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Automatic Product Counting & Sorting by Conveyor Belt

Md. Sifat Ibna Islam, Md. Riafedul Islam Rifat, Tomal Sarker,
Md. Ahamed Hossain Yousuf, Md. Rakibul Islam
Department of Industrial & Production Engineering
Rajshahi University of Engineering & Technology,
Rajshahi-6204, Bangladesh
ssifatislam@gmail.com, rifat1805060@gmail.com,
himsarker60@gmail.com, Ahamedhossainyousuf10749@gmail.com,
rbn_khan@yahoo.com

Abstract

In the quest for heightened industrial efficiency, the integration of automated product counting and sorting systems with conveyor belts has emerged as a transformative solution. Object sorting, a fundamental process employed across various domains in our daily lives, often suffers from human errors and time-intensive procedures. To address these challenges, the implementation of Low-Cost Automation (LCA) has been introduced to sorting systems, aiming to reduce production time, labor expenses, and processing complexities, while elevating product quality and production rates. This project introduces an innovative approach to automatically sort objects based on their height and accurately count them. The system employs a conveyor belt, DC Gear motor, servo motor, HC-SR04 Ultrasonic sensor, and an LCD display with an i2c converter, all Controlled by an Arduino UNO. Objects traversing the conveyor belt undergo height measurements through an ultrasonic sensor, enabling the Arduino to process the data and activate servo motors for sorting according to pre-defined height categories. The study successfully demonstrates the sorting and counting of objects with distinct sizes, showcasing the potential for improved industrial automation and efficiency.

Keywords
Conveyor Belt, Product Counting, Product Sorting, Automatic Conveyor Belt, Cost Reduction

1. Introduction
In the era of automation and efficiency, industries are increasingly turning to innovative solutions for streamlined processes. Automatic product counting and sorting systems, integrated with conveyor belts, have emerged as a game-changer. These systems leverage advanced technologies like sensors, and Arduino to accurately count and categorize products as they move along the conveyor belt. Manual error and time-consuming problems are one of the main factors when counting and sorting a product. Relying on manual counting and sorting can lead to human errors, such as miscounts, incorrect categorization, or misplaced items. Making an automatic conveyor belt system can reduce this manual error and time-consuming problem efficiently and effectively. Komol (2017) suggested the design and construction of a conveyor belt system that sorts products based on color. The system aims to achieve efficient separation using color detection technology, contributing to automated industrial processes. Janwe and Sonawane (2021) introduce a semi-automatic sorting system.

The study outlines a solution for sorting tasks through a combination of manual and automated processes, demonstrating its potential applicability in various industries. Thike and San (2019) investigated the design and development of an automatic color sorting system. The study focuses on the technical aspects of implementing a system that can accurately sort objects based on their colors, enhancing industrial efficiency. Kheman and Ramthirth (2023) suggested the design and development of an automatic color sorting system. The research emphasizes the practicality of such systems in improving production processes through accurate color-based sorting. Nuvaand Ahmed (2022) presented a object sorting system by integrating Low-Cost Automation (LCA) to streamline the process 1 based on color and weight. By incorporating components like load cells, color sensors, and motors, the system effectively identifies and segregates objects, reducing manual labor and enhancing production efficiency. Bhamre and Deshmukh (2023) introduced an Arduino-based bottle sorting machine that efficiently categorizes used glass bottles by brand through automated height and color detection using proximity and color sensors. The system employs a conveyor belt and a rotary actuator for precise sorting, while an integrated LCD keeps count of sorted bottles. Babu and Vardhini (2020) suggested automated solution utilizing a TCS3200 color sensor to sort objects according to predefined standards. By analyzing color frequencies from the sensor output, the proposed system effectively identifies colors, using chutes for placement and movement controlled by Audrino Nano. The Primary Goal of our study is to design a system that can sort the objects according to their height using an ultrasonic sensor. To fabricate the system for simultaneous sorting according to the predefined height of the object and also keep count of the sorted object. Some scopes while designing this system are: in the food processing industry, sorting and packaging the products, scaling and classification of agricultural goods, pharmaceutical businesses, assembling the same size products in one packing box, and where risky and repeated task is involved.

