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Development of an Automatic Rejection System for Medicine Packaging Industry Using OpenCV for Tablet Detection

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Abstract:- The Automatic Rejection System is a quality control solution using machine vision system and machine learning algorithms to inspect products on a production line and reject defective or non-confirming items. The system includes a camera or imaging device, processing unit, and a rejection mechanism.

It captures product images and analyzes them to defects, which are then automatically removed by rejection mechanism. The system can be tailored for various products and integrated with other quality control technologies, improving product quality, reducing waste and enhancing production efficiency across industries such as food processing, pharmaceuticals and manufacturing.

The paper presents the development of an automatic rejection system designed for the medicine packaging industry. Utilizing OpenCV and image processing techniques, the system inspects tablets for defects and uses a rejection mechanism to remove non-confirming products. The proposed solution aim to enhance the quality control process by automating tablet detection and rejection.

The system is composed of a camera module (ESP-32), OpenCV for defect identification and an actuator for rejecting faulty tablets. The implementation improves accuracy and efficiency in the packaging process , ensuring high product standards.

Keywords:- *Machine Vision , OpenCV , Tablet Detection , Medicine Packaging , Automation, Quality Control.*

I. INTRODUCTION

In today's competitive manufacturing environment ,ensuring consistent product quality while maintaining high production efficiency is essential for businesses to remain competitive. Traditional quality control methods, which often rely on manual inspection, are time consuming , prone to human error and the system operates by capturing high resolution images of products as they move through the production line using camera or other machine learning algorithms , which are trained to identify defects such as dimensional inaccuracies, surface imperfections or misalignment. When a defect is detected , the system activates a rejection mechanism-typically inefficient for large scale production

To address these challenges the "Automatic Rejection System ", integrates machine vision and machine learning technologies to automate the defective products on production lines.

A pneumatic a mechanical actuator-that removes the faulty product from production flow. This not only improves product quality but also reduces waste and enhances production efficiency by minimizing manual intervention. The Automatic Rejection System is versatile and can be tailored to suit a wide range of industries including food processing, electronics and automotive manufacturing.

Its ability to provide real-time monitoring and data analysis of the production line. The system continuously gathers and process data, which can be used to analyze trends, optimize production processes, and enhance decision making. By offering immediate feedback, manufacturers can quickly identify and address issues within the production cycle, ensuring faster response time and minimizing downtime.

Compliance with Industry Regulations like pharmaceuticals and food processing ,Stringent regulatory standards require precise quality control to ensure consumer safety and product reliability. This paper explores the design, implementation, and benefits of the "Automatic Rejection System", highlighting its potential to revolutionize quality control process.

By reducing labor costs, improving accuracy , and ensuring real time defect detection, this system addresses key challenges faced by manufacturers

II. EASE OF USE

A. Overview of Quality Control Systems)

Quality control system have long been an integral part of manufacturing to ensure that products meet predefined standards. In traditional manufacturing, manual inspection was commonly used to detect product defects, but these systems were often inefficient and prone to human error. According to [1], manual inspection is not scalable in high-speed production environments, leading to the development

of automated solutions such as machine vision based rejection systems. These system leverage the power of computer vision and machine learning algorithms to inspect products in real time, minimizing human intervention[2].

B. Machine Vision in Automated Rejection Systems

Machine vision technology has significantly transformed the quality control process, offering high precision and reliability in defect detection. Several studies have focused on the application of machine vision in automated rejection systems, which typically include camera for capturing product images, a processing unit for analysis, and a rejection mechanism for removing defective items. In [3], the authors demonstrated the effectiveness of machine vision systems identifying subtle product defects, with high-speed processing capabilities enabling real-time decision making on production lines. Machine learning algorithms further enhance defect detection by training the system to recognize specific product features, as outlined in [4].

C. Key Concepts of Machine Vision Based Rejection Systems

Automated rejection systems utilizing machine vision technology consist of three primary components : an imaging device, a processing unit, and a rejection mechanism. Research by [5] highlights the role of high-resolution cameras in capturing detailed product images, which are essential for accurate defect detection. Once captured, these images are proceed using machine learning algorithms to identify non- comforming products. As demonstrated in [6],the rejection mechanism, often pneumatic line or mechanical, removes defective products from the production line with minimal delay, defective products from the production line with minimal delay, thereby increasing production efficiency.

