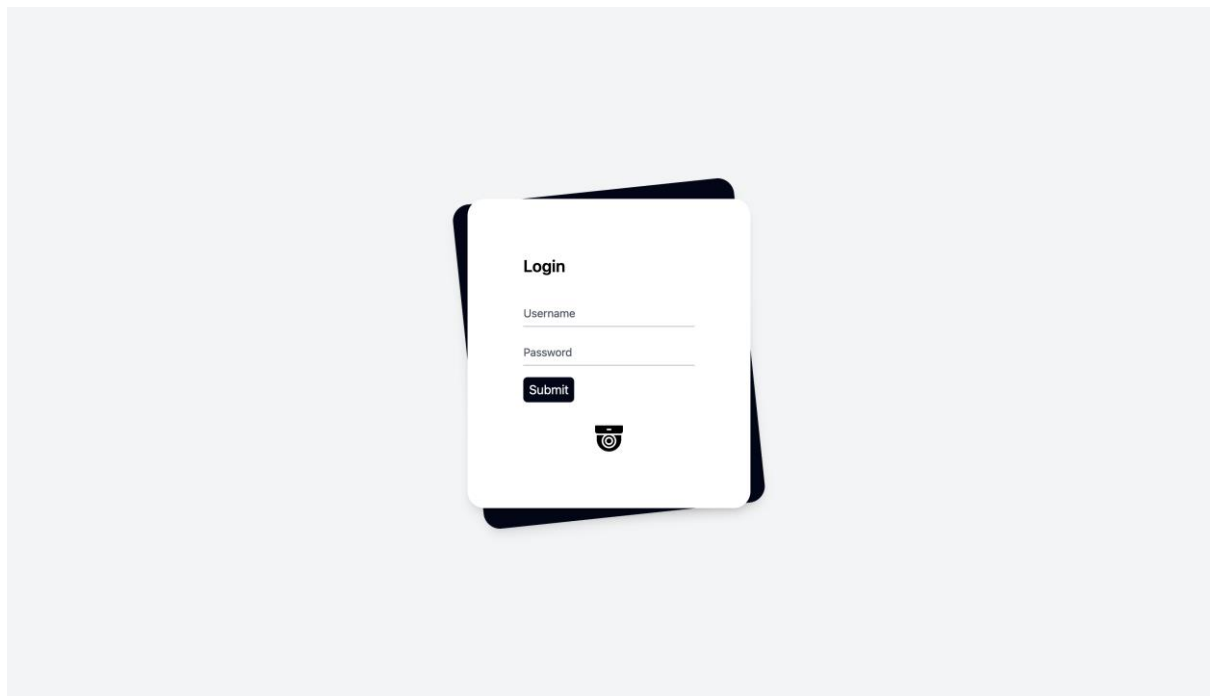- Ultralytics

DIAGRAMS

Figure 5

Database model