1.1 Objectives
The objectives of study are to count products automatically, sort products automatically by conveyor belt.

2. Literature Review
Bickman (1996) developed a system where products are sorted automatically by color-sorting. Doud (2007) applied color sensor in his automated system where products are sorted by the color. Abdulla and Sahna (2016) developed a system where products are sorted by using TCS230 Color Sensor and PIC Microcontroller. Aruna and S (2015) made a automated convey system by using PLC and HMI. The automatic counting and shorting of products in manufacturing and distribution processes play a vital role in ensuring efficiency and accuracy. Conveyor belt systems equipped with automated counting and shorting mechanisms offer significant advantages in terms of streamlining production, reducing labor costs, and minimizing errors. This literature review aims to explore the existing research and developments in automatic product counting and shorting conveyor belt systems. Discusses the need for Low-Cost Automation (LCM) in industries to accurately count products due to the increased production rate. Human errors in counting are not tolerable in fast-paced industries. To address this, an LCA system has been developed using an ultrasonic sensor. The system counts paper bundles on a conveyor belt and automatically records the count as a software entry using Node MCU (Komol and Podder 2017).

Kamboj and Diwan (2019) introduced an automated sorting method for industrial products based on their height, employing a diffused beam type photo-electric sensor for comparison. The system utilizes a conveyor belt to segregate items meeting a specific height criterion. The conventional manual sorting issues of sluggishness and inaccuracies are addressed through a programmable logic controller (PLC). The aim of these systems is to automate the sorting process of products based on specific criteria, reducing manual labor and improving accuracy. It introduces a PLC-based sorting system that utilizes pneumatic cylinders and color sensors. A conveyor belt carries the products, and the color sensor identifies the color of each product. The color sensor sends a signal to the PLC, which activates the respective pneumatic cylinder to push the product into the appropriate collection ` 14 station. This automation aims to overcome the difficulties and inconsistency associated with manual sorting. The paragraph concludes by stating that the working prototype, based on color detection and controlled by a PLC microcontroller, promises to meet the requirements for increased production and precise quality in the field of automation (Thike and San 2019). Describes a new method proposed in a paper for determining the number of products in images captured by a mobile robot's camera. The method is particularly useful for assessing stock levels in retail stores. Unlike existing approaches that provide approximate counts, this method accurately computes the exact number of products by using bounding boxes and removing them from the image.

Additionally, a grid-based search is conducted to detect missed products, utilizing various information such as histogram matching and spatial location. The effectiveness of this approach is demonstrated through experiments with the robot and mobile phone cameras, suggesting that it could replace manual stock assessments in retail stores (Janwe and Sonawane 2021). Hussain and Shukla (2021) presented an automated sorting solution using a TCS3200 color sensor and Arduino. The system efficiently categorizes colored objects, improving accuracy in industrial material sorting. Singh and Rahman (2022) outline an automated conveyor belt system using Arduino, temperature, and ultrasonic sensors to efficiently sort products based on temperature and count them. Kheman and Ramthirth (2023) developed innovative design and development of an automatic color sorting machine on belt. The literature review highlights the significance of automatic product counting and shorting conveyor belt systems in enhancing manufacturing and distribution processes. Various technologies and methodologies, including image processing, machine vision, sensor-based detection, and intelligent control systems, have been explored to achieve accurate counting and efficient product sorting. The integration of these systems, along with performance evaluation and optimization techniques, paves the way for improved productivity, reduced labor costs, and minimized errors in industrial settings. Future research should focus on addressing challenges related to complex product shapes, increased system scalability, and the integration of emerging technologies like the Internet of Things (IoT) and artificial intelligence to further advance automatic counting and shorting conveyor belt systems. Rallabandi and Yanda (2023) introduced a cost-effective Color Sensing Punching Machine for sorting goods based on color, by using a single conveyor equipped with a color sensor instead of multiple conveyors of different hues, efficiency gains are examined.