D. Benefits and Industry Applications

The applications of machine vision in rejection systems has been extensively studied, particularly in industries like food processing, pharmaceuticals and automotive manufacturing. In [7],it is argued that automated rejection systems can significantly improve product quality while reducing labor costs and waste. Real time monitoring capabilities, as discussed in [8], provide continuous data on production performance, helping manufacturers make data driven decisions to optimize their processes. Moreover, the ability to integrate these systems with other quality control mechanisms, such as metal detectors and weight- checking systems, provides a comprehensive solution for ensuring product quality.

III. PROBLEM STATEMENT

In modern manufacturing industries, ensuring product quality and minimizing defects is critical to maintaining customer satisfaction and reducing production costs. Manual inspection processes are often slow, prone to human error, and inefficient for handling large- scale production. Additionally, defective products that pass through unchecked can lead to wastage, increased returns, and reputational damage for the company.

The challenge is to develop an "**Automatic Rejection System"** that utilizes machine vision and real-time image processing to detect and reject defective products from the production line. The system should be capable of integrating with existing production setups, ensuring high-speed and accurate rejection of non-conforming items. Furthermore, it must be cost-effective, scalable, and adaptable to various product types and production environments.

IV. PROPOSED SYSTEM

The system comprises three major components:

- ESP32 Camera Module Captures high-resolution images of tablets as they move through the production line.
- OpenCV for Image Processing Performs real- time defect detection, identifying faulty tablets based on shape, size, or damage. Rejection Mechanism Utilizes a solenoid actuator controlled by an Arduino Uno to reject defective tablets from the line.
- The system is designed for ease of use and integration with existing manufacturing setups, offering modularity and flexibility for future upgrades.

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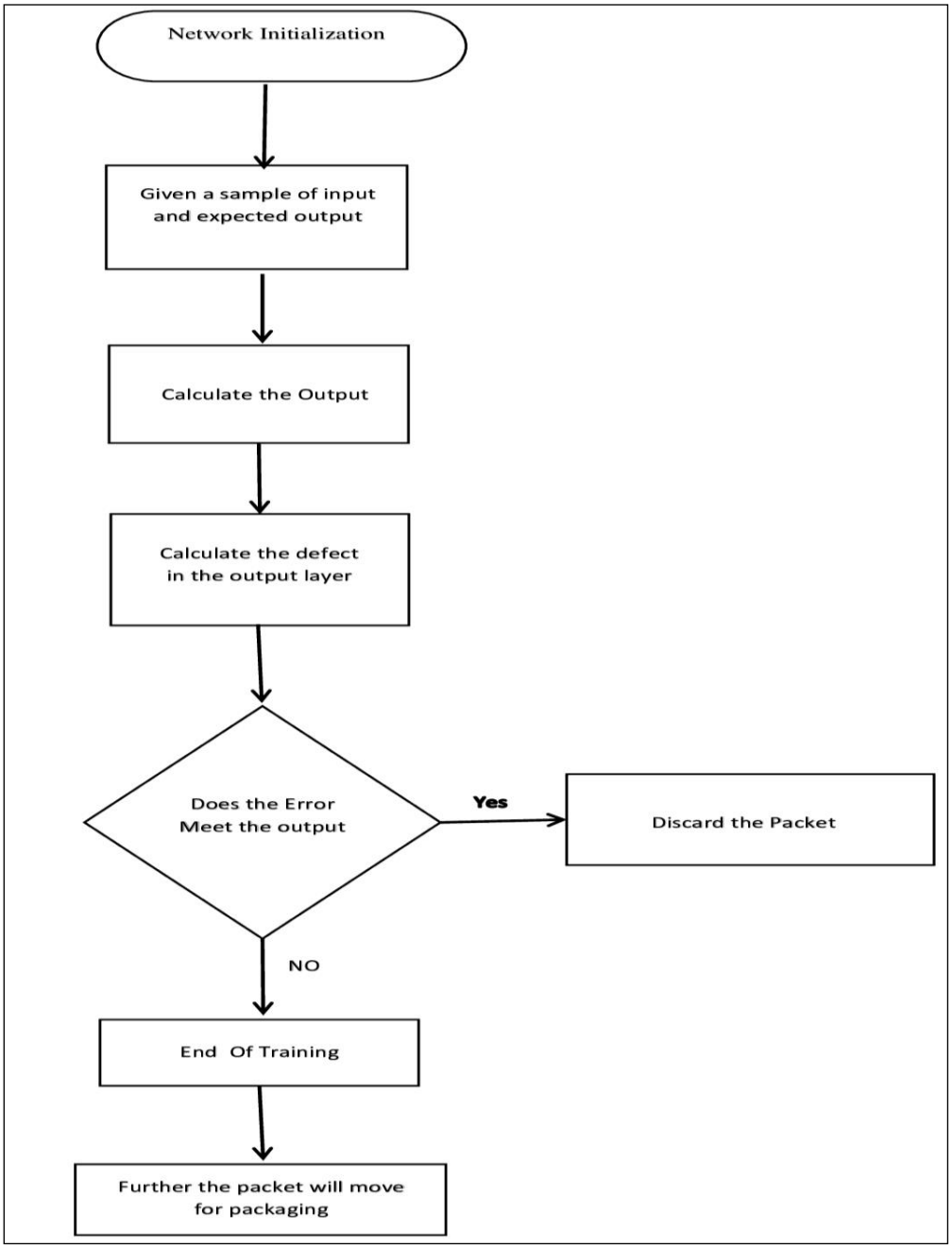

