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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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) and 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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Mini Project Approval

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

Examiners

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Date:

Place:

Contents

Abstract

India, a developing nation, has served as a hub for the development of new technologies and industries. Numerous new sectors are emerging, along with several well-established ones that require an increasing number of machines. Keeping track of the data displayed by various machines was a strenuous and exhausting chore for humans in the world of today, with its rapidly developing technology and surge in industrial development.

It is tedious to extract the data and maintain a record of it without interfering with the operation of the machines. However, with the aid of new Artificial Intelligence Tools, a workable solution can be found to these problems.

The main goal of this project is to collect data from industrial equipment display panels, identify it, and store it in a database. It sets an alarm if data exceeds acceptable limits.
The proposed system will make use of OCR techniques and YOLO models to recognise data from real-time video that would be converted to multiple frames with greater efficiency. The devices to be utilized would include a low-resolution camera capable of aiding in the detection of data from display panels.

With excellent accuracy, efficiency, and dependability, this project seeks to revolutionize wireless data extraction by employing powered artificial intelligence techniques.

Acknowledgments

We, as a cohesive team, would like to extend our heartfelt gratitude to the individuals and institutions that have played a pivotal role in the successful completion of our project, "Wireless Extraction of Data using ML Techniques." It is with great pleasure that we take this opportunity to express our appreciation to those without whom this collective endeavor would not have been possible.

First and foremost, we are deeply indebted to our esteemed Principal, Mrs J.M Nair , for providing the nurturing academic environment and unwavering support that fueled our research. Your visionary leadership, unwavering commitment, and dedication to fostering research excellence have been a source of inspiration for the entire team.

We would also like to express our deepest gratitude to our project mentor, Mrs Priya R L, whose unwavering support and mentorship were invaluable throughout this journey. Your expertise, guidance, and encouragement were instrumental in shaping the course of this project. Your insightful feedback not only improved the quality of our project but also enriched our collective knowledge in the fields of wireless data extraction and machine learning.

We are also thankful to the faculty members of the Computer Department for their guidance, feedback, and support. Their collective wisdom and suggestions were invaluable in refining our research and presentation.

We extend our appreciation to our peers and friends who provided us with continuous support and constructive feedback during this project. The discussions and interactions with them were instrumental in refining the ideas and methodologies presented in this report.

Lastly, but certainly not least, we would like to express our heartfelt gratitude to our families for their continuous support, encouragement, and understanding throughout this project. Their unwavering belief in our team and its potential has been a driving force behind our academic endeavors.

This project was a collective journey filled with challenges and learning experiences, and it is these individuals and institutions who have made it all the more rewarding.
Thank you all for being an integral part of this team endeavor.

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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1. INTRODUCTION

1.1 Introduction

Display panels are essential in numerous industries because they provide an array of useful information. Remote machine and display panel monitoring is made possible by wireless data extraction. This is especially helpful in circumstances where physical access to the panels may be constrained or impracticable, like in huge industrial sites or outdoor installations.

Real-time data analysis and insights are essential for making responsible choices in multiple companies. Instant access to data presented on panels is made possible due to wireless data extraction, enabling companies to respond quickly to changes, optimize procedures, and deal with potential problems promptly.

Even though the camera's images are of lower resolution, the goal is to still be able to utilize it because of the artificial intelligence capabilities.The camera's video is divided into several numerous frames for data extraction.

The focus of the project is on utilizing the You Only Look Once (YOLO) Model, a cutting-edge object detection method.The widespread implementation of this algorithm is due to its accuracy and quickness.It has been used in a number of applications to recognise letters, characters, figures, traffic lights, people, parking meters, and animals.

In addition, the Optical Character Recognition (OCR) algorithm, which is a method for converting a text image into a machine-readable text format, will also be applied. A simple OCR engine works by storing many different font and text image patterns as templates. The OCR software uses pattern-matching algorithms to compare text images, character by character, to its internal database.

The system will be created to support various machine displays, demonstrating versatility in digit detection and guaranteeing consistent performance in recognition across various conditions. It will also be scalable, able to handle several cameras, and capable of simultaneously extracting data from numerous equipment.

1.2 Motivation

The motivation behind this project stems from the recognition of the growing importance of real-time data analysis and the need for efficient monitoring in various industries. In today's fast-paced industrial landscape, the ability to access and analyze critical data in real-time is essential. This project aims to enable instant access to data displayed on panels through wireless extraction. This allows companies to respond quickly to changes, optimize processes, and address potential issues promptly, ultimately leading to improved operational efficiency.

In many industrial settings, physical access to display panels can be challenging, especially in large industrial sites or outdoor installations. The project seeks to address this constraint by providing a solution for remote machine and display panel monitoring. This capability is crucial for industries where physical access may be impracticable, helping to reduce downtime and maintenance costs.

In a data-driven world, the ability to make informed and responsible decisions is paramount. This project's motivation is rooted in its contribution to data-driven decision-making processes. By providing instant access to data, accurate object detection, and text recognition capabilities, it empowers companies to make well-informed choices, potentially leading to cost savings and improved safety.