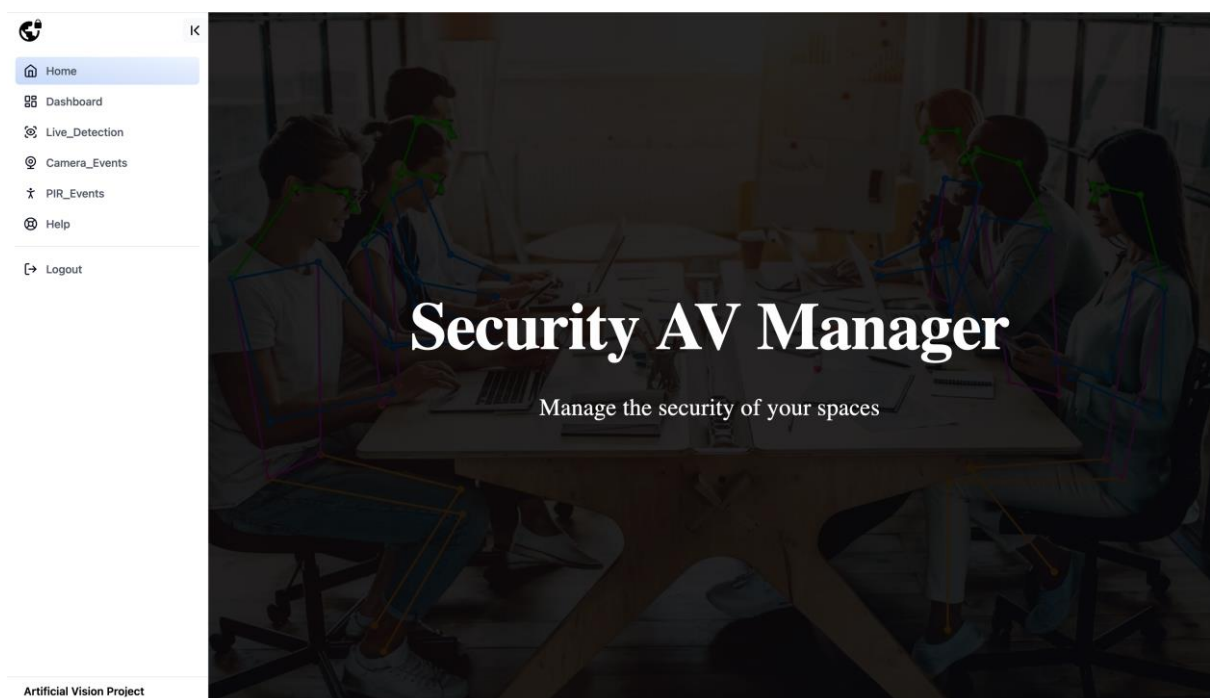

Figure 6

Application workflow

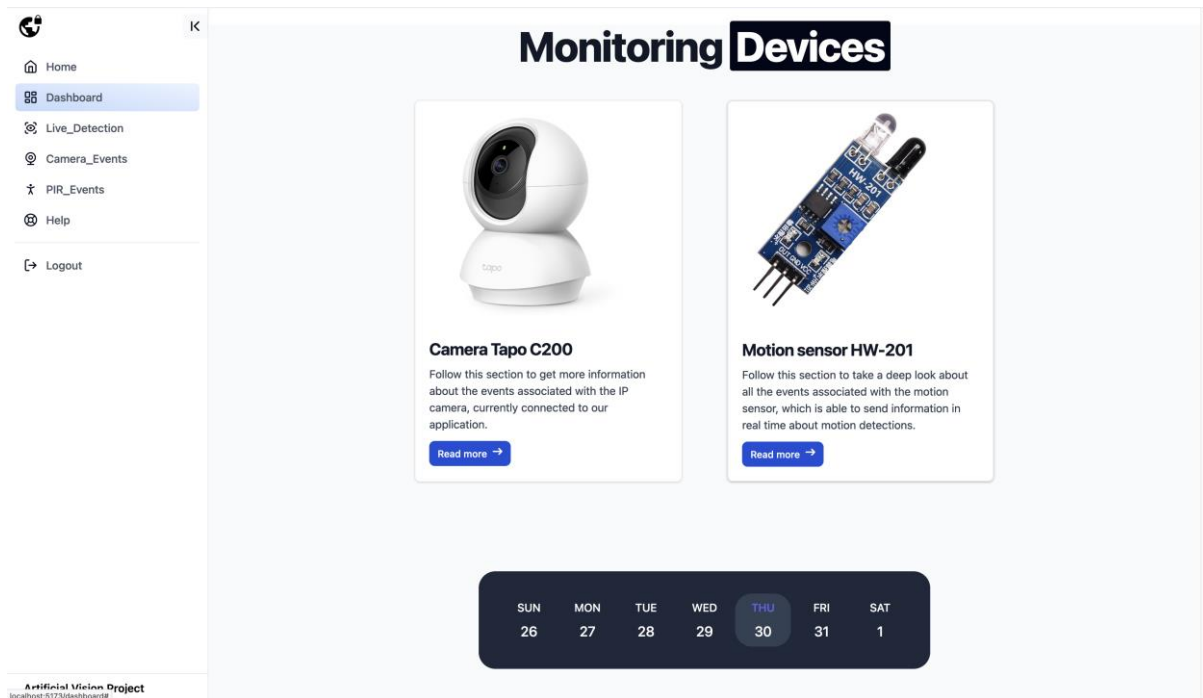**RESULTS**

