IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Smart Job Dispenser System With Quality Check Using Image Processing

Vaishnavi Kumbhar[1], Prajakta Kokane[2], Suhana Ambi[3], Amruta Balulgid[4], Rohini Bandgar[5]

Student[1], Student[2], Student[3], Student[4], Student[5]

Department of Electronics & Computer Engineering[1,2,3,4,5]

Sharad Institute of Technology, College of Engineering-Yadrav, Ichalkaranji, India

Abstract: In today's rapidly evolving manufacturing industries, efficiency, quality control, and accountability are key factors driving competitiveness. Traditional job distribution and quality verification processes are largely manual, which often leads to errors, reduced productivity, and defective products. This thesis proposes a Smart Job Distribution and Quality Verification System leveraging Raspberry Pi, Arduino, RFID technology, and machine vision (OpenCV). The system automates raw job allocation to operators, enforces accountability, verifies product quality in real-time, and maintains a digital log of operations. The project aligns with Industry 4.0 principles, reducing human dependency, improving transparency, and minimizing defective output.

Keywords **-** Raspberry Pi, Arduino Uno, RFID, Image Processing, Quality Check.

I. INTRODUCTION

In modern manufacturing industries, particularly mechanical job-oriented production lines, efficiency and accuracy are critical for sustaining competitiveness. Traditional practices often involve manual job allocation to operators and manual inspection of job quality. While these methods are inexpensive to implement, they frequently lead to human errors, delays in production, lack of accountability, and an overall decline in productivity. With the emergence of **Industry 4.0**, industries are shifting towards digitalization, where smart systems powered by IoT, machine vision, and automation replace manual processes.

1.1 Need for Automation in Mechanical Job Manufacturing:

Mechanical workshops and job manufacturing units handle hundreds of repetitive tasks daily, such as machining, shaping, drilling, and part assembly. Assigning these tasks manually not only consumes supervisory time but also introduces bias, errors, and inconsistencies. Furthermore, without strict accountability, operators may mishandle jobs, lose components, or submit incomplete work, which directly impacts customer satisfaction and company reputation. Automation helps overcome these limitations.

1.2 Overview of Industry 4.0 and Smart Manufacturing:

Industry 4.0 refers to fourth industrial revolution, where cyber-physical systems, where big data, cloud computing, IoT and cyber-physical systems are integrated into manufacturing. Smart manufacturing focuses on predictive maintenance, decision-making and real-time monitoring to ensure maximum efficiency. In this context, the proposed Smart Job Distribution and Quality Verification System fits perfectly into the Industry 4.0 framework. By using a **Raspberry Pi** as a master controller for data processing, **Arduino** for hardware control, **RFID for operator identification**, and **OpenCV for image-based quality verification**, the system enables a transition from traditional workshops to smart digital factories. It ensures transparency, reduces downtime, and maintains a high standard of quality—all of which are core principles of Industry 4.0.

II. Related Work

2.1 Review of RFID in Industrial Applications:

Review of RFID in Industrial Applications is an important aspect of the proposed Smart Job Distribution and Quality Verification System. This section elaborates on how it contributes to solving the industrial challenges faced in manufacturing. Relevant examples, theoretical explanations, and technical insights are provided to strengthen the understanding of the system design and implementation.

2.2 Quality Control Machine Vision:

Quality control Machine Vision is an important aspect of the proposed Smart Job Distribution and Quality Verification System. This section elaborates on how it contributes to solving the industrial challenges faced in manufacturing. Relevant examples, theoretical explanations, and technical insights are provided to strengthen the understanding of the system design and implementation.

2.3 Case Studies of Smart Manufacturing:

Case Studies of Smart Manufacturing is an important aspect of the proposed Smart Job Distribution and Quality Verification System. This section elaborates on how it contributes to solving the industrial challenges faced in manufacturing. Relevant examples, theoretical explanations, and technical insights are provided to strengthen the understanding of the system design and implementation.

2.4 Research Motivation and Gap Analysis:

Research Motivation and Gap Analysis is an important aspect of the proposed Smart Job Distribution and Quality Verification System. This section elaborates on how it contributes to solving the industrial challenges faced in manufacturing. Relevant examples, theoretical explanations, and technical insights are provided to strengthen the understanding of the system design and implementation.