This project is motivated by the pressing need for efficient, real-time data extraction and analysis in industries, especially in scenarios where physical access to display panels is limited. By incorporating advanced object detection and OCR technologies, it aims to provide a versatile and scalable solution that empowers companies to make informed decisions, optimize their processes, and maintain a competitive edge in their respective markets.

1.3 Problem Statement & Objectives

Creating an innovative, non-invasive, and wireless OCR-Based Display Panel Data Extraction System with Real-Time Video Analysis and Internet of Things Integration.

The project aims to address the difficulty of non-invasive and wireless display panel data extraction using AI approaches, with a particular emphasis on exploiting the YOLO Model as a robust and efficient OCR solution. The major goal is to create a real-time system that can capture video feeds from low-cost IP cameras and conduct accurate OCR to detect machine display data. Multiple machine displays should be supported by the system to provide consistent recognition performance.

Key capabilities include the capacity to accept and analyze video data from cameras, do OCR analysis, and wirelessly communicate the extracted data to a central server via IoT devices. The system should use image enhancement techniques to improve word recognition while keeping latency to a minimum for real-time video frame collecting. Cross-platform compatibility across many operating systems is critical to ensuring universal use.

Furthermore, the system should be flexible in digit detection, capable of accurately detecting digits regardless of camera-to-panel distance. Scalability is an important issue since it allows the system to handle numerous cameras and detect show results from multiple workstations at the same time, as long as the camera arrangement remains stable.

2. LITERATURE SURVEY

2.1 Survey of Existing System

Paper Name	Features	Inference
1. A research paper on the Recognition Method of Electrical Components Based on YOLO V3.	a) Image classification and dataset preparation methods b) The YOLO V3 model, combined with SRCNN, can accurately identify the position and state of objects under different angles, backgrounds and illumination intensities.	a) Understanding the YOLOv3 model.
2. A review on the Various Techniques used for OCR.	a) Converting textual content from a paper document into machine readable format using OCR.	a) Extracting text from images produced by video frames.
3. Automatic Number Plate Recognition System for Indian Number Plates using Machine Learning Techniques	a) Usage of YOLOv5 for real-time acquisition for number detection. b) YOLOv5 is used as its smallest and lightest model with fastest output to cope up with the video frames.	a) Usage of yolov5 for real-time number detection from panels.

A survey of existing services and technologies, which involves non-invasive and wireless extraction of display panel data using AI techniques, reveals several relevant aspects:

Object Detection and OCR:

YOLO (You Only Look Once) is a well-established algorithm for real-time object detection, which can be applied to recognize texts and characters in video streams. Open-source libraries and pre-trained YOLO models can be leveraged.
YOLO (You Only Look Once) is a popular object detection algorithm and model in the field of computer vision. It is known for its speed and accuracy in real-time object detection and recognition. YOLO was developed to address the limitations of traditional object detection algorithms that require multiple passes through an image and are relatively slow.
YOLO is open-source, and its models and code are available for research and application development. This accessibility has contributed to its widespread use and the development of various applications.

Image Analysis and Processing:

Specialized image processing software and libraries like Python's OpenCV can be used to preprocess and analyze images before OCR.
OpenCV, or Open Source Computer Vision Library, is an open-source computer vision and machine learning software library designed to provide a comprehensive infrastructure for developing computer vision applications. It is one of the most widely used and well-supported libraries in the field of computer vision and image processing. OpenCV offers a vast collection of functions and algorithms for tasks such as image processing, object detection, machine learning, and more.

IoT and Integration:

The ESP32-CAM is a popular development board that integrates an ESP32 microcontroller and a camera module. It is often used in IoT (Internet of Things) applications for capturing and streaming images or video.With the camera module, the ESP32-CAM can capture images and video frames, which can be processed, transmitted, or saved locally. Images and video can be captured in various formats, including JPEG. The ESP32-CAM can be used to stream live video over Wi-Fi. It is commonly used in applications like video surveillance and live streaming.

2.2 Limitation in Existing System

1. **Limited Training Dataset:**

The system lacks an extensive and diverse training dataset. It relies on a limited dataset, primarily focused on a narrow set of display panels commonly found in industrial settings.

2. **Numeric Character Recognition:**

The system's primary focus on digit recognition implies a particular limitation on its functionality as it is not capable of recognizing alphanumeric characters. Although it excels at identifying and processing numeric data, its scope is limited to numeric values and excludes recognition of letters or special characters. This constraint imposes limitations on the flexibility and usefulness of the system, especially in applications that require the interpretation of both numeric and alphanumeric content. In contexts where alphanumeric characters are an integral part, such as in text document processing, license plate recognition, or natural language interfaces, the system's inability to distinguish between letters and symbols are a notable drawback.

3. **Low Image Resolution:**

The system's absence of image resolution enhancement techniques leads to a notable drawback. Without such capabilities, the video frames it generates remain at a lower resolution, which can result in images that lack clarity and sharpness. This limitation can significantly impact the visual quality of the output, affecting tasks like object recognition or visual analysis. Implementing image resolution enhancement techniques would be essential to improve the system's ability to capture and process higher-quality images, enhancing its overall performance.

