VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY

(An Autonomous Institute Affiliated to University of Mumbai)

Department of Computer Engineering

Project Report on

Wireless Extraction of Data from Industrial Panels

Submitted in partial fulfillment of the requirements of the degree

BACHELOR OF ENGINEERING IN **COMPUTER ENGINEERING**

By

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University of Mumbai

(AY 2023-24)

VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY

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CERTIFICATE

This is to certify that the Mini Project entitled **"Wireless Extraction of Data from Industrial Panels"** is a bonafide work of **Shreya Hadkar(17), Johan John(22), Manali Patil(41), Vedang Rathi(47)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of **"Bachelor of Engineering"** in **"Computer Engineering" .**

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Letter of Permission

This is to certify that following Third year students of Department of Computer Engineering of Vivekanand Education Society's Institute of Technology, Chembur, are working on a TIFR project titled "**Wireless Extraction of Industrial data**", under the guidance of **Mrs. Priya R. L** for the academic year 2023-24.

1. **Shreya Hadkar**
2. **Johan John**
3. **Vedang Rathi**
4. **Manali Patil**

We will provide all technical assistance to students required during the completion of the project. The progress seminars and meetings will be regularly conducted to take feedback.

SRDugad

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Professor, Department of High energy Physics,

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Mini Project Approval

This Mini Project entitled "**Wireless Extraction of Data from Industrial Panels"** by **Shreya Hadkar(17), Johan John(22), Manali Patil(41), Vedang Rathi(47)** is approved for the degree of **Bachelor of Engineering** in **Computer Engineering.**

Examiners

1...
(Internal Examiner Name & Sign)

2...
(External Examiner name & Sign)

Date : 30/03/2024

Place : Chembur , Mumbai

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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(Manali Patil - 41)

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Date: 30/03/2024

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Abstract

India, a burgeoning nation, has become a focal point for technological advancement and industrial growth. With the proliferation of new sectors and the expansion of existing industries, the demand for machinery has surged. However, monitoring and recording the data displayed by these machines has posed a significant challenge in the face of rapid technological development.

In response to this challenge, this project aims to leverage cutting-edge hardware such as the ESP32 microcontroller and routers to streamline data collection from industrial equipment display panels. By integrating OCR techniques and YOLO models, the system will be able to accurately identify and store data in a database while setting alarms for data that exceeds acceptable limits. The use of low-resolution cameras, coupled with the ESP32's capabilities, will enable efficient detection of data from display panels in real-time.

With a focus on accuracy, efficiency, and reliability, this project endeavors to revolutionize wireless data extraction using state-of-the-art hardware and powered artificial intelligence techniques.

List of Abbreviations

Sr.No	Abbreviations	Full Form
1.	OCR	Optical Character Recognition
2.	YOLO	You Only Look Once
3.	CNN	Convolutional Neural Network
4.	SRCNN	Super Resolution Convolutional Neural Network

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Chapter 1: Introduction

1.1 Introduction

Display panels are crucial in many industries because they show useful information. Wireless data extraction helps monitor machines and display panels from afar, which is handy when reaching them physically is hard, like in big industrial areas or outside.Getting data quickly from panels helps companies make smart decisions, improve processes, and solve problems fast. Even if camera images are not super clear, using artificial intelligence is still important. Cameras' videos are split into lots of pictures for getting data.

In the realm of real-time data extraction, the integration of hardware components plays a pivotal role in enabling seamless capture and processing of data streams. Among the array of hardware options available, the ESP32 camera stands out as a versatile and powerful tool for capturing real-time video access.

The ESP32 camera module combines the capabilities of the ESP32 microcontroller with a camera sensor, offering a compact and cost-effective solution for applications requiring video capture. One of its standout features is its support for the Real-Time Streaming Protocol (RTSP), which facilitates the seamless streaming of video data over networks. This means that the ESP32 camera can directly provide access to live video feeds, making it an ideal choice for real-time surveillance, monitoring, and analysis applications.

Furthermore, the ESP32 camera's compact form factor and low power consumption make it suitable for deployment in diverse environments, ranging from indoor facilities to outdoor installations. Its compatibility with popular development platforms and programming languages also simplifies the process of integrating it into existing systems or developing custom solutions tailored to specific requirements.

In the context of surveillance systems, for example, multiple ESP32 cameras can be strategically deployed to provide comprehensive coverage of a given area. These cameras can be networked together to form a cohesive surveillance network, with each camera streaming live video feeds to a central monitoring station for real-time analysis. This distributed approach enhances situational awareness and enables prompt responses to potential security threats or anomalous activities. Also,Port forwarding facilitates remote access to camera feeds by establishing a direct pathway over the internet, enabling users to view and control the camera from any location with internet connectivity.

1.2 Motivation

The motivation behind this project is deeply rooted in recognizing the escalating necessity for efficient monitoring solutions across various industries. As the industrial landscape rapidly evolves, there is an increasing reliance on real-time data processing to ensure swift access to critical information. The project aims to address this demand by employing wireless extraction methods, specifically leveraging hardware integration such as the ESP32 camera, to swiftly deliver data displayed on panels.

In many industrial settings, physical access to display panels poses significant challenges, especially in large-scale or outdoor installations. To overcome this limitation, the project endeavors to provide a remote monitoring solution for machines and display panels, integrating the ESP32 camera for seamless real-time data capture. This capability is particularly crucial in industries where physical access is impractical, as it helps minimize downtime and maintenance costs.

In today's data-driven society, the ability to make informed decisions in real-time is paramount. This project is driven by its potential to support data-driven decision-making processes through instantaneous data access, precise object detection, and text recognition capabilities facilitated by the integration of advanced hardware like the ESP32 camera.

By integrating advanced object detection and Optical Character Recognition (OCR) technologies alongside the ESP32 camera, the project seeks to offer a flexible and scalable solution that enables businesses to make informed judgments and adapt to dynamic environments. Additionally, incorporating port forwarding capabilities allows for the utilization of any camera from any network, further enhancing scalability and accessibility in diverse industrial settings.

1.3 Problem Definition

The project seeks to develop an innovative system for non-invasive and wireless extraction of data from display panels, integrating real-time video analysis and OCR capabilities, and IoT integration. The primary challenge addressed by this research lies in enabling efficient data extraction from machine display panels using AI approaches, notably leveraging the YOLO Model for robust OCR functionality. A core objective is to create a real-time system capable of capturing video feeds from low-cost IP cameras and accurately conducting OCR to detect machine display data, ensuring consistent recognition performance across multiple displays.

Key capabilities include real-time video data analysis, OCR functionality, wireless communication of extracted data via IoT devices, image enhancement techniques for improved word recognition, and cross-platform compatibility. The integration of the ESP32 camera module, facilitated by the Arduino IDE, plays a pivotal role in capturing video feeds and seamlessly integrating them into the system. Additionally, the system can dynamically adjust the frame rate through Arduino IDE to optimize performance based on specific requirements.

Furthermore, an alarm system has been integrated to notify operators when monitoring values surpass predefined thresholds, enhancing operational reliability and security. Overall, the project aims to provide a flexible, scalable, and efficient solution for real-time display panel data extraction, catering to diverse industrial applications.Port forwarding enables remote access to camera feeds by establishing a direct pathway through the internet. This allows users to view and control the camera from anywhere with an internet connection. While offering convenience, security measures such as strong authentication and encryption are crucial to prevent unauthorized access. Dynamic DNS services further simplify access by assigning a domain name to the camera's IP address. Overall, port forwarding enhances surveillance capabilities, providing users with secure and convenient remote monitoring of assets.

1.4 Lacuna of the existing systems

1. Compatibility Issues: The ESP32 camera module may encounter compatibility issues when integrating with legacy surveillance or monitoring systems due to differences in communication protocols, data formats, or hardware specifications.