3. Methods

In this project, an automatic product counting and sorting system is constructed using a cardboard box, white cork sheets, an ultrasonic sensor, Servo motors, a Gear motor, an LCD display with I2C converter, Arduino, batteries, and necessary wiring. The cardboard box was used to create a functional conveyor belt with rollers, build stable supporting frames using white cork sheets for the conveyor and height measurement structure, attach the ultrasonic sensor above the belt securely to measure product height, design a sorting system using servo motors, connecting the LCD display and I2C converter to show product counts. All of the hardware equipment was attached above the conveyor belt. Arduino has controlled the whole system. A power supply has been provided through the adapter to activate the sorting system.

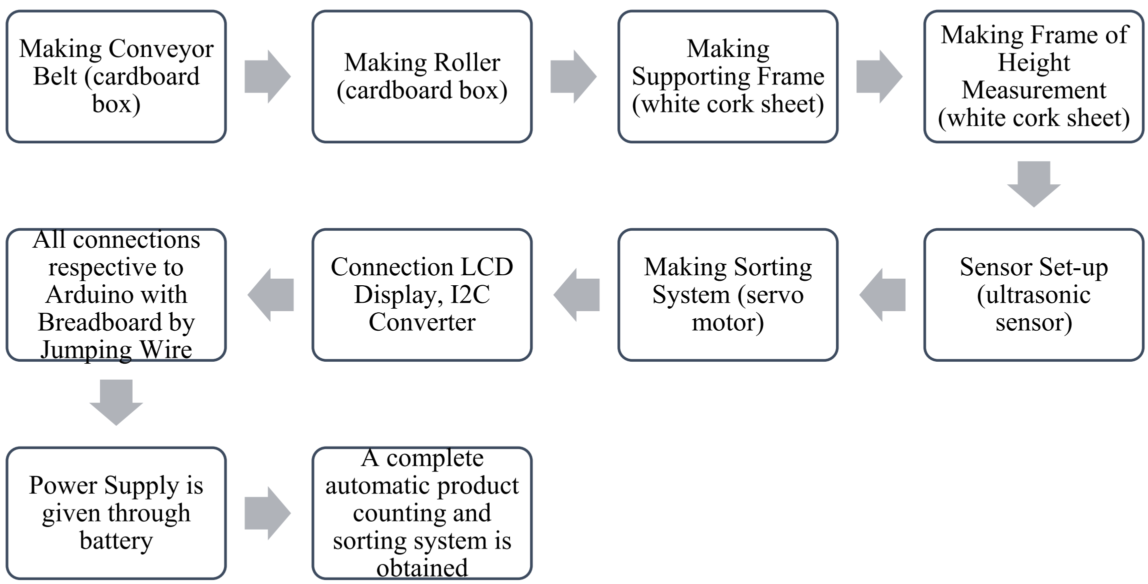

Figure 1. Schematic Diagram of the Whole Process

Design and Construction of Conveyor Belt

Conveyor belt systems have a wide range of applications in manufacturing, warehousing, food processing, packaging, and heavy industry. By automating material handling, it increases efficiency, productivity, and cost savings. It optimizes operations to meet changing industry demands through accuracy, safety, customization, and scalability. The conveyor belt system's design and construction involve a series of steps aimed at creating an efficient and functional automated product handling setup. The system's design begins with the selection of materials such as a cardboard box and white cork sheets. Within the cardboard box, the conveyor belt is assembled, with rollers for smooth movement. To ensure the stability of both the conveyor and the height measurement components, supporting frames are constructed from white cork sheets. The ultrasonic sensor, which is used for measuring distance from the sensor to the object, is securely mounted on frame above the belt. A sorting system is also designed using servo mechanism to sort products based on predefined height. The LCD display with I2C converter are integrated into the design to show the count of products. All the components are wired together and connected to the Arduino Uno to control the system.