Fig 1.Flow of the Proposed Method

V. METHODOLOGY

- The following steps outline the implementation of the automatic rejection system:
- For Image Acquisition the ESP32 camera captures images of the tablets as they pass through the conveyor belt.
- Later then image processing was performed the images are processed in real-time using OpenCV, which identifies defects based on predefined parameters like shape and size.
- Defective tablets are removed from the production line using a solenoid actuator, ensuring smooth operation.

The flowchart depicts a decision making process, most likely to a neural network or machine learning model for packet inspection or defect detection. Here's a description process:

- The process begins with initializing the neural network, setting up parameters such as weights and biases for the model.
- Given a sample input packets & expected output a sample input is fed into the system along with the expected output for comparison.
- The output is analyzed to identify any defects or missing parts by comparing the actual output with expected output.

VI. DESIGN OF THE SYSTEM

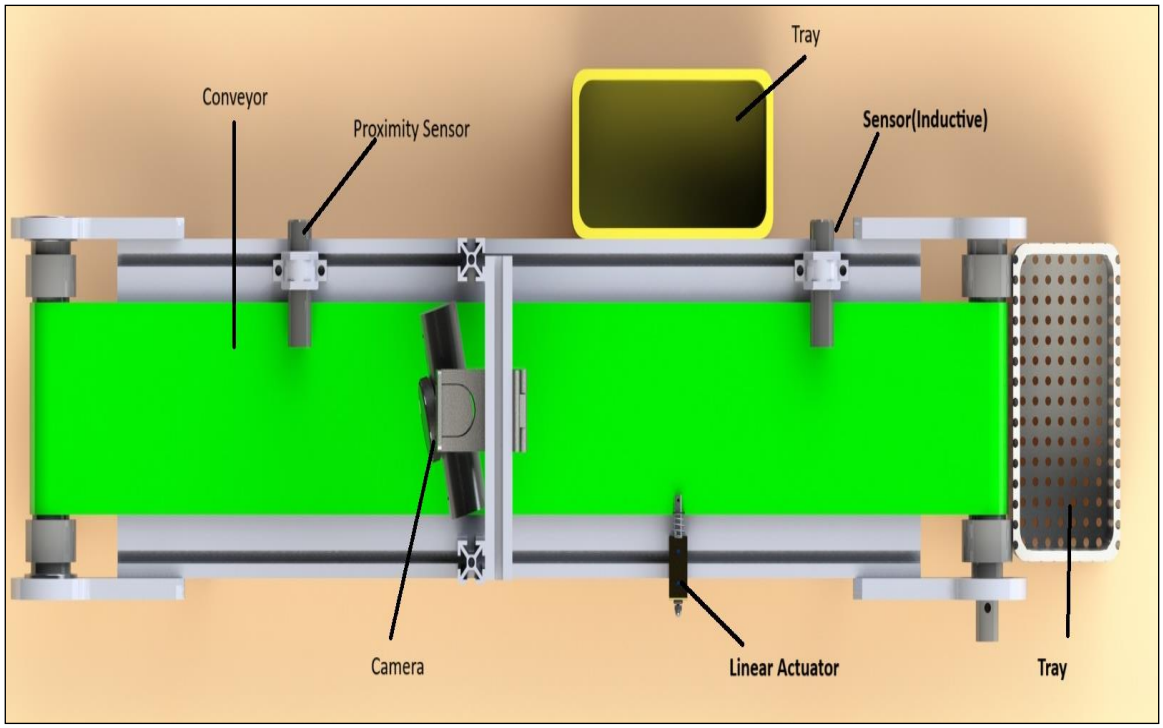

Fig 2. Automatic Rejection System

The prototype design of the robot is developed on the software SolidWorks. It is design according to the parameters and accurate measurements taken to develop the system and its applications.

A. Designing the Prototype

Designing a prototype using solidworks involves several steps:

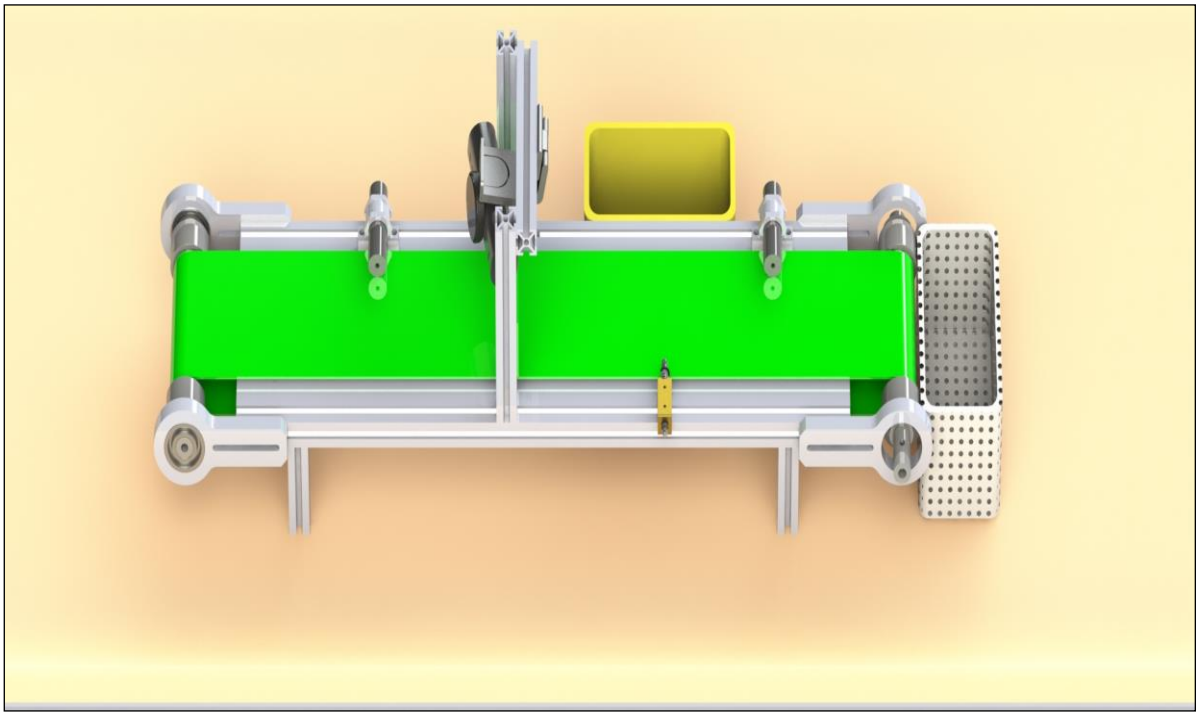

Fig 3. System Front Side View

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VII. CALCULATIONS

In this project, calculations are employed to determine the operational efficiency of the automatic rejection system. Critical factors such as conveyor speed, sensor triggering time, and actuator force are key to ensure smooth and accurate defect detection.