2. Interoperability Challenges: Ensuring seamless interoperability between the ESP32 camera module and other components of the surveillance system, such as central monitoring stations or network infrastructure, can be challenging, requiring additional development efforts and potentially hardware modifications.

3. Power Supply Constraints: In remote or outdoor installations, ensuring a reliable power supply to the ESP32 camera module may pose challenges, potentially impacting its operational reliability and uptime.

4. Network Connectivity: Maintaining stable network connectivity for the ESP32 camera module, especially in environments with limited Wi-Fi coverage or interference, can be challenging and may require the deployment of additional network infrastructure or optimization of antenna placement.

5. Hardware Maintenance: Regular maintenance and monitoring of the ESP32 camera module and associated hardware components are essential to prevent hardware failures and ensure long-term reliability. This includes routine inspections, cleaning, and potentially replacing worn-out components to maintain optimal performance.

6. Scalability and Expansion: As the surveillance system grows or evolves, ensuring the scalability and expandability of the ESP32 camera module and associated hardware infrastructure to accommodate increased camera deployments or additional functionality may require careful planning and investment in modular and flexible hardware solutions.

1.5 Relevance of the Project

The relevance of implementing wireless data extraction from industrial panels lies in its potential to address the lacuna of existing systems and unlock various benefits, including:

1. **Enhanced flexibility:** Wireless systems allow for easier reconfiguration and relocation of industrial panels, facilitating agile operations.

2. **Cost-effectiveness:** Eliminating the need for extensive wiring reduces installation and maintenance costs associated with traditional wired systems.

3. **Improved scalability:** Wireless solutions offer scalability without the constraints of physical cabling, enabling seamless expansion as industrial needs evolve.

4. **Real-time monitoring:** Wireless data extraction enables real-time monitoring of industrial processes, facilitating prompt decision-making and proactive maintenance.

Chapter 2: Literature Survey

2.1 Research Papers Referred

1. **Surveillance Camera Using Wi-Fi Connection**
   Methodology: The research methodology involved several key steps to design and evaluate the energy-efficient surveillance camera utilizing the ESP32-CAM module.
   Performance Measure: Connectivity,Power Consumption and Integration.
   Inference: The study findings highlight WebSocket as a highly efficient protocol for streaming video from the ESP32-CAM web server to a client device. Its browser-based approach enables full-duplex communication through a single TCP connection, ensuring real-time interaction between the client and server. In contrast, protocols like HTTP, RTP, and RTSP showed drawbacks such as high power consumption, latency issues, and disruption in video playback due to their inherent characteristics.
   Limitations: Overheating and latency problems were observed with RTP and RTSP, limiting their suitability for real-time video streaming. The RTSP library's lack of sleep mode support caused continuous operation issues. Although WebSocket showed efficient power usage and smooth playback, scalability and compatibility optimizations are necessary, with the study mainly focusing on power consumption, neglecting factors like video quality and latency.

2. **Remote Access Methods of Virtual Private Network**
   Methodology: The research paper conducts an empirical review of current VPN remote access methods, identifying security pitfalls, analyzing various access technologies, and proposing solutions to enhance endpoint security.
   Performance Measure: Connectivity,Power Consumption and Integration.
   Inference: The research paper identifies endpoint security weaknesses in various VPN remote access methods and proposes a security protocol emphasizing encryption and dual-factor authentication to mitigate risks. It recommends implementing this protocol to enhance endpoint communication security and reduce the likelihood of unauthorized data transfers and security breaches. Overall, the study underscores the importance of addressing vulnerabilities in remote access methods and provides a practical solution for strengthening endpoint security within VPNs.
   Limitations: The research paper highlights limitations in endpoint security, incomplete mitigation of security gaps, user compliance dependencies, integration challenges, and evolving cybersecurity threats in remote access methods for VPNs. While proposing a security protocol to address these challenges, it emphasizes the need for organizations to carefully consider these limitations when implementing security measures for virtual private networks.

2.2 Books Referred

1. **ESP32 Wireless Adventure:A Comprehensive Guide to IoT**
   Inference: ESP32-C3 Wireless Adventure: A Comprehensive Guide to IoT" by Espressif Systems provides an extensive exploration of utilizing the ESP32-C3 microcontroller in IoT applications. This comprehensive guide likely covers various aspects of IoT development, including hardware integration, wireless communication, and software programming, tailored specifically for the ESP32-C3 platform. With insights from Espressif Systems, a leading provider of IoT solutions, readers can expect detailed instructions, practical examples, and expert tips to navigate the world of IoT with the ESP32-C3 efficiently.

2. **Kolban’s Book on ESP32**
   Inference: The Book appears to comprehensively cover various aspects of ESP32 development, ranging from power management and debugging tools to libraries like libssh2 and IoT.js. It distinguishes between ESP8266 and ESP32, indicating separate documentation for each device due to significant differences. The author expresses an intention to share collated and polished notes on ESP32, fostering collaborative learning and continuous updates. Emphasizing the importance of understanding ESP32 SDK APIs, readers are directed to the ESP32 SDK API Guide and ESP-IDF documentation for detailed information. Additionally, the document likely includes concluding remarks, additional resources, or an index related to ESP32 content, with introductory information setting the tone for the document's contents and the author's initial thoughts on ESP32 development.

3. **Guide to Enterprise Telework, Remote Access, and Bring Your Own Device (BYOD) Security**
   Inference: The NIST Special Publication 800-46 Revision 2 serves as a comprehensive guide to Enterprise Telework, Remote Access, and Bring Your Own Device (BYOD) Security. It outlines security considerations for various types of remote access solutions and provides recommendations for securing telework, remote access, and BYOD technologies. The publication emphasizes the importance of securing organization-issued and personal devices against potential threats identified through threat models. Additionally, it offers advice on developing security policies related to telework, remote access, and BYOD. The document also highlights the significance of protecting sensitive information to maintain public trust, safeguard organizational missions, and prevent harm to individuals in case of unauthorized data disclosure.

2.3 Patents Referred

1. Devices, systems, and methods that observe and classify real - world activity relating to an observed object, and track and disseminate state relating to the observed object.

Inference: The patent application discusses using various sensor devices such as magnetometers, heat sensors, vibration sensors, security cameras, depth sensors, sound sensors, and power usage sensors to infer and track the state of appliances, machines, people, and objects of interest . Additionally, the invention utilizes accelerometer sensor devices and heat gyroscope sensor devices for tracking the state of appliances, machines, people, and objects. These sensors collect data that is then processed using machine learning techniques, including neural networks, convolutional neural networks, recurrent neural networks, long short-term memory neural networks, and deep learning, to correlate observed data to real-world actions performed on or by the machine or sensor devices .

Furthermore, the patent application describes the use of infrared detectors, LIDAR, or other range detectors to determine proximity to objects and infer actions such as opening doors or windows . The system can also analyze data collected from sensors to train neural networks, which can then provide probability values for different states of appliances or objects, enabling the device to determine the current state or drive a finite state machine model .

Overall, the intelligent monitoring device combines sensor data with advanced machine learning techniques to infer and track the state of various objects, providing valuable insights and alerts to users based on the observed data.

2. Tunneling over SSH

Inference: Based on the provided excerpts from the patent document, it can be inferred that the invention described involves a computer system with various components such as a processor , main memory , network interface device , video display unit , alphanumeric input device , cursor control device , signal generation device , and secondary memory . The secondary memory includes a machine-readable storage medium storing instructions for executing methodologies described in the patent.

The patent discusses the use of network tunnels to facilitate communication between different ports and systems, enabling the configuration of applications to receive traffic on specific ports. The invention allows for the reception of information via multiple ports by a single-socket application, enhancing its functionality and flexibility.

Furthermore, the patent emphasizes the broad applicability of the disclosed technology, stating that the described algorithms and displays are not tied to any specific computer system and can be implemented on various general-purpose systems or specialized apparatus. It also highlights the versatility of programming languages that can be used to implement the invention.