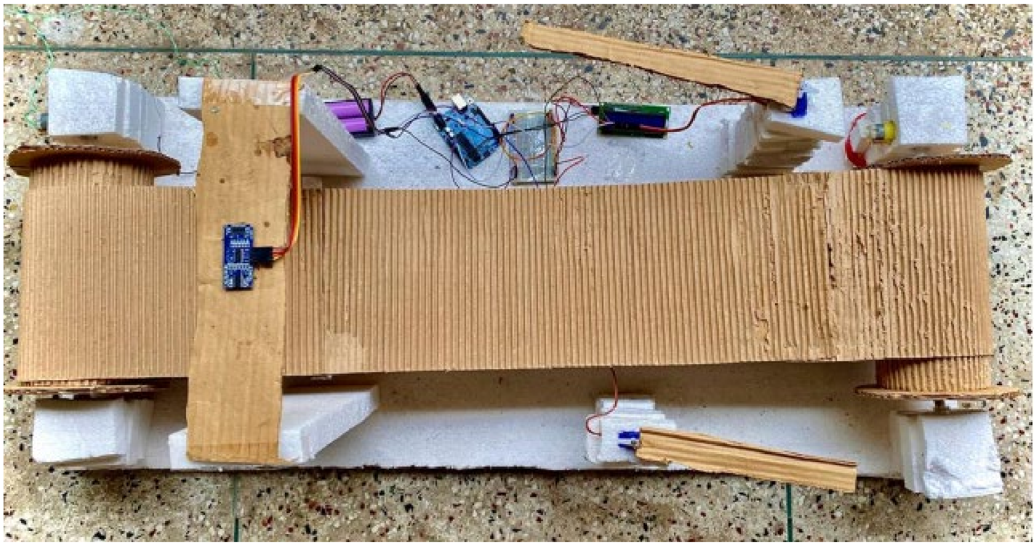

Figure 2. Conveyor Belt

Development of Mechanical Structure

White cork sheets are used to construct supporting frames. At the very beginning of the conveyor belt, the ultrasonic sensor is adjusted above the belt to measure the height from the sensor to the object, and the servo motor is placed adjacent to the conveyor belt for sorting the products and pushing them away from the belt. A gear motor is used for rotating the belt. An LCD display with an i2c converter is used for showing the product count which is placed on the belt. All of the system is connected to Arduino UNO. The different sizes of products is used to test the system.

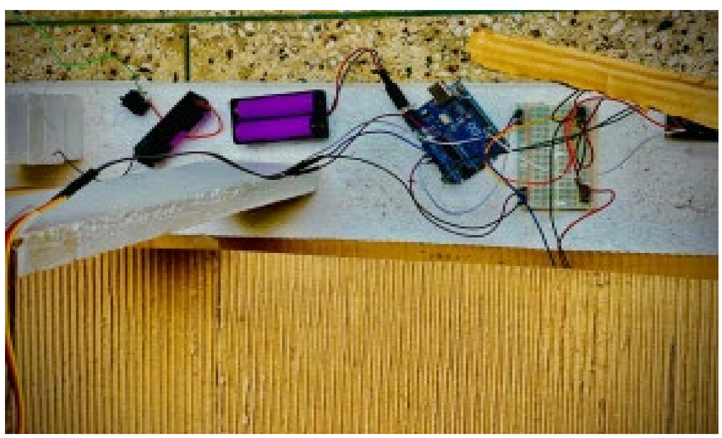

Figure 3. Components and circuit

Electrical System Development

Three 3.7V battery is used to power supply the whole system. Two 3.7V battery through the power adapter is used to activate the sorting system, ultrasonic sensor and LCD display and Audrino. Here, sensors are input, and motors are output for Arduino.one 3.7V battery was used separately to run the conveyer belt with a gear motor.