Figure 7
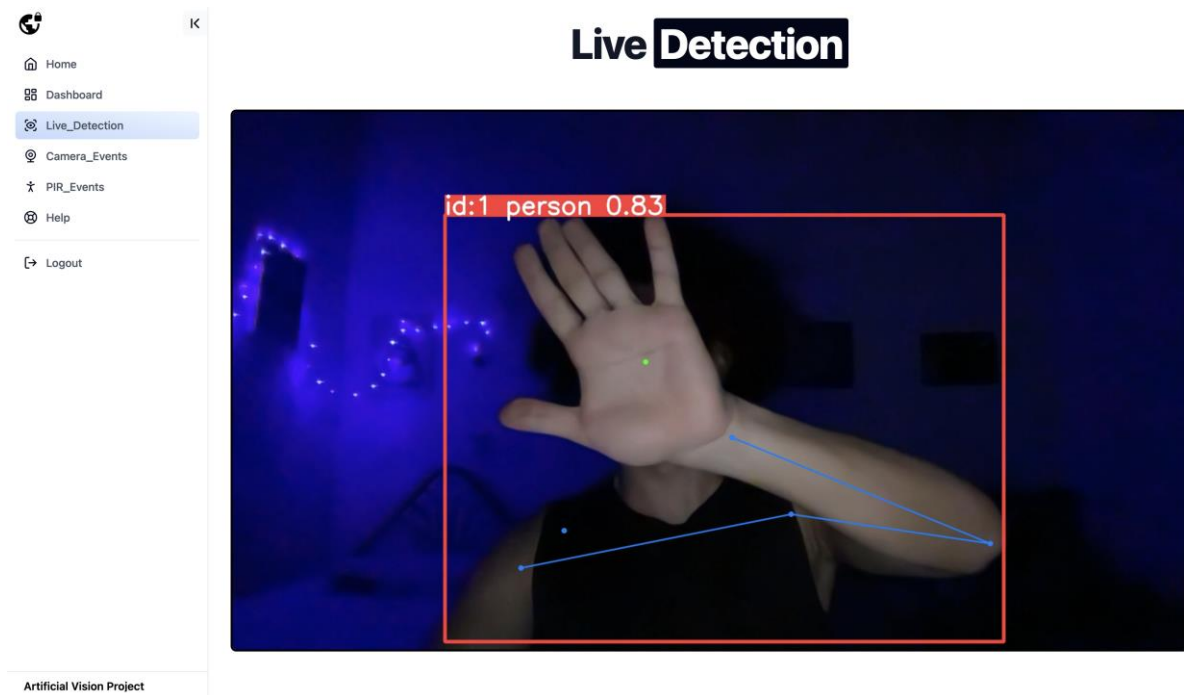
Login page

Figure 8

Home page

Figure 9