The patent also mentions the machine-readable medium as a mechanism for storing and transmitting information for programming computer systems to perform processes according to the invention. It discusses the structure and components of the computer system in detail, emphasizing the execution of instructions to carry out the methodologies described.

2.4 Comparison with the existing system

In the context of surveillance camera systems utilizing Wi-Fi connection, the research findings indicate notable differences between the energy-efficient surveillance camera using the ESP32-CAM module and remote access methods via Virtual Private Networks (VPNs).

- **Connectivity:**The surveillance camera system leveraging ESP32-CAM module offers direct connectivity over Wi-Fi, enabling seamless integration and real-time interaction between the camera and client devices. In contrast, VPN remote access methods rely on establishing secure connections over the internet, providing remote access to network resources while ensuring data confidentiality and integrity.

- **Power Consumption:**The ESP32-CAM-based surveillance camera system focuses on energy efficiency, with the study emphasizing protocols like WebSocket for optimized power usage during video streaming.On the other hand, VPN remote access methods may vary in power consumption depending on the encryption algorithms and authentication mechanisms employed.

- **Integration:**The ESP32-CAM surveillance camera system presents a holistic approach to integration, emphasizing the hardware capabilities of the ESP32-CAM module and protocol optimization for efficient data transmission.VPN remote access methods require integration with existing network infrastructure, implementation of security protocols, and user authentication mechanisms to ensure secure remote connectivity.

- **Cost Effectiveness**:Leveraging the ESP32-CAM module for surveillance offers a cost-effective solution, minimizing the need for expensive hardware and infrastructure.Compared to complex VPN setups, the ESP32-CAM system provides an affordable alternative for remote monitoring applications.Its low-cost hardware and integrated Wi-Fi connectivity make it accessible for various users and scenarios, particularly those with budget constraints.

Chapter 3: Requirement Gathering for the Proposed System

3.1 Introduction to requirement gathering

Requirement gathering for wireless extraction of data using Python involves understanding the specific needs and objectives of the project, identifying the data sources and their formats, determining the communication protocols and technologies involved in wireless data extraction, assessing security and privacy requirements, defining the scope and limitations of the system, and outlining the desired outcomes and performance metrics. This process entails close collaboration with stakeholders to ensure that the solution effectively addresses their needs while considering technical constraints and feasibility within the Python ecosystem for wireless data extraction.

3.2 Functional Requirements

Functional requirements outline the specific functionalities and features that the proposed system must possess to fulfill its intended purpose. These requirements describe what the system should do, such as user interactions, data processing, and system outputs.

1. **Panel Data Acquisition:**
   Enable wireless data acquisition from industrial panels using ESP32 devices.
   Integrate hardware components with the ESP32 for seamless data acquisition and processing.

2. **Data Processing and Analysis:**
   Upon data acquisition, the system should process and analyze the received data.Data processing algorithms should be implemented to extract relevant information from the received data streams.

3. **Real-time Monitoring and Visualization:**
   The system should provide real-time monitoring of panel data.Data should be presented to users through intuitive and interactive visualization interfaces.

4. **Scalability and Fixation:**
   Ensure the system is scalable to accommodate multiple ESP32 devices for expanded coverage.Implement port forwarding mechanisms to enable remote access to camera feeds for monitoring and visualization.Incorporate fixation techniques to securely mount ESP32 devices for stable and reliable operation in industrial environments.

3.3 Non-Functional Requirements

The non-functional requirements include:

1. **Performance:**
   Ensure efficient handling of large volumes of data by optimizing data acquisition and processing algorithms on the ESP32 hardware.Minimize latency in data retrieval and user interactions to maintain acceptable response times.Utilize hardware capabilities for real-time processing to enhance system performance.

2. **Scalability:**
   Design the system architecture to seamlessly scale with the addition of more ESP32 devices and industrial panels.Ensure scalability without compromising performance or system reliability by leveraging the ESP32's capabilities for distributed computing.

3. **Reliability:**
   Implement measures to ensure reliable operation of the system under various environmental conditions and network constraints, leveraging the robustness of the ESP32 platform.Enforce data integrity and prevent data loss during transmission or processing using built-in security features of the ESP32.

4. **Security:**
   Employ robust security measures, including encryption and authentication protocols, to protect sensitive data stored and transmitted by the ESP32-based system.Utilize hardware-based security features of the ESP32 to prevent unauthorized access and ensure secure communication channels.

5. **Usability:**
   Develop an intuitive and user-friendly interface for the system, leveraging the ESP32's capabilities for graphical user interface (GUI) development.
   Ensure clear navigation and informative feedback to facilitate user interactions, minimizing the need for extensive training or technical expertise.

6. **Compatibility:**
   Ensure compatibility of the system with a wide range of devices, operating systems, and web browsers by adhering to industry standards and protocols.Conduct compatibility testing to verify seamless integration with different hardware configurations and software environments, leveraging the flexibility of the ESP32 platform.

7. **Availability:**
   Maximize system availability by implementing redundancy and failover mechanisms to mitigate the impact of hardware failures or network disruptions.
   Ensure continuous operation of critical system components by leveraging the reliability and stability of the ESP32 platform for uninterrupted data processing and communication.

3.4.Hardware, Software , Technology and tools utilized

3.4.1 Hardware Requirements

1. Desktop / Laptop requirement with Operating System(OS):
A laptop with good specifications with a minimum of 8GB RAM is recommended along with Ubuntu as an OS but other OS will also do fine.

2. Graphical Processing Unit (GPU):

For faster training and inference of deep learning models, consider using a dedicated GPU, which can significantly speed up computations.

3. Storage Space:
Minimum free space of 10 GB in memory for execution of the project.

4. ESP32 Camera Module:
The ESP32 Camera module is a low-cost camera module used for real-time video capture.

5. ESP32 Camera Module Shield:
This shield is used to transfer the code from the laptop to the ESP32 Camera Module and also for powering the camera module automatically.

6. Micro USB Cable:
This cable can be used for powering up the programmer shield or even for flashing the ESP32-CAM module.

3.4.2 Software Requirements

1. Python (3.9.10):
The server of the application is built using Python and many libraries of Python.

2. PyQt5 and QtDesigner:
PyQt5 is required to develop the UI of the application.

3. Arduino Integrated Development Environment (IDE):
The Arduino Integrated Development Environment - or Arduino Software (IDE) - connects to the Arduino boards to upload programs and communicate with them.

4. OpenCV:
OpenCV is used for image processing in video streams and blur detection of images in streams.

5. YOLO v5 Model:
Used for text detection and text recognition.

6. PyTorch
PyTorch is a machine learning framework based on the Torch library, used for applications such as computer vision and natural language processing, originally developed by Meta AI and is now part of Linux. Foundation umbrella. It is free and open-source software released under the modified BSD license.

7. TensorBoard (from Tensorflow)
TensorBoard helps in YOLO Model evaluation.

3.5 Constraints

1. **Real-Time Processing Requirement:** The project aims for real-time data extraction and analysis. Any delays or lags in processing could hinder its effectiveness, potentially leading to missed data or delayed responses.

2. **Network Connectivity:** The inability to access a public router for configuration poses a limitation, as it affects the system's ability to transmit data wirelessly to a central server. Dependency on network infrastructure introduces potential points of failure and connectivity issues.

3. **Storage Limitation:** The requirement of a minimum of 10 GB of free memory space imposes a constraint, especially for devices with limited storage capacity. This could limit deployment options or require additional storage solutions.

4. **Data Security and Privacy:** Transmitting data wirelessly introduces potential security risks, especially if sensitive information is involved. Ensuring data encryption and secure transmission protocols is crucial to mitigate these risks.