The above models describe the system's behaviour, quantifying the timing and force required for effective operation.

The conveyor speed (v) is essential to determine the throughput and inspection timing. Using the formula v=d/t , where d is conveyor length and t is required time , we can calculate the speed that governs the entire system. This informs the available time for inspection before a product reaches end of line. Also here we employ calculations such as delay between the proximity sensor detection and the camera capturing an image, we ensure accurate image acquisition.

The forced required for reject defective item from the line depends on the mass and acceleration of the product, modeled by F=m*a. This equation helps to determine the actuator's power based on the product weight and required rejection speed.

VIII. CALIBRATION AND CODING

Calibration of the relay-controlled motor is critical to ensure the motor operates efficiently for precise timing during product rejection on the conveyor systems. The relay controls when the motor is turned on and off, based on predetermined intervals is essential to align the motor's operation with the rest of the automatic rejection system, preventing delays or mistimed movements.

The code and the synchronization between the motors and other components (conveyor ,motors) was completed and the communication between conveyor and Arduino was established.

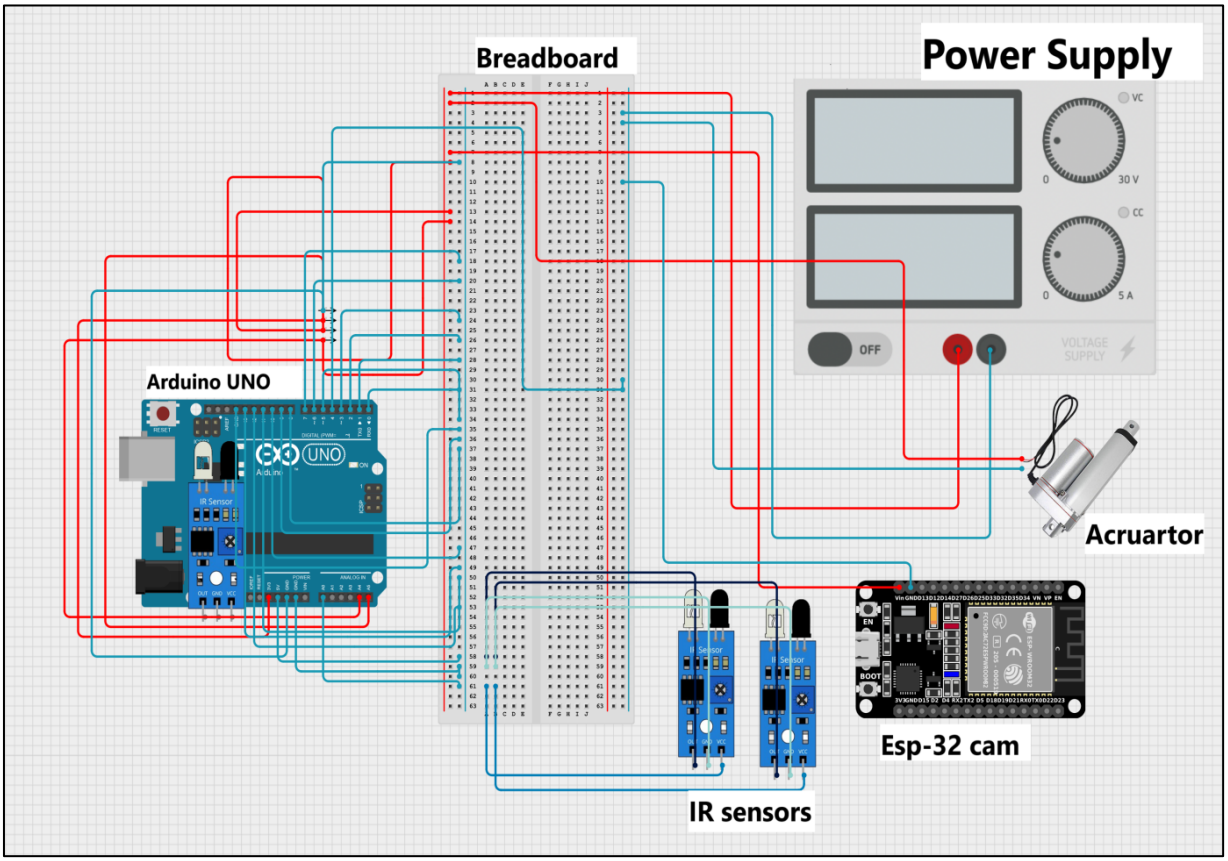

Fig 4.Communication between (a) Arduino (b) Actuator (c) ESP32 cam module

IX. RESULTS

The system was tested in a simulated production environment and achieved .The “The Automatic Rejection System” was tested for performance and accuracy of detecting defective delivery. The image processing and rejection system operate in real time , matching the conveyor belt speed. Significant in manual errors and overall increase in production efficiency.