Dashboard page

Figure 10

Live detection page
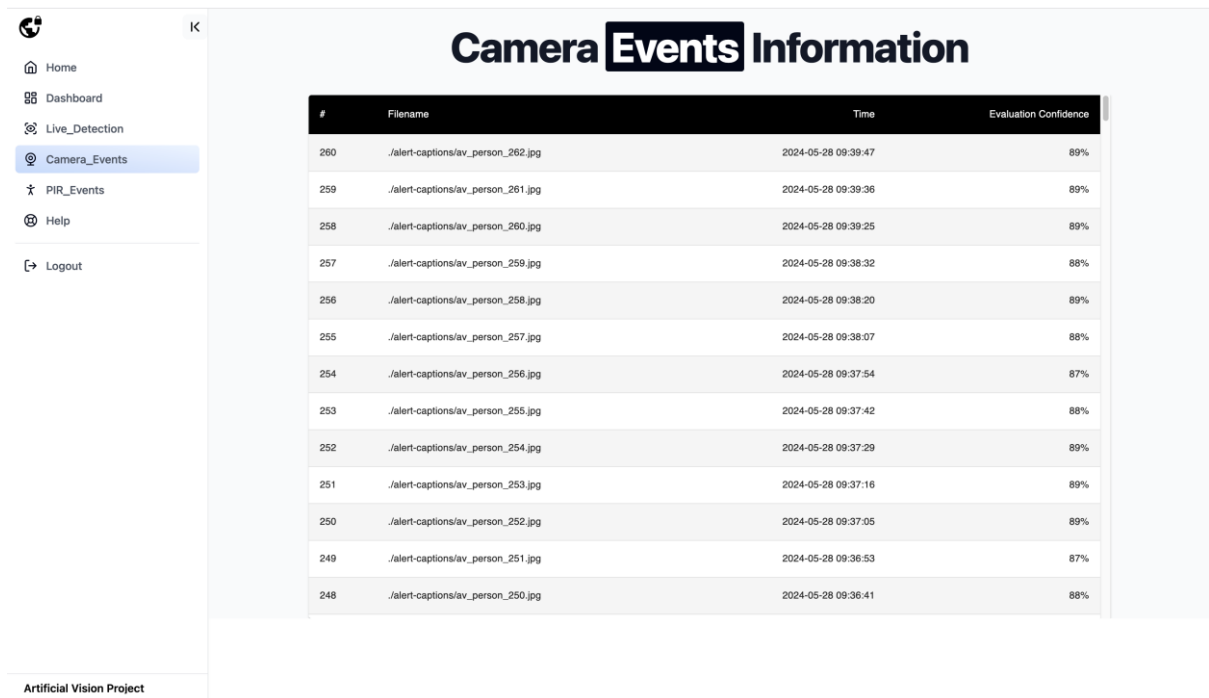

Figure 11