5. **Scalability and Maintenance**: The project's scalability may be limited by factors such as hardware compatibility, network infrastructure, and computational resources. Additionally, ongoing maintenance and updates may be required to address evolving requirements or issues.

6. **Cost Considerations:** The use of specific hardware components and computational resources may incur costs, which could be a limiting factor for deployment, especially in resource-constrained environments.

7. **Availability:** High system availability is crucial to minimize disruptions in image extraction and communication. Redundancy and failover mechanisms mitigate the impact of hardware failures, network issues, or power outages.

Chapter 4:Proposed Design

4.1 Block diagram of the system

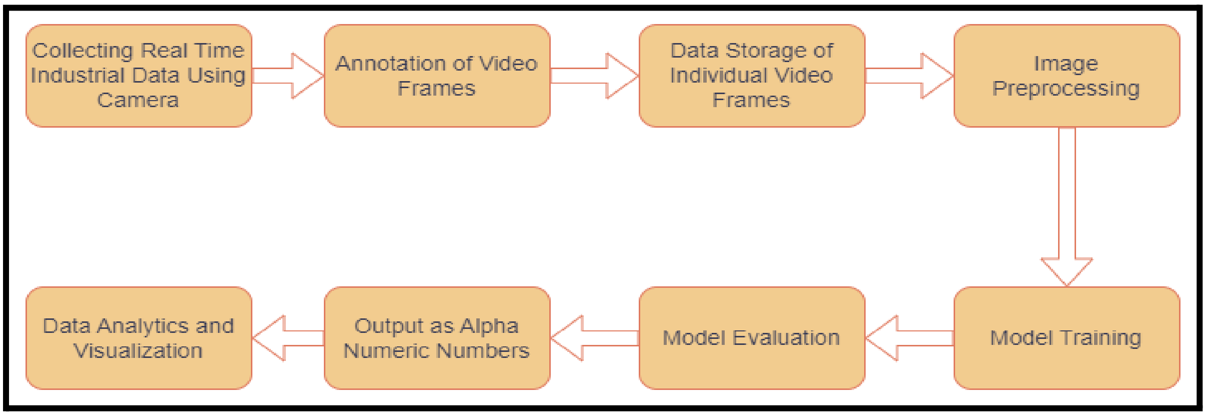

Figure1: Block Diagram

High-definition camera footage from industrial processes undergoes preprocessing to filter noise, convert formats, and resize frames. Individual frames are then extracted and annotated to identify objects or events. The preprocessed data and annotations are stored for subsequent stages. A machine learning model is trained on labeled video data to identify patterns, evaluated for generalizability on a separate dataset. The trained model is then used to analyze new video data, visualizing results as numerical data or charts, yielding alpha-numeric outputs representing the analysis results.

4.2 Modular design of the system

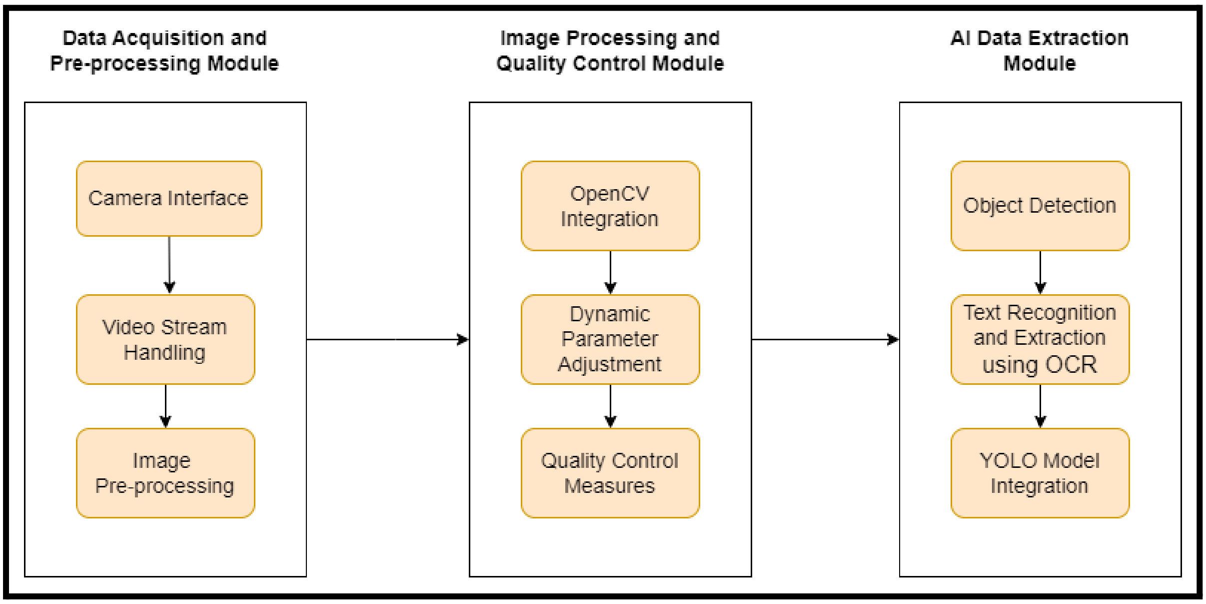

Figure 2: Modular Design of the system

The Data Acquisition and Pre-processing Module initiates by capturing video feeds and refining them for analysis, including noise filtration and format conversion. The Camera Interface connects security cameras to the system, while Video Stream Handling manages incoming streams. Image Pre-processing ensures raw data is prepared for analysis through noise reduction and resizing. OpenCV is integrated for real-time computer vision tasks, including image processing. The YOLO Model enhances object detection within video frames. Image Processing and Quality Control Module enhances image quality, dynamically adjusting parameters for optimal performance. Quality Control Measures ensure clarity and usability of video footage. The AI Data Extraction Module extracts relevant data, including object identities and movements. Text Recognition and Extraction using OCR further augments capabilities by extracting textual information from video frames.

4.3 Detailed Design

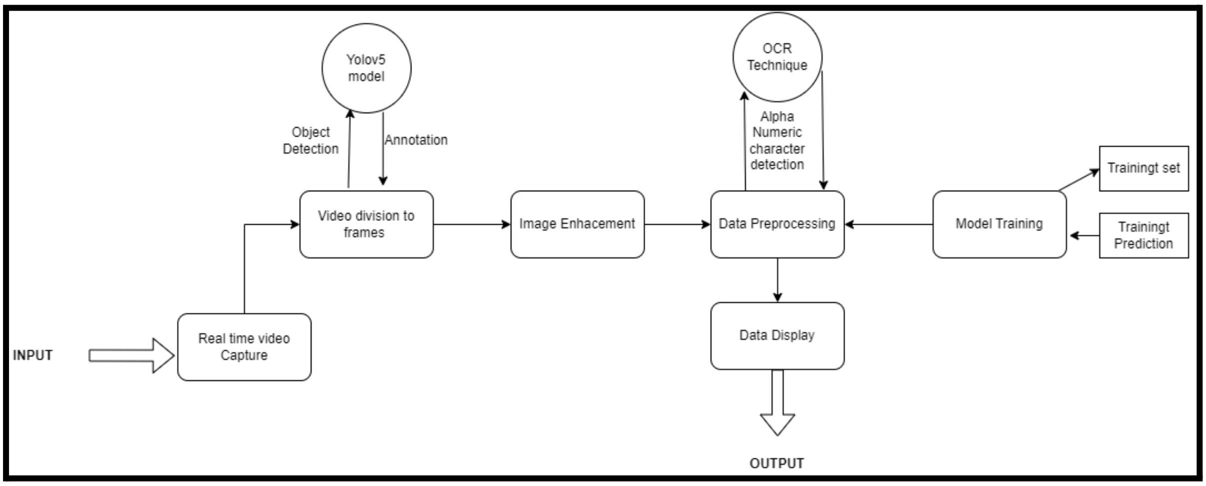

Figure 3: Detailed Design of the system

The app accepts various user inputs through its intuitive User Interface, facilitating interaction via buttons, menus, and visual elements. Upon input, raw data undergoes Data Preprocessing, refining it for further analysis by filtering out invalid data or standardizing formats. Model Training capabilities enable machine learning models to be trained within the app, leveraging an embedded Training Set. For video data, the app partitions frames through Video Division and enhances image quality via Image Enhancement techniques. Object Detection capabilities discern objects within images, followed by Annotation of identified elements. Alpha-Numeric Character Detection enables recognition within images. Processed data is then visually presented to users through Data Display, utilizing charts or graphs, culminating in the Output of final results.