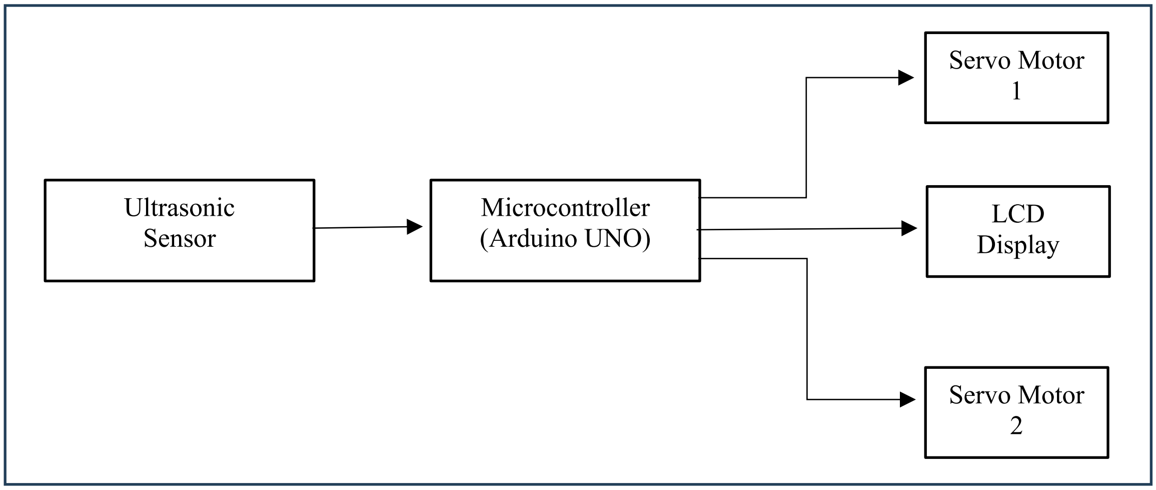

Figure 4. Block Diagram of Counting & Sorting System

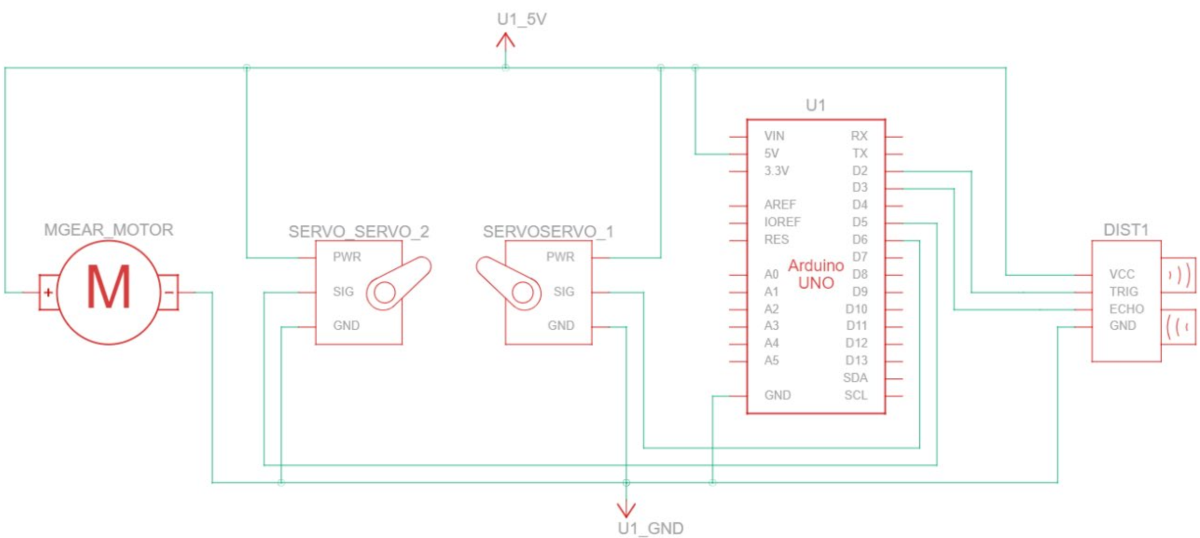

Figure 5. Circuit Diagram

Fig 5 shows he circuit diagram of proposed system. Our system has been built by following this circuit.