Camera events page
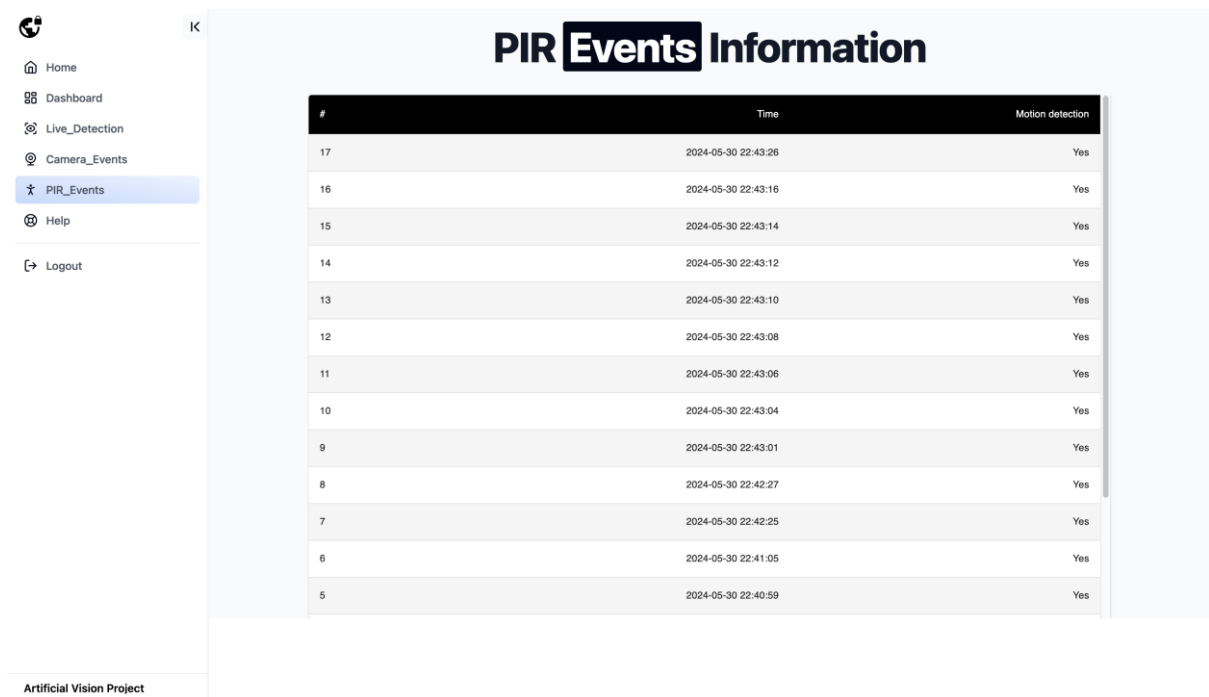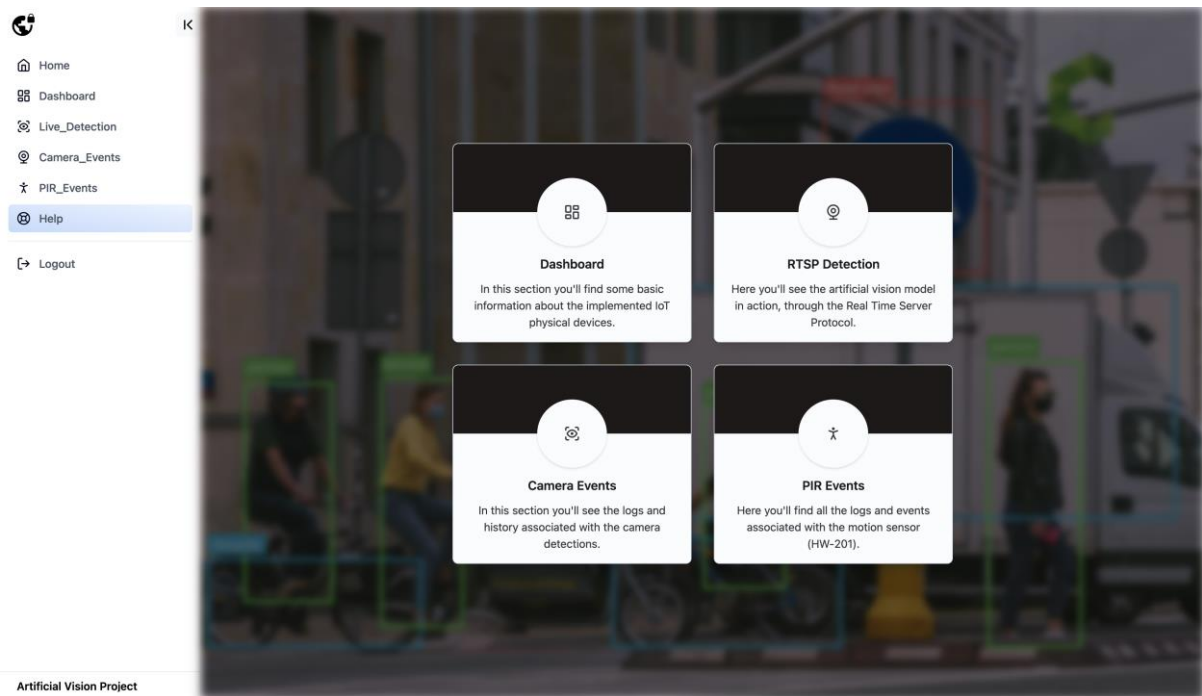
Figure 12