4.4 Project Scheduling & Tracking using Timeline / Gantt Chart

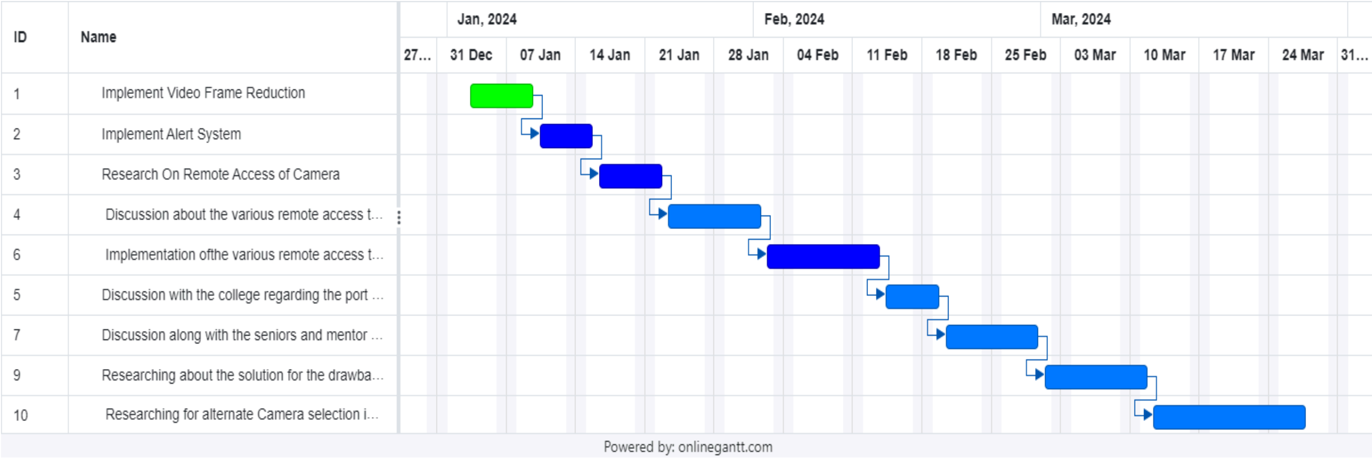

Figure 4:Gantt Chart

The timeline, spanning from December 21, 2023, to March 24, 2024, meticulously tracks the progress of a project centered around remote camera access. Organized into weeks and labeled for January, February, March, and April, the spreadsheet outlines various tasks pivotal to the project's advancement. Tasks such as implementing video frame reduction, introducing the Avert System, and engaging in discussions regarding remote access methods and port configurations are meticulously listed. Additionally, the project involves extensive research into remote access solutions, camera selection, and addressing potential drawbacks. While the completion status of tasks isn't explicitly indicated, dates listed alongside certain tasks likely signify milestones or completion dates. Overall, the spreadsheet illustrates a comprehensive effort to explore and implement efficient methods for remotely accessing cameras, underscoring the project's significance and complexity.

4.5 ESP Configuration

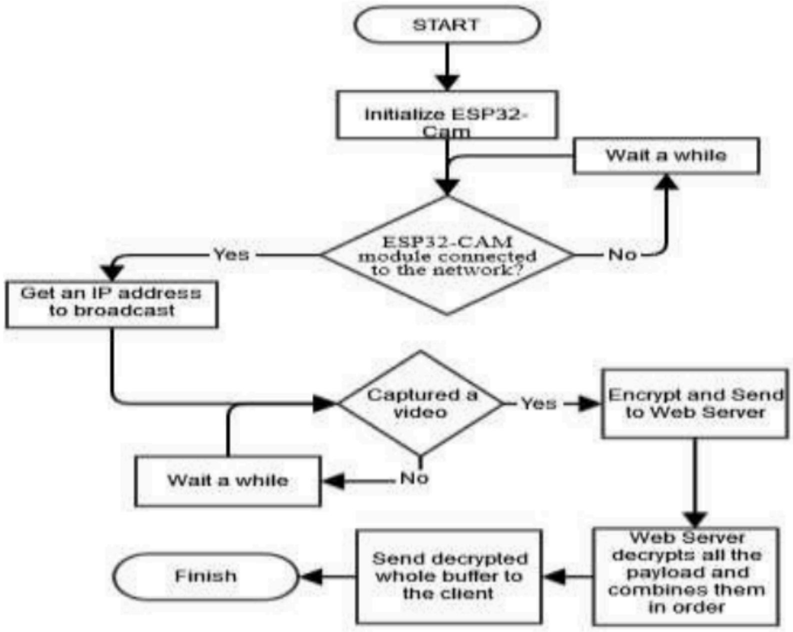

Figure 5: ESP32 Camera Module Configuration

The depicted flowchart outlines a streamlined process for securely capturing and transmitting video using the ESP32-CAM microcontroller module. Initiated by initializing the module, the system then pauses briefly before checking if the module is successfully connected to a network; if not, it loops until a connection is established. Once connected, an IP address is obtained for broadcasting the video stream. The system continuously checks if video capture is complete, waiting until it is before proceeding to encrypt and transmit the captured video to a designated web server. Following transmission, the system pauses briefly before concluding the process. In essence, this flowchart illustrates a systematic approach to reliably capture, encrypt, and transmit video data, showcasing the capabilities of the ESP32-CAM module in facilitating secure remote video surveillance or streaming applications.

Chapter 5: Implementation of the Proposed System

5.1 Methodology Employed for Development

1) Select and Set Up Appropriate Industrial Cameras:
The choice of cameras should align with project requirements, considering factors like resolution, frame rate, and cost. Once selected, careful consideration must be given to camera placement to ensure an unobstructed view of the industrial panel. Proper camera positioning and secure installation are critical to optimal data capture. Configuration settings, such as focus, and frame rate, must be adjusted to suit the specific requirements of the monitoring task. Ensuring synchronization of cameras, if needed, is also part of this step. Ultimately, the successful setup of industrial cameras lays the foundation for acquiring high-quality data from the industrial panels.

2) Connectivity of ESP32 Camera module:
RTSP is commonly used for streaming audio and video over the internet. The ESP32-CAM can stream live video using the RTSP protocol, allowing clients to view the video feed in real-time. The ESP32-CAM module comes with built-in Wi-Fi capability, allowing it to connect to local Wi-Fi networks. This is essential for wireless communication and data transfer. Station (STA) Mode involves configuring the ESP32-CAM to connect to an existing Wi-Fi network as a station. This allows the module to leverage the internet connection provided by the network, enabling it to communicate with other devices or servers over the internet. This can work in two ways:

Local Network Access:
Configurable SSID and Password with AP Mode: The ESP32-CAM can start as an access point (AP) with a captive portal, allowing users to connect to it and input their local Wi-Fi network credentials through a web interface. Once configured, the module switches to STA mode and connects to the specified local network.

Remote Access (Over the Internet):
Dynamic DNS (DDNS): By configuring a Dynamic DNS service, you can assign a domain name to your home network, even if your ISP assigns dynamic IP addresses. The ESP32-CAM can then connect to the local Wi-Fi network and use the DDNS domain to establish remote access from anywhere with internet connectivity.