4. **No Threshold Value Alarms:**

The system's monitoring and alerting functionality currently lacks alarm-triggering features, resulting in operators and responsible personnel remaining unaware when displayed values surpass predefined thresholds. This deficiency can lead to delays in addressing critical issues, as anomalies or deviations from acceptable parameters go unnoticed until manual inspections are initiated.

This hinders real-time responsiveness, raising concerns about operational efficiency and safety, particularly in scenarios demanding prompt intervention. To bolster system reliability, safety, and performance, the imperative is to institute a robust alarm system for swift notification when thresholds are breached, mitigating potential problems.

5. **User Interface:**

The absence of user-friendly features in the system's interface presents a notable hurdle for users. Without convenient setup and configuration options, users may encounter difficulties in getting the system up and running efficiently.

2.3 Mini Project Contribution

The project uses various available algorithms like YOLO an.

Various libraries like:

- OpenCV
- PyTorch
- Pyqt5 Designer
- Matplotlib
- Decorator

Many more other libraries were installed using generated bash files (use bash file to avoid version compatibility issues).

The code is written in python where an attempt has been made to connect the cameras on the same network. and the camera used to handle the video and digital character detection has been done. The extracted video frames will be converted into multiple frames.

We also tried to extract data from multiple cameras to improve scalability and improve efficiency.

3. PROPOSED SYSTEM

3.1 Introduction

The project on wireless data extraction from industrial panels presents a practical approach to harnessing modern technology for enhanced data insights in industrial settings.The project ensures these cameras are strategically placed and configured to optimize data acquisition. Machine learning models, such as convolutional neural networks (CNNs) or optical character recognition (OCR), are then trained on labeled data, aiding in real-time data extraction and subsequent post-processing.

Real-time data analysis and insights are essential for making responsible choices in multiple companies. Instant access to data presented on panels is made possible due to wireless data extraction, enabling companies to respond quickly to changes, optimize procedures, and deal with potential problems promptly.

Even though the camera's images are of lower resolution, the goal is to still be able to utilize it because of the artificial intelligence capabilities.The camera's video is divided into several numerous frames for data extraction.

The system will be created to support various machine displays, demonstrating versatility in digit detection and guaranteeing consistent performance in recognition across various conditions. It will also be scalable, able to handle several cameras, and capable of simultaneously extracting data from numerous equipment.

3.2 Architectural Framework

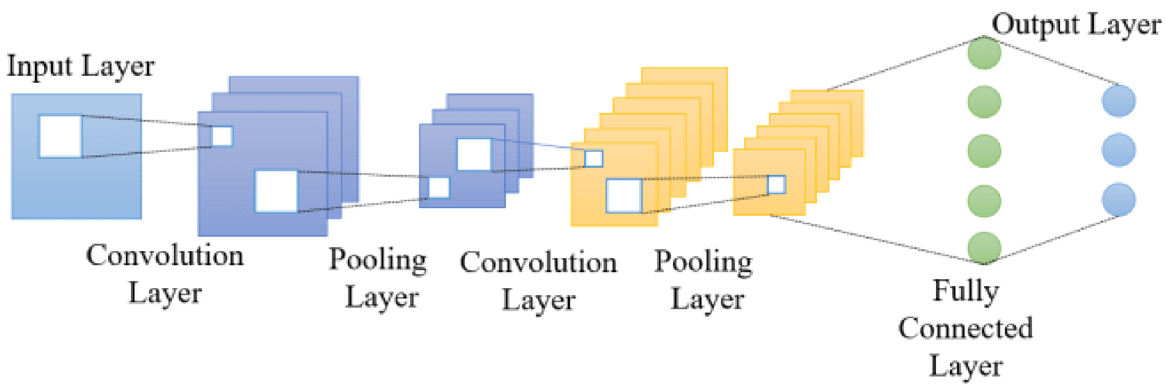

Figure1: Architectural Framework for CNN

An architectural framework for a Convolutional Neural Network (CNN) typically consists of several key components that work together to process and extract features from input data. Below is an overview of the architectural framework for a CNN:

1. Input Layer:

The input layer receives the raw data, typically in the form of images but can also be used for other structured data.

2. Convolutional Layers:

Convolutional layers are the heart of a CNN. They consist of multiple filters (also called kernels) that slide over the input data to detect features. Each filter captures different patterns or features. Convolution operations apply these filters to create feature maps, highlighting relevant patterns in the input data.

3. Pooling (Subsampling) Layers:

Pooling layers reduce the spatial dimensions of the feature maps while retaining the most important information. Common pooling methods include max-pooling and average-pooling.

4. Fully Connected Layers (Dense Layers):

Fully connected layers process the high-level features extracted by the convolutional and pooling layers and combine them to make predictions. These layers are typically used in the final stages of the network and are connected to the output layer.

5. Output Layer:

The output layer produces the network's predictions or classifications. The activation function used here depends on the task, such as softmax for multi-class classification or linear for regression.

6. Model Evaluation Metrics:

The choice of evaluation metrics depends on the specific task. For classification, metrics like accuracy, precision, recall, and F1-score are commonly used.