Working process for product counting and Sorting

Generally, the working process of the systems can be seen in Figure 10. The explanation is as follows. At first, the power supply was given through the adapter, and pressed the button for initialization of the system. Subsequently, the LCD screen initializes and displays the project as shown in Figure 11. Secondly, the objects of different Sizes are placed onto the moving conveyor belt. As each object passes under the ultrasonic sensor, its distance from the sensor is measured. Then, the response of the ultrasonic sensor is transmitted to the Arduino Uno. So, the objects are propelled along the conveyor belt. The system also incorporates two servo motors that are linked to the Arduino Uno. When the measured distance from the ultrasonic sensor falls within the predefined range, one of the servo motors is activated. Specifically, if the measured distance ranges between 1 and 8, servo motor 1 rotates by 90 degrees. Alternatively, if the distance falls between 12 and 16, servo motor 2 rotates by 90 degrees, facilitating the removal of products from the conveyor belt. In cases where the distance measured by the ultrasonic sensor does not correspond to the desired ranges, no servo motors are activated. The LCD display, connected to the Arduino Uno, provides a visual representation of the product count with each movement of the servo motors.

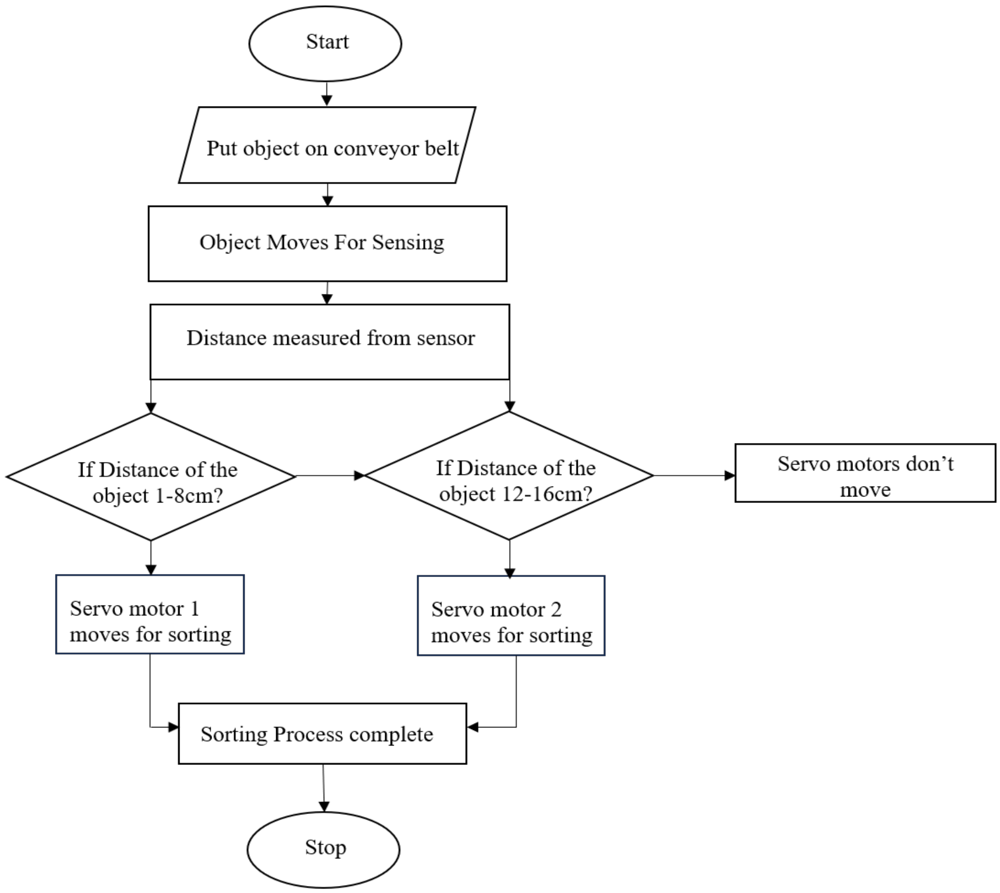

Figure 6. Flow Chart of the sorting process

4. Data Collection

Upon completing the conveyor belt system, we conducted 12 trials to evaluate its performance and determine its accuracy. Each trial involved measuring object heights, sorting them based on predefined categories using servo motors, and counting the items. The results demonstrated consistent sorting accuracy and reliable measurements, showcasing the system's efficiency and precision in automating object sorting processes for industrial applications.