Port Forwarding: If your ESP32-CAM needs to be accessible from the internet, you can set up port forwarding on your router to forward incoming connections on a specific port to the ESP32-CAM's local IP address and port. This allows external devices to communicate with the ESP32-CAM over the internet.

Virtual Private Network (VPN): Implementing a VPN server on your home network allows secure remote access to devices like the ESP32-CAM. The module connects to the VPN server upon startup, enabling secure communication over the internet as if it were on the local network.

Custom SSL Tunneling Protocol: Develop a custom SSL tunneling protocol tailored to your project's needs. This protocol would establish a secure communication channel between the ESP32-CAM and a remote server or client over the internet. The protocol would handle encryption, authentication, and data transmission, ensuring the security and integrity of the communication (like serveo).

5.2 Algorithms & Flowcharts for the Respective Modules Developed

Real-Time Streaming Protocol (RTSP) is a network control protocol designed for use in entertainment and communication systems to control streaming media servers. Here's a simplified algorithm for handling RTSP protocol:

1. Client Connection Initialization:
The client initiates a connection to the RTSP server over TCP.

2. Session Establishment:
The client sends a SETUP request to the server, specifying the media stream to be set up (e.g., video or audio). The server responds with a SETUP response, providing transport information for the media stream, such as the transport protocol (UDP, TCP) and port number.

3. Media Stream Control:
The client sends PLAY, PAUSE, or STOP requests to control the playback of the media stream.The server responds accordingly, either starting, pausing, or stopping the media stream.

4. Optional: RTCP Communication:
Real-Time Control Protocol (RTCP) packets may be exchanged between the client and server to provide feedback on the quality of the media stream, such as packet loss or jitter.

5. Session Teardown:
The client sends a TEARDOWN request to the server to end the session and release resources.The server acknowledges the TEARDOWN request, and both client and server close the connection.

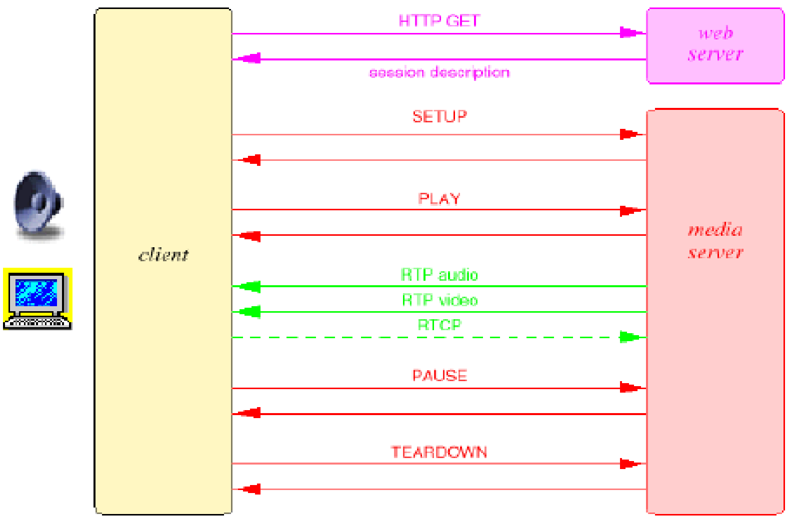

Figure 6: RTSP Protocol

5.3 Dataset Source & Utilisation

The dataset utilized in this project constitutes video footage obtained from a display panel featuring numerical digits. This dataset, crucial for training and testing various components of the system, was sourced from the prestigious TATA Institute of Fundamental Research (TIFR).

1) Origin and Characteristics:
The video dataset procured from TIFR comprises sequences of high-definition images capturing the display panel's contents over time. These images encompass a variety of scenarios, including different lighting conditions, varying digit positions, and potential occlusions. This diversity ensures robustness in the models' training process, enabling them to generalize well to real-world conditions.

2) Preprocessing and Annotation:
Prior to utilization, the dataset underwent preprocessing steps aimed at enhancing its quality and relevance. Preprocessing involved tasks such as noise reduction, image stabilization, and frame alignment to ensure consistency across frames. Additionally, each frame was meticulously annotated to mark the regions of interest containing the numerical digits. This annotation facilitated supervised learning tasks by providing ground truth labels for model training and evaluation.

3) Utilization in Model Training:
The annotated dataset served as the cornerstone for training the deep learning models central to this project's objectives. For instance, in the case of object detection using YOLOv5, the dataset was used to train the model to identify and localize digits within the display panel. Similarly, for image super-resolution tasks employing SRCNN, the dataset enabled the model to learn the mapping between low-resolution and high-resolution representations of the digit images.

4) Evaluation and Validation:
Following model training, the dataset played a crucial role in evaluating and validating the performance of the developed systems. Performance metrics such as detection accuracy, localization precision, and super-resolution quality were computed using subsets of the dataset reserved for validation purposes. Rigorous evaluation ensured that the systems met the project's objectives and performance criteria.

Chapter 6: Testing of the Proposed System

6.1. Introduction to Testing

In the process of developing the proposed system for wireless data extraction from industry panels, rigorous testing is imperative to ensure its functionality, reliability, and performance. Testing involves evaluating different aspects of the system under various conditions to verify its compliance with project requirements and objectives.

6.2. Types of Tests Considered

Several types of tests are considered to comprehensively assess the proposed system:

1. **Functional Testing:** Examining the system's functionality against specified requirements.
2. **Performance Testing:** Assessing the system's responsiveness, scalability, and resource utilization.
3. **Integration Testing:** Verifying the interaction and compatibility of individual components.
4. **Usability Testing:** Evaluating user interface design and user experience.
5. **Security Testing:** Ensuring the system's resilience against potential vulnerabilities and threats.
6. **Compatibility Testing:** Checking compatibility across different devices and platforms.

6.3. Various Test Case Scenarios Considered

A range of test case scenarios is considered to cover diverse operational scenarios and potential edge cases:

- **Normal Operation:**Testing under typical operating conditions to verify expected behavior.
- **Edge Cases:** Assessing system performance under extreme or uncommon conditions.
- **Fault Tolerance:** Evaluating the system's ability to handle errors and recover gracefully.
- **Stress Testing:** Subjecting the system to heavy loads to assess its stability and resilience.
- **Wireless Connectivity:** Testing the system's performance in wireless communication environments.
- **Data Integrity:** Ensuring accurate and reliable extraction of data from industry panels.

6.4. Inference Drawn from the Test Cases

Through systematic testing, several key inferences can be drawn regarding the proposed system:

- **Validation of Functionality:** Testing confirms that the system effectively extracts data from industry panels wirelessly, meeting project requirements.
- **Performance Assurance:** Performance testing indicates that the system operates efficiently, with acceptable response times and scalability.
- **Reliability Confirmation:** Testing validates the reliability of the system, with minimal downtime and robust error handling mechanisms.
- **Usability Insights:** Usability testing reveals positive user experiences, with intuitive interfaces and seamless interactions.
- **Security Validation:** Security testing demonstrates that the system safeguards data integrity and confidentiality, mitigating potential risks.
- **Compatibility Confirmation:** Compatibility testing ensures the system's compatibility across various devices and platforms, enhancing its versatility and accessibility.

Chapter 7: Results and Discussion

7.1. Screenshots of User Interface for the respective module

Figure 7 : Implementation - Login Page

The web application "Wireless Display Data Extraction using AI Techniques" features a login page with the TIFR logo, fields for username and password, and buttons for login and sign up.