This architectural framework provides a structured approach to building and training CNNs for various computer vision tasks, such as image classification, object detection, and image segmentation. The design and configuration of the CNN architecture can vary based on the specific problem and dataset being addressed.

3.3 Process Design

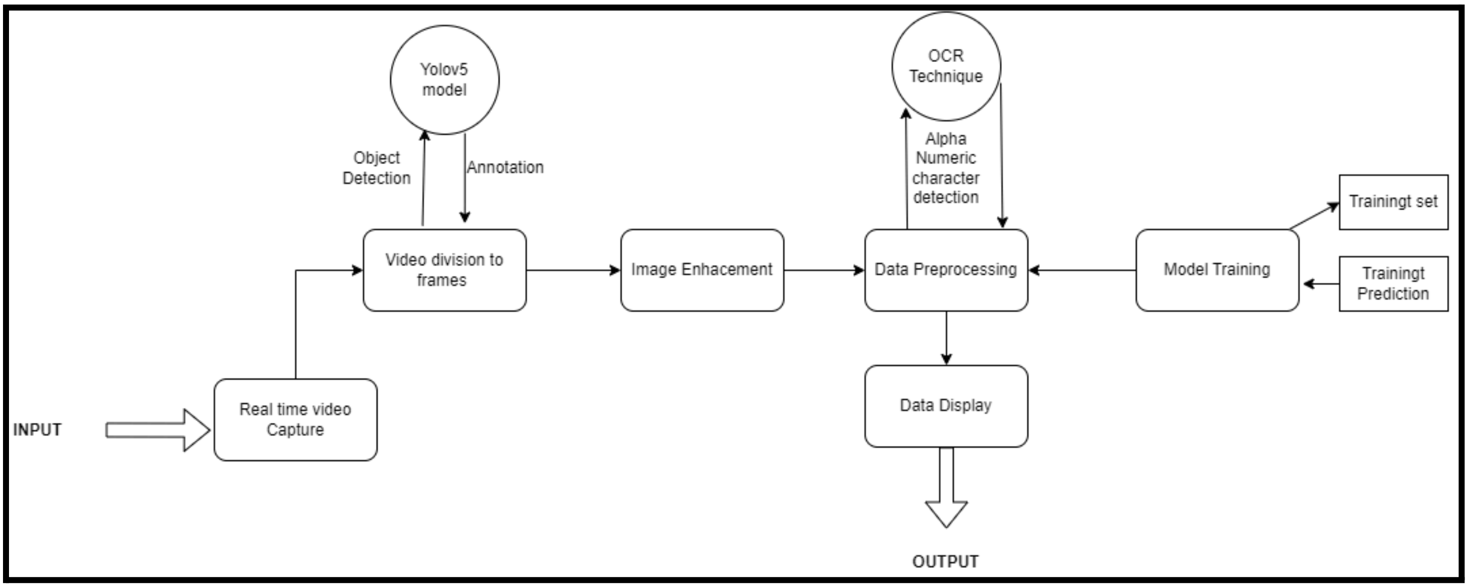

Figure 2: Process Design

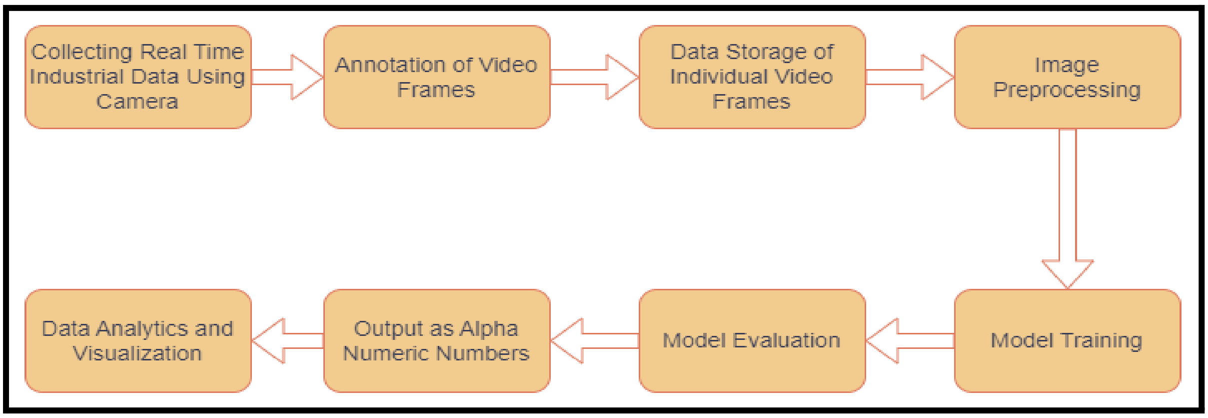

Figure 3: Process Flow

3.4 Methodology Applied

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.