PIR events page
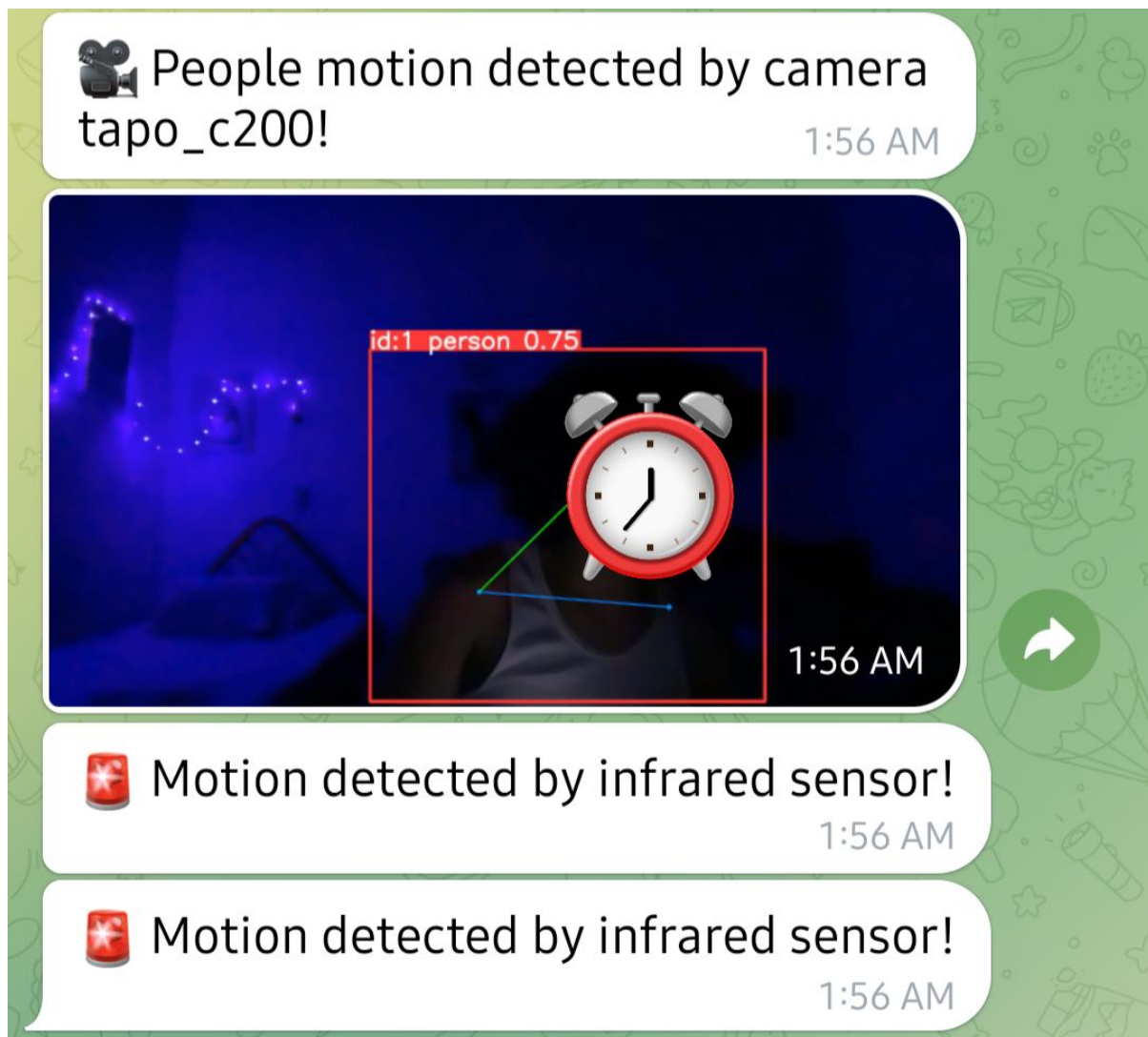

Figure 13

Help page

Figure 14

Telegram camera alert

Figure 15

Telegram motion sensor and camera alert

CONCLUSION

The proposed IoT system, with all its extensions and modules meets the proposed objectives, allows managing security events associated with the camera and motion sensor HW-201 correctly, in turn sending alerts as soon as the event is captured. The interface of the web application is intuitive and user-friendly. In terms of security and access to the administration platform, it is effective; the different sections within the page can only be accessed once the user's credentials have been validated.

On the other hand, the IoT application in its infrared sensor module presented inconveniences when communicating with the AWS IoT and sending information, this only when it was tested connected to a public network, it should be noted that networks of this

type usually have a number of restrictions for connected devices, this could explain what happened.

ANNEXES

Figure 16

ESP8266 WiFi & AWS IoT connection

```
WiFi connected
IP address:
192.168.100.32
Setting time using SNTP.done!
Connecting to AWS IoT
.connected
```

Figure 17

Events data structure from Arduino

```
Published: {"id":0,"detected_motion":true,"time":"2024-05-30 22:40:10"}
Published: {"id":1,"detected_motion":true,"time":"2024-05-30 22:40:12"}
Published: {"id":2,"detected_motion":true,"time":"2024-05-30 22:40:16"}
Published: {"id":3,"detected_motion":true,"time":"2024-05-30 22:40:56"}
Published: {"id":4,"detected_motion":true,"time":"2024-05-30 22:40:59"}
Published: {"id":5,"detected_motion":true,"time":"2024-05-30 22:41:05"}
Published: {"id":6,"detected_motion":true,"time":"2024-05-30 22:42:25"}
Published: {"id":7,"detected_motion":true,"time":"2024-05-30 22:42:27"}
Published: {"id":8,"detected_motion":true,"time":"2024-05-30 22:43:01"}
Published: {"id":9,"detected_motion":true,"time":"2024-05-30 22:43:04"}
Published: {"id":10,"detected_motion":true,"time":"2024-05-30 22:43:06"}
Published: {"id":11,"detected_motion":true,"time":"2024-05-30 22:43:08"}
Published: {"id":12,"detected_motion":true,"time":"2024-05-30 22:43:10"}
Published: {"id":13,"detected_motion":true,"time":"2024-05-30 22:43:12"}
Published: {"id":14,"detected_motion":true,"time":"2024-05-30 22:43:14"}
Published: {"id":15,"detected_motion":true,"time":"2024-05-30 22:43:16"}
Published: {"id":16,"detected_motion":true,"time":"2024-05-30 22:43:26"}
```