III. Problem Statement

Mechanical industries face challenges such as unorganized job distribution, a lack of operator accountability, and manual job quality inspection[5]. These issues lead to inefficiencies, reduced productivity, and higher rates of defective outputs[6]. There is a strong need for an automated solution that ensures systematic job allocation, operator accountability, and accurate quality verification with digital record keeping[7].

- Issues in Manual Quality Verification
- Impact of Lack of Accountability
- Need for Integrated Automation Solution

IV. Objectives

Primary goal of this project is to create an automated and intelligent system for job distribution and quality verification in mechanical manufacturing. The system aims to automate the allocation of raw jobs using **RFID-based authentication** for operators. It enforces **accountability** by ensuring operators return all jobs before receiving new ones. A key objective is the integration of a **Raspberry Pi** and an **Arduino** for a robust, two-tiered control system. The project also uses **OpenCV** for real-time quality inspection and maintains a **digital log** of all transactions. Ultimately, it seeks to improve productivity and reduce defects by minimizing human error.

V. Proposed System

The proposed Smart Job Distribution and Quality Verification System is designed to automate and streamline the manufacturing workflow. The system's core architecture relies on the collaboration between two main controllers: a **Raspberry Pi** and an **Arduino Uno**. The Raspberry Pi serves as the high-level master controller, managing complex tasks like operator authentication via an RFID reader, processing user inputs from a keypad, and logging all transaction data to a database. Most importantly, it uses **OpenCV** to perform sophisticated image processing on captured images from a USB camera, a critical step for automated quality verification. The Arduino Uno, on the other hand, acts as the dedicated hardware controller, handling all real-time, low-level tasks. It directly manages the conveyor belt's DC motor using a relay module, reads from sensors for accurate job counting and presence detection, and controls the LCD display and a buzzer for immediate feedback. These two controllers communicate through a serial connection, with the Raspberry Pi sending commands to the Arduino for hardware execution and the Arduino reporting back status updates. This division of labor ensures that the Raspberry Pi can focus on complex data and logic, while the Arduino provides reliable, real-time control of the physical components, making the entire system robust and efficient for an industrial environment.

5.1 Role of Raspberry Pi (Master Controller):

The **Raspberry Pi** serves as the **master controller**, handling the system's high-level logic and complex processing tasks. It is responsible for validating operator RFID credentials against a digital database, managing the data logs of all job transactions, and executing the sophisticated **OpenCV** image processing for quality verification. In this role, the Raspberry Pi effectively solves the challenge of manual record-keeping and subjective quality checks.

5.2 Role of Arduino Uno (Hardware Controller):

The **Arduino Uno** acts as the dedicated **hardware controller**, managing all real-time interactions with the physical components. It receives commands from the Raspberry Pi and precisely controls the conveyor belt's **DC motor**, reads data from the RFID & keypad, and provides immediate feedback to the operator via the **LCD display and buzzer**. This division of labor allows the Arduino to focus on the time-sensitive tasks of controlling and monitoring hardware, ensuring a reliable and rapid response.

5.3 Communication Between Units (UART/USB):

To enable this collaboration, the two units communicate via a robust **UART/USB serial connection**. The Raspberry Pi sends commands, such as "start motor" or "check sensor," to the Arduino, which then executes the instruction and reports back the status. This communication link is the foundation of the system, enabling the Raspberry Pi's intelligence to control the Arduino's physical actions, thereby automating the entire job distribution and quality verification process to solve critical industrial challenges.

5.4 Block Diagram Representation:

Block Diagram Representation is an important aspect of the proposed Smart Job Distribution and Quality Verification System.

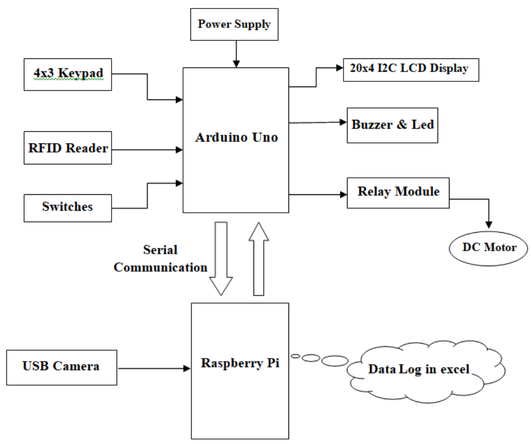

Fig. Block Diagram

VI. Hardware and Software Requirements

1. **Hardware Requirements:**

7.1.1 Raspberry Pi (Master Controller): This single-board computer acts as the system's brain. It processes complex logic such as RFID authentication, runs the OPENCV image processing algorithms for quality control, and manages the database for logging all transactions.