Develop or Select a Methodology for Annotating Key Information within Video Frames:

The annotation process is pivotal for training and validating models used in wireless data extraction from industrial panels. This phase involves developing or selecting a methodology to annotate critical information within video frames. Annotation tasks may encompass identifying and labeling relevant objects, regions of interest, or specific data points in the footage. It is essential to employ annotation tools or software to meticulously label objects and data in a subset of video frames. This annotated dataset serves as a reference for training machine learning models. The accuracy and completeness of the annotations significantly impact the effectiveness of subsequent model training and data extraction.

Apply Preprocessing Techniques to Enhance Video Frame Quality:

Before data extraction can occur, the captured video frames often require preprocessing to enhance their quality and suitability for analysis. This phase involves several image enhancement techniques, such as noise reduction to eliminate unwanted artifacts, image stabilization to compensate for camera movement, and adjustments to lighting conditions for consistent frame quality. Techniques like background subtraction may be used to isolate the objects of interest within the frames. By applying these preprocessing methods, the data is refined, ensuring that the subsequent data extraction and analysis steps are based on a clean and reliable dataset.

Train the Models on a Labeled Dataset:

To automate the data extraction process, machine learning models must be trained on a labeled dataset. This step involves selecting appropriate algorithms and techniques tailored to the specific data extraction task. Common choices include convolutional neural networks (CNNs) for object recognition and optical character recognition (OCR) tools for extracting alphanumeric data. The labeled dataset created during the annotation phase serves as the training data. During model training, the algorithms learn to recognize and extract relevant information from video frames, enabling the subsequent automated data extraction process.

Deploy Trained Models and Implement Post-Processing Steps:

After successful model training, the next phase is to deploy these trained models to process real-time video frames and extract alphanumeric data from industrial panels. Once the models are actively processing data, post-processing steps come into play. These steps are crucial for validating and refining the extracted data as necessary. Post-processing may include error correction, data verification, or data formatting to ensure accuracy and consistency in the extracted information. This phase ensures that the data extracted from the industrial panels is reliable and can be used effectively for further analysis or decision-making.

Implement Real-Time Monitoring and Reporting for Actionable Insights:

At last the focus shifts to real-time or near-real-time monitoring and reporting of the data extracted from industrial panels. This involves setting up a system for continuous data analysis, generating actionable insights, and delivering reports or alerts to relevant authorities. The real-time aspect is critical for timely responses to any issues or anomalies detected during data extraction. It completes the cycle of wireless data extraction from industrial panels, transforming raw data into actionable knowledge.

3.5 Hardware and Software Requirements

3.5.1 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.

3.5.2 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. Makesense.ai/ Label Studio

These tools are used for annotating the custom objects in the images.

7. 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.

8. TensorBoard (from Tensorflow)

TensorBoard helps in YOLO Model evaluation.