4.1 Data Analysis

he collected data from the trials was analyzed using Excel to evaluate the system's performance. This analysis focused on determining the accuracy of height measurements and sorting processes. The results highlighted the system's ability to consistently achieve high accuracy in both aspects, validating its effectiveness as a reliable and efficient solution for automated object sorting and counting applications.

5. Results and Discussion

This project of automatic product sorting and counting is an excellent one because of its working principle and wide implementation. Also, the cost of building this prototype project is very low. By applying the idea of this project an industry can easily sort the required product according to product height. The outcomes are overwhelmingly favorable.

5.1 Numerical Results

Table 1. Measurement of Height and Movement of motor

SL NO	Object	Movement of Motor	Height Measured (cm)
1	Size-1	Motor-1	4.71
2	Size -2	Static	8.32
3	Size -3	Motor-2	14.5
4	Size-1	Motor-1	4.81
5	Size-3	Motor-2	14.41
6	Size -2	Static	9.62
7	Size-1	Motor-1	5
8	Size-3	Motor-2	14.72
9	Size -2	Static	10
10	Size-1	Motor-1	5
11	Size-2	Static	9.32
12	Size-3	Motor-2	15

Table 1 details the performance of a sample sorting system designed to categorize objects by their heights. Objects of three distinct sizes, Size-1, Size-2, and Size-3 are subjected to height measurements via ultrasonic sensors, and their sorting is controlled by motors. The table showcases actual and measured heights, motor movements, and accuracy percentages for both height measurement and sorting. The accuracy of height is remarkably high, with measurements typically within 96-100% accuracy.

5.3 Proposed Improvements

Table 2. Accuracy of height and sorting

SL NO	Object	Actual height (cm)	Movement of Motor	Height Measured (cm)	Accuracy of Height (%)	Accuracy of Sorting (%)
1	Size-1	5	Motor-1	4.71	94.20	100
2	Size -2	10	Static	8.32	83.20	100
3	Size -3	15	Motor-2	14.5	96.61	100
4	Size-1	5	Motor-1	4.81	96.20	100
5	Size-3	15	Motor-2	14.41	96.01	100
6	Size -2	10	Static	9.62	96.20	100
7	Size-1	5	Motor-1	*5*	100.00	100
8	Size-3	15	Motor-2	14.72	98.13	100
9	Size -2	10	Static	10	100.00	100
10	Size-1	5	Motor-1	*5*	100.00	100
SL NO	**Object**	**Actual height (cm)**	**Movement of Motor**	**Height Measured (cm)**	**Accuracy of Height (%)**	**Accuracy of Sorting (%)**
11	Size-2	10	Static	9.32	93.20	100
12	Size-3	15	Motor-2	15	100.00	100

The 100% sorting accuracy ensures precise categorization of objects, based on their measured heights. There are two motors that activate, according to the signal coming from the Arduino, which is programmed by two sizes, 1-8 cm for motor-1, and 12-15 cm for motor-2. If the object size stands in the range of 8cm¡object size¡12cm, no motor will be activated and it will pass through the conveyor belt, which is called a static situation. This data underscores the system's effectiveness in automating the sorting process with precision. Accuracy comparison across different sizes is given in Figure 7. The figure shows that the sensors were able to detect the height of different sizes very accurately.

This table presents data for sorting accuracy and height measurement for objects of different sizes. It includes actual and measured heights, motor movements (Motor-1 or Motor-2), and accuracy percentages. The table demonstrates consistent sorting accuracy (100%) and varied height measurement accuracy, highlighting performance variations for different object sizes and motor movements.