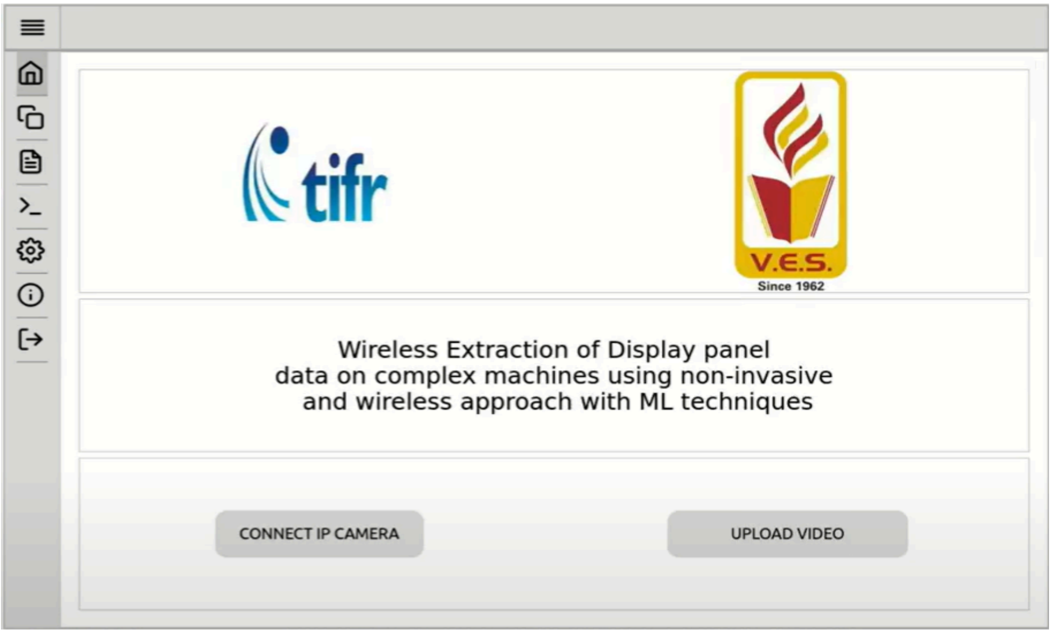

Figure 8 : Implementation - Home Page

The webpage showcases a system for extracting data from complex machine display panels using non-invasive, wireless methods and machine learning (ML) techniques. The system allows users to connect an IP camera or upload video, suggesting it extracts data from video feeds. The unclear button "Anonymous Cormorant" adds ambiguity to the system's exact functionality.

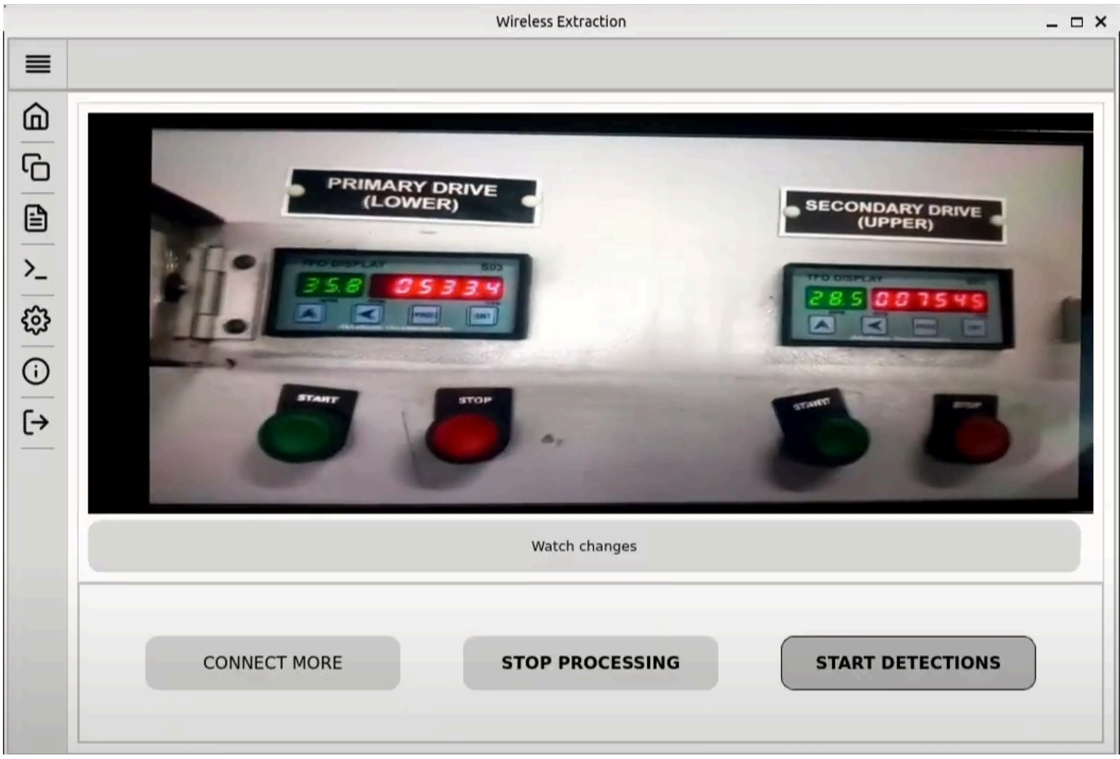

Figure 9 : Implementation-Detection of Frames

The control panel titled "Wireless Extraction" monitors data from a primary and secondary drive using non-invasive and wireless methods with machine learning techniques. It offers buttons to start, stop processing, connect more, and initiate detections, while displaying data values for each drive.

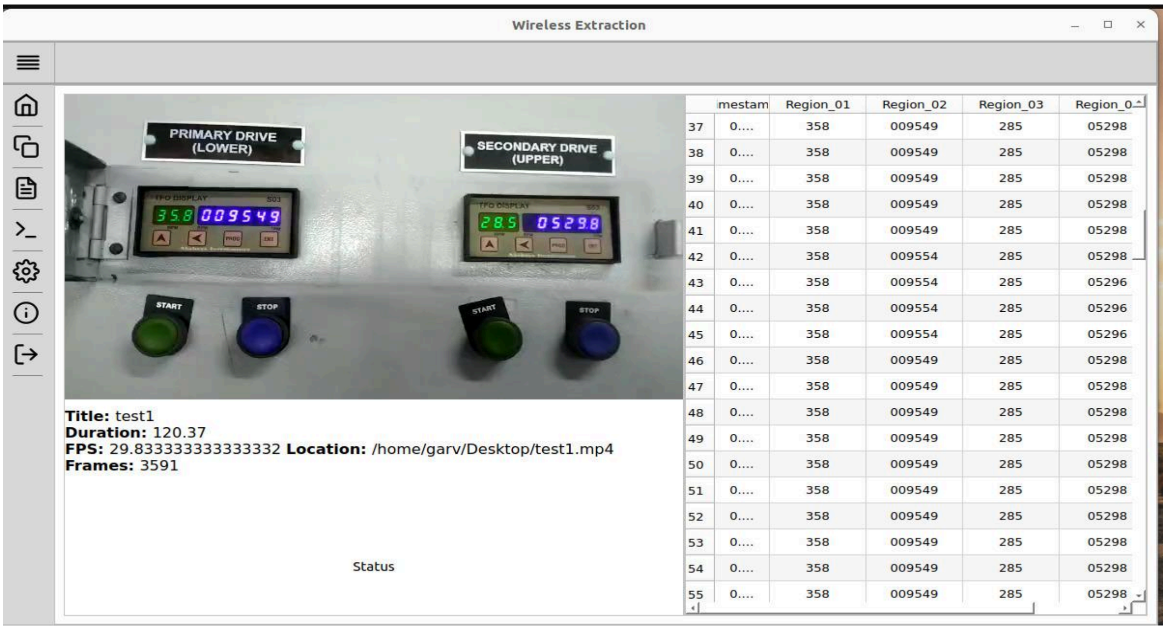

Figure 10 : Implementation - Results

The control panel titled "testl" presents a system for wirelessly extracting data from a machine, utilizing machine learning (ML) techniques and organized by different regions. Multiple rows of data are displayed, while buttons like STOP and the right arrow allow users to control data extraction and navigation. The data seems to be managed in regions and stored for further analysis.