3.6 Experiment and Results for Validation and Verification

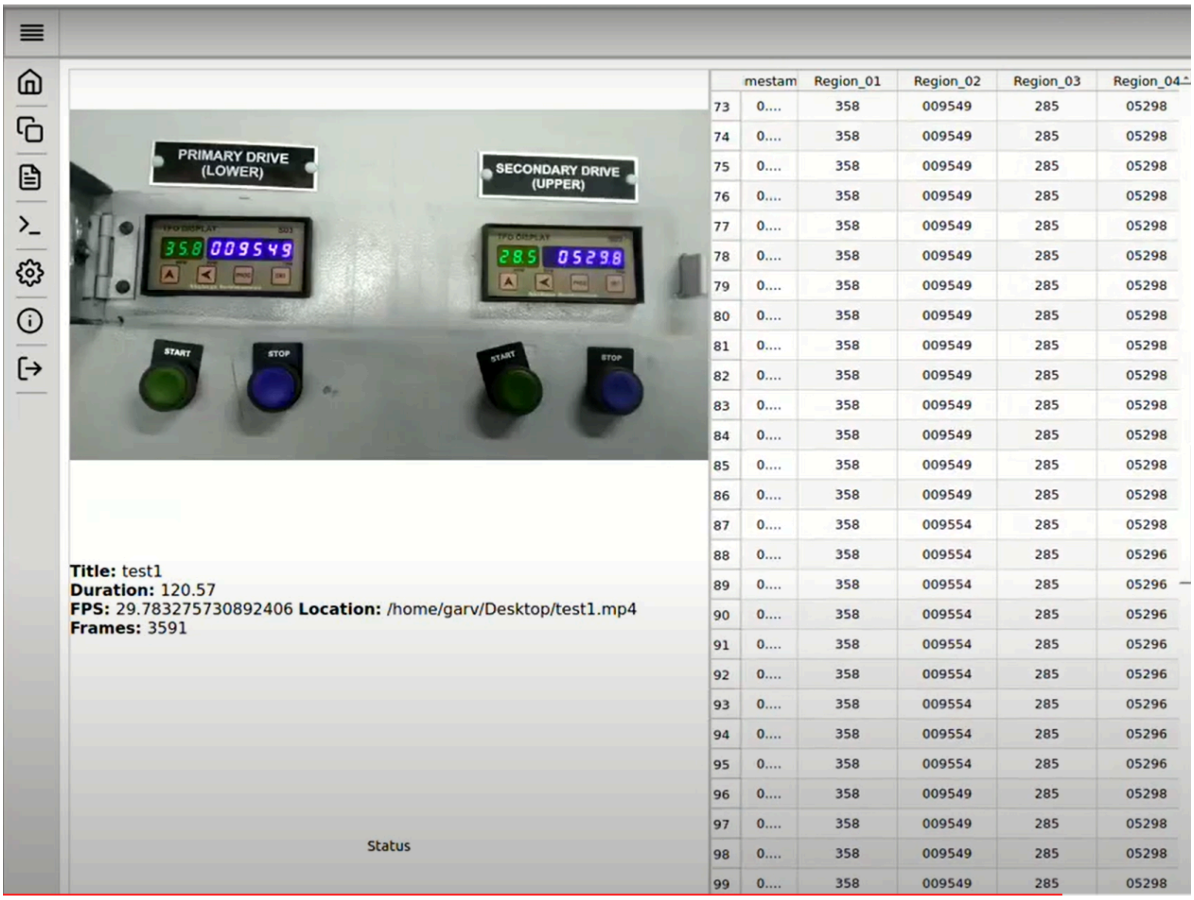

Figure 4: Using Testing Video Provided by TIFR

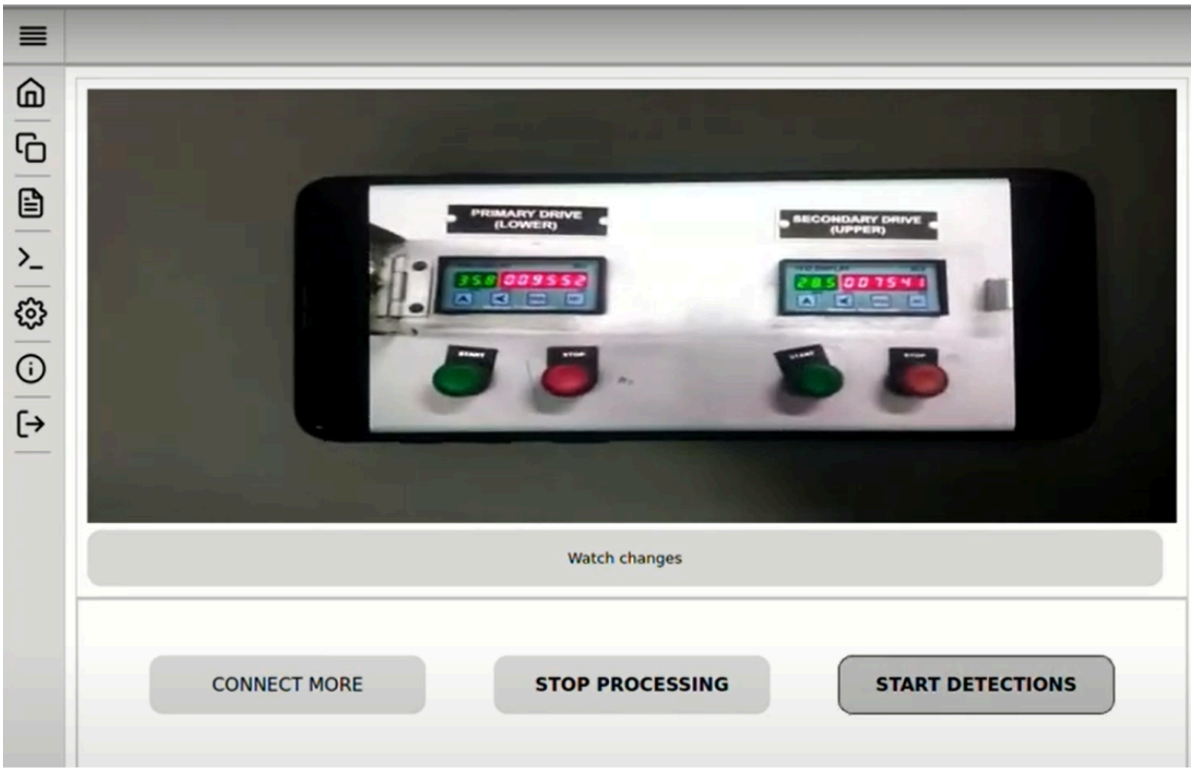

Figure 5: Integrating 1 Smartphone Camera to start detections.