7.1.2 Arduino Uno (Hardware Controller): This microcontroller is responsible for the system's real-time hardware control. It directly interfaces with the various sensors, motors, and displays, executing commands from the raspberry pi.

7.1.3 RFID Reader + Cards: Used to identify and authenticate operators. Each operator is assigned a unique RFID card, which they scan to access the system for job distribution or collection.

7.1.4 USB Camera: Captures images of the jobs as they pass along the conveyor belt. The image data is sent to the raspberry pi for quality inspection.

7.1.5 Relay Module & DC Gear Motor with Conveyor Belt: DC gear motor powers the conveyor belt, moving jobs through the system. A relay module acts as an electronic switch, allowing the Arduino to safely control the high-power motor with its low-power signals.

7.1.6 20x4 LCD Display (i2c): A screen that provides real-time information to the operator, such as system status, instructions, and job counts. The i2c protocol simplifies the wiring, making the setup cleaner.

7.1.7 4x3 Keypad: Allows the operator to input numerical data, such as the number of jobs they need.

7.1.8 Switches for Job Type Selection: These physical switches allow the operator to select the type of job they are working on, helping the system accurately log and categorize the work.

7.2 Software Requirements

7.1.1 ***Raspbian OS / Linux:*** *The operating system that runs on the Raspberry Pi. It provides the necessary environment to run the Python scripts and manage the system's files and network connections.*

7.1.2 **Arduino IDE:** The development environment used to write and upload the control code to the Arduino Uno. This code tells the Arduino how to interact with the various hardware components.

7.1.3 **Python 3 with OpenCV: Python** is the primary programming language for the Raspberry Pi. The **OpenCV** library is a crucial component that provides the tools for real-time computer vision and image processing, allowing the system to automatically inspect job quality.

7.1.4 **SQLite / CSV for Data Logging:** A **SQLite** database or a simple **CSV file** is used to store all the system's data. This includes information on operator IDs, job types, timestamps, and quality statuses, creating a digital log for accountability and analysis.

VII. Methodology

This section details the step-by-step process of the system's operation and the technical principles behind it.

1. **Job Distribution Process (Step-by-Step):** Describe the sequence of events from when an operator scans their RFID card to when the requested number of jobs is dispensed. This should include the roles of the RFID reader, keypad, Raspberry Pi's logic, and the Arduino's control of the conveyor and sensors.
2. **Job Return and Quality Verification:** Explain the process of an operator returning completed jobs. Detail how the ultrasonic sensor triggers the camera, how OpenCV processes the image, and how the system logs the quality status.
3. **Integration of RFID, Sensors, and Camera:** Discuss how these different components are combined to create a cohesive workflow. Explain how the RFID enables accountability, how sensors provide real-time data, and how the camera facilitates automated inspection.
4. **Image Processing Using OpenCV:** Elaborate on the specific techniques used for quality verification. Describe the image acquisition under controlled lighting, the algorithms for defect detection (e.g., edge detection, color analysis), and the logic for classifying a job as "OK" or "NOT OK."

VIII. Implementation

This section covers the practical aspects of building the prototype.

A. Hardware Setup and Interfacing: Describe how all the hardware components were physically assembled and wired. Detail the connections between the Raspberry Pi, Arduino, and all peripherals, including power management.

B. Software Coding and Algorithms: Explain the programming logic and algorithms developed for both the Arduino and the Raspberry Pi. This should cover the code for serial communication, database interaction, and the image processing scripts.

C. Database Management (SQLite/CSV): Detail the structure of the database used to store transaction logs. Explain what data is stored (e.g., Operator ID, Job Count, Timestamp) and how it's used for record-keeping and accountability.

D. Testing and Debugging: Describe the testing procedures followed to ensure the system functions as intended. Discuss the challenges faced during the build and how they were resolved (e.g., calibration of sensors, camera focus issues, communication errors).

E. Snapshots of the Prototype: Include photographs of the completed physical prototype to visually demonstrate the project's result.

IX. Results and Discussion

This section evaluates the system's performance and discusses its broader implications.

A. Performance of Automated Job Distribution: Present data on the system's efficiency and accuracy in dispensing jobs. Compare the time taken by the automated system versus a manual process.