Figure 11.1 : Implementation of ESP32 Camera

Figure 11.2 : Implementation of ESP32 Camera

This illustrates the focus of the ESP32 camera, where it captures readings from a phone display and determines the optimal distance range for efficient image capture.

7.2. Performance Evaluation Measures

Performance evaluation of the proposed system involves assessing various metrics related to data extraction accuracy, processing speed, and alarm system responsiveness, while also considering the hardware capabilities of the ESP32-CAM module.

- **ESP32-CAM Module Hardware Capabilities:**The ESP32-CAM module offers real-time video access, ideal for instant data capture and analysis needs. Its affordability and simple installation make it a practical choice for surveillance systems. Moreover, its scalability supports multiple camera integration, enhancing coverage and performance across diverse settings.

- **Speed of Data Extraction and Processing:** The speed of data extraction and processing is measured in frames per second (FPS). This metric evaluates the system's efficiency in processing video frames captured by the ESP32-CAM module in real-time. The faster the data extraction and processing speed, the more responsive the system will be in detecting and analyzing information from the video streams.

- **Efficiency of the Alarm System:** The efficiency of the alarm system in detecting and responding to threshold exceedances is another important measure. This involves assessing the system's ability to detect anomalies or predefined thresholds in the extracted data and trigger appropriate alerts or actions in real-time.

- **Cost-effectiveness:** Evaluating the cost-effectiveness of the system considers the balance between performance and expenses. This includes assessing the total cost of setup, maintenance, and operation relative to the system's capabilities and benefits. A cost-effective solution ensures that the desired performance levels are achieved without unnecessary expenditure, maximizing the value proposition for stakeholders.

7.3. Input Parameters / Features Considered

Input parameters and features considered in the project with respect to hardware scalability, adjusting frame reduction, and fixation include:

1. Image quality and resolution captured by the ESP32 camera, which impacts the clarity and detail of data extracted from industry panels.
2. The scalability of the hardware setup, enabling the integration of multiple ESP32 cameras to cover larger areas and enhance monitoring capabilities.
3. Features extracted by the OCR model for digit recognition, influenced by the quality of images captured and the efficiency of the OCR algorithm.
4. Threshold values set for triggering the alarm system based on panel data, adjustable to accommodate variations in environmental conditions and operational requirements.

7.4. Graphical and Statistical Output

Graphical and statistical outputs provide visual representations of the system's performance and data analysis results.

Outputs may include:

1. Graphs depicting trends in data extraction accuracy and processing speed over time, considering adjustments made to frame reduction for scalability.
2. Statistical summaries of alarm system activations and threshold exceedances, reflecting the system's responsiveness and reliability in real-time monitoring.
3. Comparative visualizations of OCR and YOLOv5 model outputs with ground truth data.

7.5. Comparison of Results with Existing Systems

Results are compared with existing systems or methodologies to assess the efficacy of the proposed solution. Comparison considerations include:

- Accuracy and efficiency improvements achieved by optimizing hardware scalability and fixation techniques compared to traditional methods.
- Performance advantages of the ESP32 camera-based wireless extraction system with adjustable frame reduction over wired alternatives.
- Effectiveness of the alarm system in enhancing industrial monitoring and safety practices, taking into account hardware scalability and fixation adjustments.

7.6. Inferences Drawn

Based on the results and discussions, several inferences can be drawn regarding the project's outcomes and implications:

- Hardware scalability and fixation techniques lead to enhanced accuracy and efficiency compared to traditional methods.
- ESP32 camera-based wireless extraction system offers performance advantages with adjustable frame reduction, surpassing wired alternatives.
- The alarm system effectively enhances industrial monitoring and safety practices, considering hardware scalability and fixation adjustments.

Chapter 8: Conclusion

8.1 Limitation

Network Dependency:

The project's reliance on the ESP32 camera and the screen displaying values being on the same network poses a significant limitation. This requirement restricts the system's usability to environments where a local network infrastructure is available, limiting its applicability in remote or decentralized industrial settings.

8.2 Conclusion:

1. Acknowledgment of Limitation: Despite the project's success in wireless data extraction from industry panels, the constraint of requiring both the ESP32 camera and the display screen to be on the same network is acknowledged as a notable limitation.

2. Effectiveness within Constraints: Within the confines of a localized network environment, the system demonstrates effectiveness in extracting and displaying panel data wirelessly. However, its adaptability to diverse networking conditions and deployment scenarios is constrained by this requirement.

3. Future Optimizations Required: To overcome this limitation and enhance the system's versatility, future optimizations and developments are essential. These optimizations should focus on addressing the network dependency issue while maintaining the system's functionality and reliability.

8.3 Future Scope

1. **Alternative Communication Protocols:** Explore the integration of alternative communication protocols, such as Bluetooth or ad-hoc networking, to enable communication between the ESP32 camera and the display screen without relying on a shared network infrastructure.

2. **Low Cost of Setup:** Continuous exploration of alternative components or newer versions is crucial for maintaining low setup costs. Partnerships with manufacturers or suppliers can secure bulk discounts, contributing to cost-effectiveness.

3. **Fixation:** Investigating newer Wi-Fi standards or technologies is crucial for deployment flexibility. Researching alternative communication protocols like LoRa or BLE may better suit long-range communication needs. Experimenting with antenna designs or signal amplification techniques can enhance wireless range cost-effectively.

4. **Port Forwarding:** Exploring alternative remote access solutions eliminates manual port forwarding. Investigating zero-configuration networking protocols simplifies remote access setup, reducing complexity and potential security risks. Collaborating with manufacturers develops standardized protocols for automated secure device exposure to the internet.

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Review Sheets :

Mentor: Mr. Priya R.L

Industry / ~~Inhouse~~: TIFR

~~Research~~ / ~~Innovation~~: Research

Project Evaluation Sheet 2023-24

Class: D12 B

Title of Project (Group no): Wireless Extraction of Data (GROUP NO : 25)

Group Members: Johan John, Vedang Rathi, Shreya Hadkar, Manali Patil

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg & Mgmt principles (3)	Life-long learning (3)	Professional Skills (5)	Innovative Approach (5)	**Total Marks (50)**
Review of Project Stage 1	4	4	4	2	4	2	2	2	2	3	3	3	4	5	44

Comments: → Database storage can be discussed with the company, ~~post~~ Access for remote can be given to authenticated users.

Name & Signature Reviewer1

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg & Mgmt principles (3)	Life-long learning (3)	Professional Skills (5)	Innovative Approach (5)	**Total Marks (50)**
Review of Project Stage 1	4	4	3	2	4	2	2	2	2	3	3	3	4	4	42

Comments:

Date: 10th February, 2024

Name & Signature Reviewer2

25

Project Evaluation Sheet 2023 - 24

Title of Project: Wireless Extraction of Data from Industrial Panels (Group No -25)

Class- D12B

Group Members: Shreya Hadkar (17), Johan John (22), Manali Patil (41), Vedang Rathi (47)

Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (2)	Applied Engg&Mgmt principles (3)	Life-long learning (3)	Professional Skills (3)	Innovative Approach (3)	**Research Paper (5)**	**Total Marks (50)**
4	4	4	2	4	2	2	2	2	2	2	3	3	2	2	40

Comments:

Inhouse/ Industry _Innovation/Research:

Name & Signature ~~Reviewer1~~

Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (2)	Applied Engg&Mgmt principles (3)	Life-long learning (3)	Professional Skills (3)	Innovative Approach (3)	**Research Paper (5)**	**Total Marks (50)**
4	4	4	3	4	2	2	2	2	2	2	3	3	3	3	43

Comments: Numerical value retrieval has to be implemented

Date: 9th March, 2024

Avg: 42

Name & Signature Reviewer 2