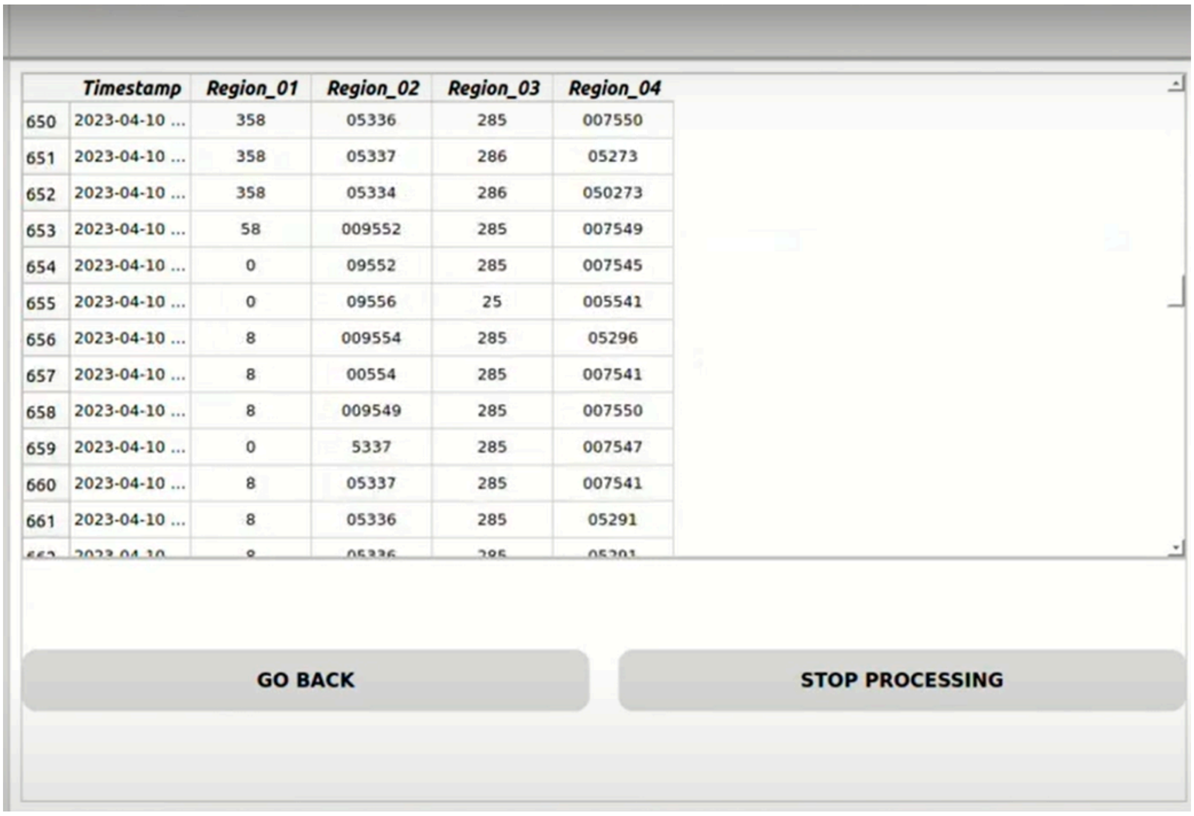

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Figure 6: Result of integration of 1 Smartphone Camera

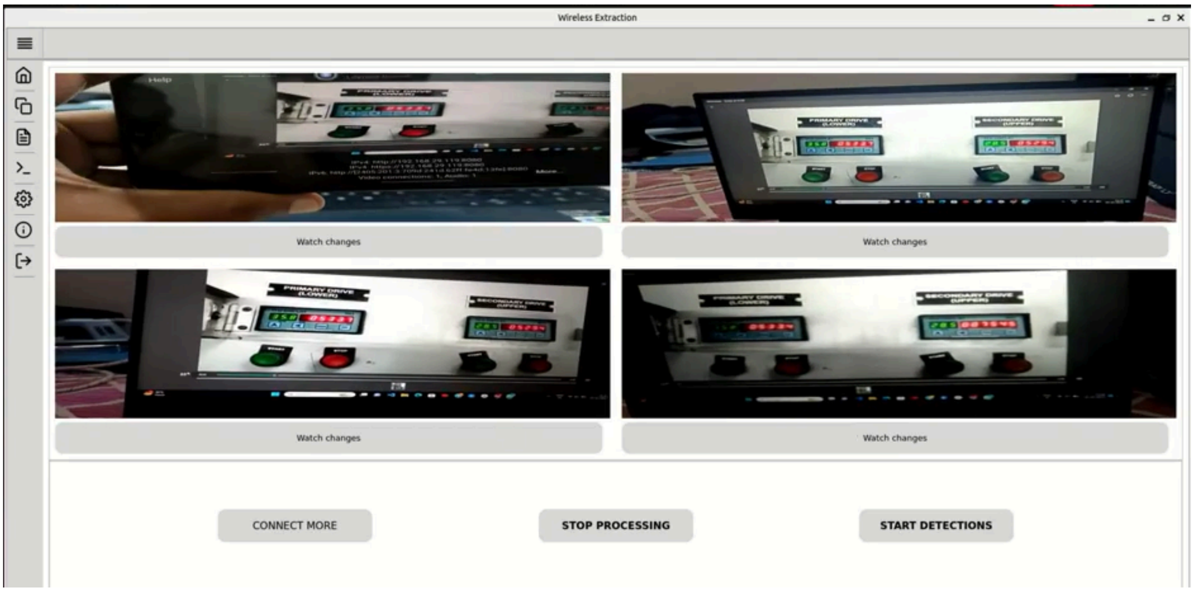
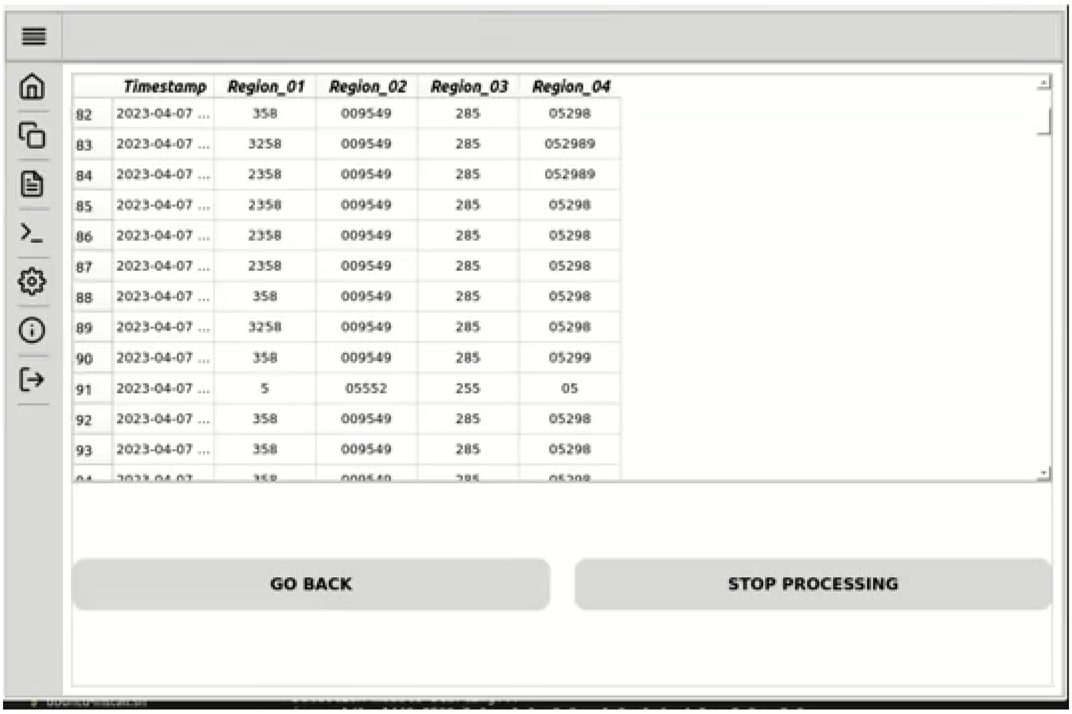