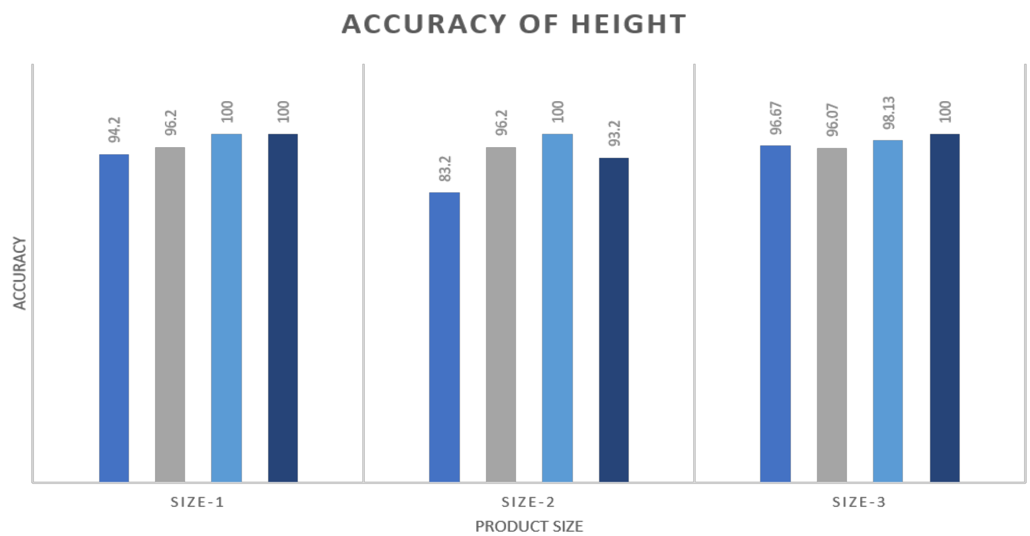

Figure 7. Accuracy Comparison Across Different Sizes

6. Conclusion

In the dynamic realm of industrial manufacturing, precision and efficiency have taken center stage. Seamlessly managing the product journey, from raw materials to the final output, Therefore, the idea of an automated system for categorizing products based on their dimensions is advantageous for big, mass-producing businesses. With this invention, higher production rates, more uniformity, cheaper labor costs, fewer mistakes, and simplified material handling are all promised. Thus, the proposition of an automated product sorting system based on dimensions stands promising for large-scale, mass-producing industries. This innovation promises escalated production rates, heightened consistency, lowered labor costs, diminished errors, and streamlined material handling. The cost of implementing this prototype in industries is very cheap. By intelligently separating items by size and packaging, it simplifies operations, aligning with mechanical and electrical finesse via Arduino, servo motors, and sensors. This system not only saves resources but also suits diverse industries, a testament to its simplicity and efficiency. Ultimately, this sorting solution is poised to shape industries and contribute to national economic advancement.

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Biographies

Md. Sifat Ibna Islam is a graduate student at Rajshahi University of Engineering & Technology (RUET), achieved a degree in Industrial and Production Engineering. He is passionate about machine learning and focuses on developing models to improve supply chain management and additive manufacturing. His work focuses on developing machine learning models for supply chain and additive manufacturing.

Md. Riafedul Islam Rifat is a student of the Department of Industrial & Production Engineering at Rajshahi University of Engineering & Technology, Rajshahi-6204, Bangladesh. Major academic courses include Operations Research, Probability and Statistics, CAD/CAM, Computer Integrated Manufacturing (CIM), Environment and Project Management, Measurement and Instrumentation, Project Management and Legal Issues, and Industrial Management.

Tomal Sarker is a student of the Department of Industrial & Production Engineering from Rajshahi University of Engineering & Technology (RUET), located in Rajshahi-6204, Bangladesh. His core areas of study encompassed subjects like Operations Research, Statistical Analysis, CAD/CAM, Advanced Manufacturing Systems, Environmental Management, Instrumentation Techniques, Legal Aspects of Project Management, and Industrial Operations Management.

Md. Ahamed Hossain Yousuf is a student of the Department of Industrial & Production Engineering at Rajshahi University of Engineering & Technology, Rajshahi-6204, Bangladesh. His core areas of study encompassed subjects like Operations Research, Environmental Management, Instrumentation Techniques, Legal Aspects of Project Management, and Industrial Operations Management.

Md. Rakibul Islam is an Assistant Professor, who received the University Gold Medal at RUET's 5th Convocation (2019) and the Queen Elizabeth Scholarship at the University of Regina, Canada. A former lecturer at MIST (2015-2017), he teaches courses in Operations Research, CAD/CAM, Project Management, Industrial Management, and related fields. Currently, he is in America for his Ph.D. degree.