Figure 18

Application database structure

security_app

    captions

    fs.chunks

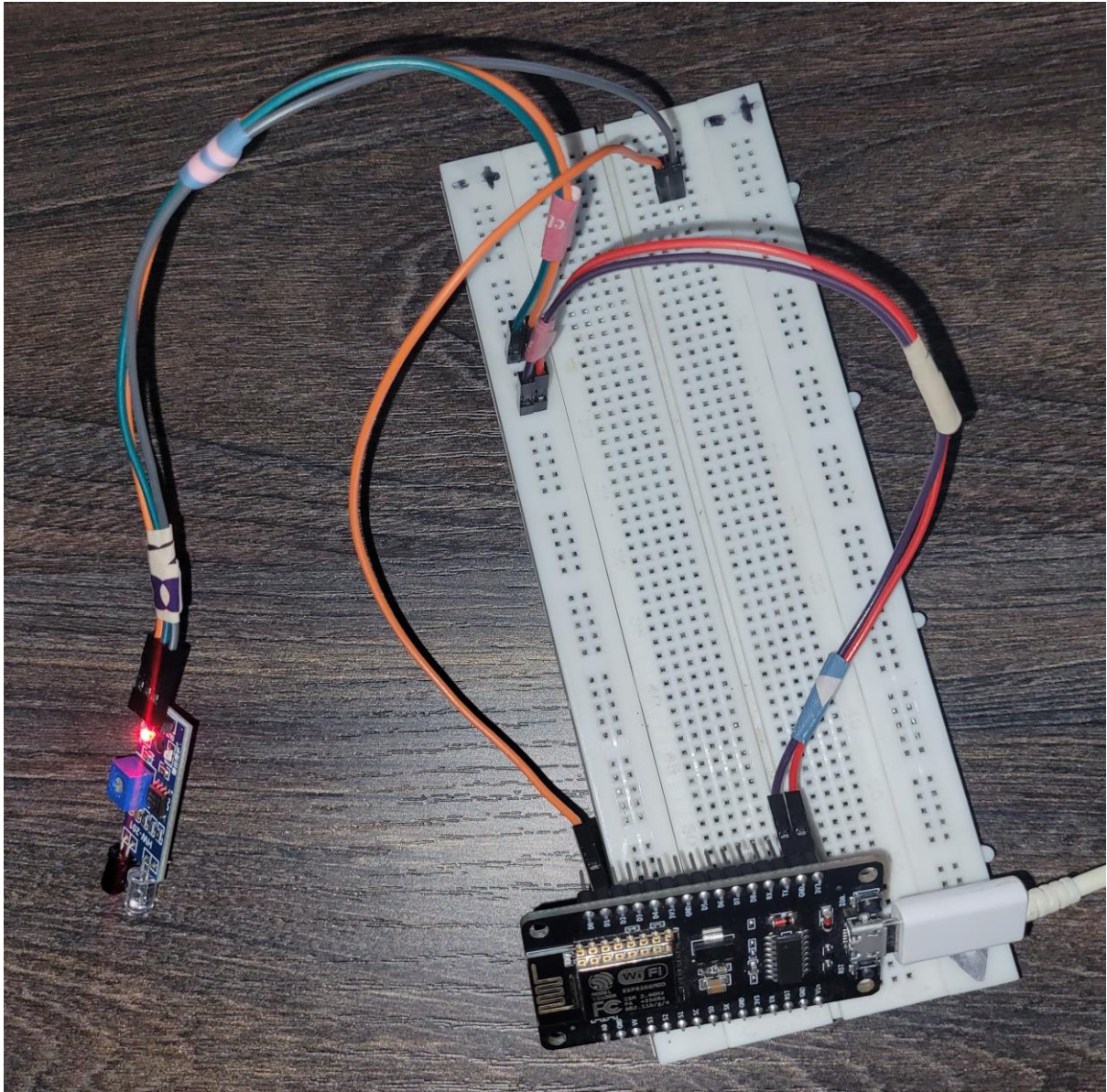   fs.files

    users

Figure 19

Motion sensor circuit

Figure 20

Spring boot dependencies

Dependencies

ADD DEPENDENCIES... ⌘ + B

Spring Boot DevTools   DEVELOPER TOOLS

Provides fast application restarts, LiveReload, and configurations for enhanced development experience.