Figure 7: Integration of 4 Cameras



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92	2023-04-07 ...	358	009549	285	05298
93	2023-04-07 ...	358	009549	285	05298

Figure 8: Result of integration of 4 Cameras

3.7 Result Analysis and Discussion

The result analysis of our Wireless OCR-Based Display Panel Data Extraction System with Real-Time Video Analysis and IoT Integration holds significant promise for various industries and applications. This innovative solution, built around the YOLOv5 Model and Optical Character Recognition (OCR) techniques, offers several key features that contribute to its effectiveness and practicality.

1. Data Extraction

The system's extensive and diverse training dataset is a crucial component in achieving versatility in data extraction. By encompassing a wide range of display panels commonly found in industrial settings, the system can adapt to varying layouts and extract data accurately. This adaptability is vital for applications in industries with diverse types of machinery and equipment.

2. Alphanumeric Recognition:

The extension of the system's capabilities to recognize both numerical and textual data will further enhance its utility. This advancement will allow the system to extract information beyond just numerical values, catering to industries where textual data is integral to decision-making processes.

3. Image Resolution Enhancement:

The incorporation of image resolution enhancement techniques will contribute to the system's reliability. Clearer and sharper video frames result in improved text recognition accuracy, even when dealing with display panels located at varying distances from the camera. This is especially valuable in scenarios where physical access to panels is constrained, and the camera's images might have lower resolution.

4. User-Friendly Interface:

The system's user-friendly interface simplifies setup, configuration, and monitoring. This aspect is essential for ensuring that the technology can be adopted by a wide range of users, including operators and technicians who may not have in-depth technical knowledge. The intuitive interface streamlines the deployment and utilization of the system.

3.8 Conclusion and Future work

In this project, we have successfully developed a wireless IoT-based OCR system for real-time extraction of display panel data using the YOLOv5 algorithm. The system demonstrated robustness, high accuracy, and low latency, showcasing its potential to transform industrial data acquisition, storage, and analysis. The utilization of low-cost cameras with static IP addresses facilitated easy setup and functionality for the users, enhancing the system's accessibility.

To ensure accurate OCR results, we employed image enhancement techniques and model optimizations, further enhancing the system's accuracy and real-time processing capabilities. The system's wireless data transmission through IoT devices enabled seamless communication with the central server, providing users with instant access to crucial display panel data.

However, we acknowledge that there is always room for further improvement. Future enhancements could include exploring advanced image processing algorithms, integrating additional deep learning techniques, and optimizing the system's hardware and network components for even lower latency.

In conclusion, this project has successfully demonstrated the power of IoT and AI in transforming society and improving human life. The developed system's accuracy, speed, and scalability pave the way for a new era of real-time industrial data extraction and analysis,thereby automating the industry .

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