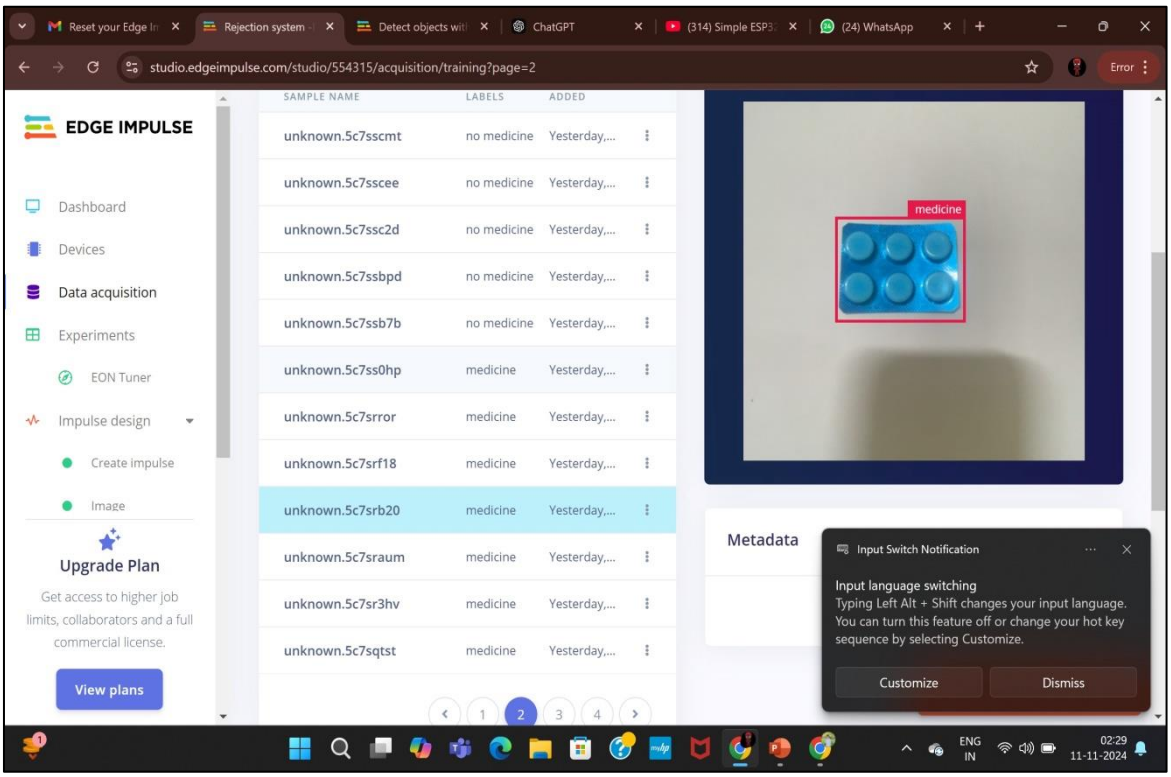

Fig.5 Result of Presence of Medicine

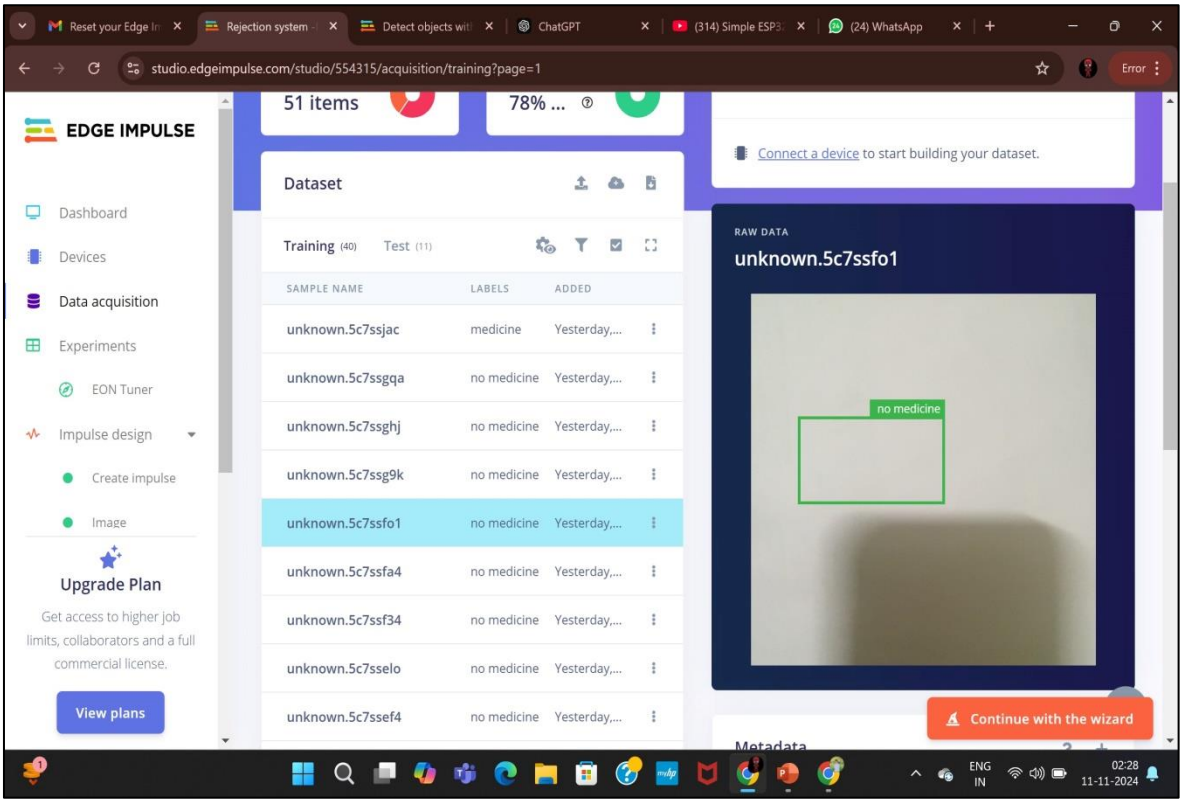

Fig.6 Result of Absence of Medicine

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XI. CONCLUSION

The developed Automatic Rejection System using machine vision has successfully demonstrated its ability to enhance its ability to enhance quality control on production line across multiple industries, including pharmaceuticals and manufacturing. By employing real-time image processing and machine learning algorithms, the system can detect defects with high precision and remove faulty items efficiently, leading to improved product quality, reduced waste and operational efficiency. While this design meets essential quality control needs, it presents opportunities for further refinement, such as resolution imaging and integration with other systems like weight checking and metal detection. The project is a cost effective solution that holds potential for future scalability and customization to meet evolving industry requirements.

The Automatic Rejection System designed in this project integrates cutting-edge machine vision and machine learning technologies to improve quality control processes in production lines.

The system's ability to identify and reject defective products in real-time significantly reduces human error, lower labor costs, and enhances overall production efficiency only conforming the products reach the end of the line. The versatile system is adaptable to various industries, such as food processing and manufacturing and can be easily integrated with other quality control mechanisms like metal detection and weight checking.

In conclusion, this projects offers a robust, cost-effective solution for improving product quality on industrial production lines. With further development, it could become an even more comprehensive tool for advanced quality assurance and operational efficiency.

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