Lombok   DEVELOPER TOOLS

Java annotation library which helps to reduce boilerplate code.

Spring Web   WEB

Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

Spring Data MongoDB   NOSQL

Store data in flexible, JSON-like documents, meaning fields can vary from document to document and data structure can be changed over time.

Spring Data Reactive MongoDB   NOSQL

Provides asynchronous stream processing with non-blocking back pressure for MongoDB.

Spring Security   SECURITY

Highly customizable authentication and access-control framework for Spring applications.

Validation   I/O

Bean Validation with Hibernate validator.

Figure 21

AWS IoT event logs

▼ esp8266/pub   May 26, 2024, 19:38:00 (UTC-0500)

```
{
  "id": "16327048113445",
  "motion_detected": true,
  "detection_time": "2024-05-26 19:38:00"
}
```

▶ Properties

▼ esp8266/pub   May 26, 2024, 19:37:40 (UTC-0500)

```
{
  "id": "1632704893440",
  "motion_detected": true,
  "detection_time": "2024-05-26 19:37:40"
}
```

▶ Properties

REFERENCES

Automated People flow tracking | with Computer Vision and AI - Pysource. (n.d.). Retrieved May 29, 2024, from https://pysource.com/2023/03/11/automated-people-flow-tracking-with-computer-vision-and-ai/

Object Tracking in Computer Vision (Complete Guide) - viso.ai. (n.d.). Retrieved May 29, 2024, from https://viso.ai/deep-learning/object-tracking/

What is an AI security camera? Chris Cullen, May 10, 2024. Retrieved May 29, 2024, from https://sirixmonitoring.com/blog/ai-security-camera/

Surveillance Cameras with Artificial Intelligence. (n.d.). Retrieved May 29, 2024, from https://www.visiotechsecurity.com/en/news/365-surveillance-cameras-with-artificial-intelligence

ESP8266 Wi-Fi Module Datasheet : Working & Its Applications. (n.d.). Retrieved May 29, 2024, from https://www.elprocus.com/esp8266-wi-fi-module/

PIR Sensor. (n.d.). Retrieved May 29, 2024, from https://www.sema-for.cz/shop/en/building-kit/13628-hw-201-ir-obstacle-avoidance-module-for-arduino-smart-car-robot-3.html

What is an IP Camera and How Does it Work? | Advantex. (n.d.). Retrieved May 29, 2024, from https://www.advantex.uk.com/what-is-an-ip-camera/

Ultralytics Yolo Docs. (n.d.). Https://Docs.Ultralytics.Com/. Retrieved November 11, 2023, from https://docs.ultralytics.com/

What is the Internet of Things (IoT)? | IBM. (n.d.). Retrieved May 29, 2024, from https://www.ibm.com/topics/internet-of-things

What is Real Time Streaming Protocol (RTSP)? | Definition from TechTarget. (n.d.). Retrieved May 29, 2024, from https://www.techtarget.com/searchvirtualdesktop/definition/Real-Time-Streaming-Protocol-RTSP

What is an IP Address? How it works? How to Locate it? | Fortinet. (n.d.). Retrieved May 29, 2024, from https://www.fortinet.com/lat/resources/cyberglossary/what-is-ip-address

What is HTTP? | Cloudflare. (n.d.). Retrieved May 29, 2024, from https://www.cloudflare.com/learning/ddos/glossary/hypertext-transfer-protocol-http/

A Guide to YOLOv8 in 2024 - viso.ai. (n.d.). Retrieved May 29, 2024, from https://viso.ai/deep-learning/yolov8-guide/

What is Computer Vision? | IBM. (n.d.). Retrieved May 29, 2024, from https://www.ibm.com/topics/computer-vision

Accuracy - machine learning. (n.d.). Retrieved May 29, 2024, from https://www.evidentlyai.com/classification-metrics/accuracy-precision-recall