B. Accuracy of Quality Verification: Provide data on the accuracy of the OpenCV-based quality inspection. This could include a summary of the system's success rate in correctly identifying defective products.

C. Challenges Faced During Implementation: Discuss the technical and logistical hurdles encountered and how they were overcome.

D. Comparison with Existing Research: Place your project in the context of the existing body of work. Highlight what makes your system unique or how it improves upon similar concepts found in the literature

X. Applications, Advantages, Limitations, Future Scope

1. Industrial Applications:

This system has wide-ranging applications within mechanical manufacturing and other job-oriented industries. By automating processes, it aligns with **Industry 4.0 principles** and can be implemented in production lines for parts, tools, and consumer goods. The technology is particularly valuable in small to medium-sized enterprises (SMEs) where manual processes lead to significant inefficiency. The system can be adapted for assembly lines, quality control stations, or even as a central inventory management solution, providing a tangible example of a smart factory solution.

2. Benefits of the Proposed System:

Implementing this system offers numerous benefits over traditional manual methods. It dramatically **enhances accountability** by digitally tracking every job an operator handles, eliminating lost or unaccounted-for work. The automated quality verification reduces the rate of defective products by catching faults early and consistently, unlike subjective human inspection. Furthermore, the digital logging provides a transparent, data-driven record of production, which is crucial for performance analysis and continuous improvement. Overall, the system leads to **increased productivity**, lower waste, and a streamlined, error-resistant workflow.

3. Limitations and Possible Errors:

Despite its many advantages, the system has certain limitations and potential sources of error. The accuracy of the image processing is heavily dependent on consistent lighting and clear images, and external factors like dust or uneven lighting could lead to misclassification of products. The system relies on the operator correctly using the RFID reader and placing jobs on the conveyor, introducing a human element that could cause errors. Additionally, the ultrasonic and IR sensors may face challenges with certain materials or environmental conditions, requiring careful calibration to maintain accuracy.

4. Future Scope and Improvements:

The project's design lays the groundwork for several future improvements. The **OpenCV** quality verification could be enhanced using more advanced machine learning models (e.g., neural networks) to detect a wider range of complex defects. The system could be integrated with an **IoT dashboard** (like Node-RED or Things Board) to allow for remote monitoring and real-time alerts. Future iterations could also include a system for automatic sorting of defective products into a separate bin and the implementation of a more robust, cloud-based database to handle larger datasets and provide better security. These improvements would further align the system with the vision of a fully autonomous and intelligent manufacturing environment.

References

[1] Lin, H.-I. & Wibowo, F. S., "Image Data Assessment Approach for Deep Learning-Based Metal Surface Defect-Detection Systems," IEEE Access, 2021.

[2] Wu, W. & Li, Q., "Machine Vision Inspection of Electrical Connectors Based on Improved YOLOv3," IEEE Access, 2020.

[3] He, Z. & Liu, Q., "Deep Regression Neural Network for Industrial Surface Defect Detection," IEEE Access, 2020.

[4] Liu, et al., "Surface Defect Detection of Aluminum Profiles Based on Multiscale and Self-Attention Mechanisms," IEEE Access (paper indexed / referenced online).

[5] "Defect Transformer / Hybrid Transformer Architectures for Surface Defect Detection," IEEE Access (2021).

[6] Rivera, L. et al., "Object Detection Using Deep Learning in a Manufacturing Plant to Support Quality Control," IEEE Xplore (conference/journal paper, 2021).

[7] "Automated Vision Inspection with Conveyor Belt and Rejecting Arm" — IEEE conference / article (document referenced on IEEE Xplore, 2021).

[8] Patel, R. et al., "Leveraging Robust CNN Architectures for Real-Time Object Recognition on Conveyor Belts," IEEE Xplore (2024).

[9] "Deep Transfer Learning for Industrial Automation: A Review and Discussion of New Techniques for Data-Driven Machine Learning Models," IEEE Xplore (2021).

[10] Shu, Y.; Xiong, C.; Fan, S., "Interactive Design of Intelligent Machine Vision Based on Human–Computer Interaction Mode," IEEE (2020).

[11] "Real-Time Locating Systems and RFID for Production Management" — survey paper in Sensors / IEEE-referenced works (includes IEEE citations).

[12] "MQTT / Lightweight IoT Architectures for Shop-Floor Telemetry" — IEEE conference/paper (example case studies demonstrate streaming inspection results to dashboards).