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Automation of Fruit Sorting Process Using Conveyor Belt System

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Abstract: Fruit sorting is an important step in the fruit industry since it ensures that only high-quality fruits are sold. Manual sorting takes time, is labour-intensive, and is prone to human error. The use of a conveyor belt system with machine vision to automate the sorting process can increase the efficiency and accuracy of fruit quality sorting. This study describes the design and execution of a conveyor belt system for sorting fruit quality using machine vision. The approach is intended to sort fruits based on their appearance, such as colour, size, and form. The machine vision system is trained using a collection of photos of variable quality fruits, allowing it to differentiate between high-quality and low-quality fruits. The conveyor belt system is made up of a motor, sensors, and a camera that takes pictures of the fruits as they move along the belt. The machine vision system processes the photos in real time, determining the quality of each fruit and directing it to the right bin. The precision, speed, and efficiency of the system are all measured. The technology looks potential for increasing the efficiency and accuracy of fruit quality sorting in the fruit sector.
Keywords: fruit sorting, conveyor belt system, machine vision, quality control, automation, image processing

I. INTRODUCTION

Fruits are separated according to their size, shape, colour, weight, texture, and ripeness during the process of fruit sorting. This is a crucial stage in the post-harvest management of fruits since it ensures that only fruits of excellent quality are sold, while the defective or subpar fruits are thrown away or used in processing. Fruit sorting can be done by hand or with a machine's assistance. Using human labour to manually sort the fruits according to visual inspection is a classic technique. However, this approach is labour- and time-intensive, and it is challenging to get reliable sorting outcomes. Contrarily, machine sorting is a contemporary technique that sorts fruits using a variety of sensors and algorithms. The algorithms can utilise this data to sort the fruits based on predefined criteria. These sensors can identify several fruit attributes such as size, shape, colour, weight, texture, and maturity. Fruit sorting is widely employed in the fruit industry, particularly for fruits like apples, oranges, grapes, and strawberries that are gathered in enormous quantities. It contributes to fruit quality and safety improvement, waste reduction, and production process efficiency.

II. LITERATURE REVIEW

Fruit sorting is a crucial step in the fruit industry since it makes sure that only fruits of the highest calibre are sold. Traditional fruit sorting techniques are frequently laborious, labour-intensive, time-consuming, and error-prone. There has been a noticeable shift towards automating the fruit sorting process using conveyor belt systems with machine vision as a result of improvements in automation and machine vision technologies. In their research, Dhok, S., Gautam, A., Patel, V., & Tiwari, A.[1] used a conveyor belt and machine vision to construct an automated fruit sorting system. Fruits were categorised using a combination of colour and shape-based criteria. The system managed to sort fruits at a rate of up to 400 per minute with a 95% accuracy. The study showed how automated fruit sorting might be accomplished using machine vision. A fruit quality identification system based on a conveyor belt and deep learning algorithm was proposed in a different study by Liu, Y., Zhang, Z., Liu, X., & Wang, X [2]. When it came to identifying fruit flaws including bruising, rot, and insect infestation, the system had a 92% accuracy rate. The study emphasises how deep learning algorithms may increase the precision of fruit quality sorting. Zhang, Y., Zhang, X., Zhang, L., & Yang, J. [3] proposed a fruit quality rating system based on a conveyor belt and machine vision in a study that was similar to this one. To rank fruits according to their outward appearance, the approach combines parameters based on colour and texture. The system graded apples with an accuracy of 95%, highlighting the promise of machine vision in judging fruit quality. Li, J., Wei, J., Sun, Y., Wang, S., & Zhang, Y. [4] reviewed the state-of-the-art developments in machine vision-based fruit sorting. They came to the conclusion that fruit sorting systems based on machine vision have the potential to considerably increase the speed and precision of the procedure.

The literature suggests that a promising approach to automating the fruit sorting process is the combination of conveyor belt systems with machine vision. The research shows how machine vision has the potential to increase fruit quality sorting efficiency and accuracy.

III. METHODOLOGY

A. Description of the Fruit Sorting Conveyor Belt System

The following elements make up the proposed conveyor belt and machine vision fruit quality sorting system:

1) *Conveyor Belt System:* Fruits are transported along a belt using a conveyor belt system. The system includes a camera, sensors, and a motor that moves the fruits along the belt while taking pictures of them.
2) *Image Acquisition:* The camera continuously records photos of the fruits. To make sure that all of the fruit's sides are visible, the pictures are taken from various angles and situations. The machine vision algorithm then processes the photos in real-time.
3) *Machine Vision Algorithm:* This algorithm examines photos of fruit and determines the fruit's external features, including colour, size, and form. The system can discriminate between high-quality and low-quality fruits because it was trained using a dataset of photos of fruits of various quality.
4) *Fruit Sorting:* Based on their outward characteristics, the fruits are categorised by the machine vision algorithm, which also assigns them to the proper bins according to their quality. Fruits of various qualities can be collected using varied configurations of the containers.

The suggested methodology entails using a dataset of fruit photos with known quality levels to train the machine vision system. Machine vision algorithms learn to discriminate between high-quality and low-quality fruits based on the external characteristics of the fruits after the photos are labelled according to their quality level. Fruits are loaded onto the conveyor belt during operation, and the camera records photos of the fruits as they move along the belt. The machine vision system analyses the photos in real-time and classifies the fruit according to its quality level and external attributes. Depending on its quality level, the fruit is subsequently directed to the proper bin. The proposed methodology is anticipated to decrease labour expenses and human errors while increasing fruit sorting process accuracy and efficiency.

B. Quality Metrics used for Sorting

Machine vision is utilised to sort fruits on a conveyor belt system based on size and faults, two crucial quality indicators. Here are some specifics on how these fruit sorting criteria are applied:

1) *Size:* Size is a key quality indicator that can impact a fruit's market value, consumer choice, and suitability for various uses including juicing, canning, or fresh eating. Machine vision methods like image processing and machine learning algorithms can be used to measure the size of the fruit. For instance, by measuring the fruit's length, width, and height from various camera angles, the size of the fruit can be ascertained. Computer vision algorithms like contour analysis, edge identification, or deep learning models can be used to analyse the photos of the fruit. To determine whether the fruit should be accepted or rejected, the size measurements might be compared to a predetermined size range or threshold. Based on the particular system needs and the fruit industry's quality standards, the size range or threshold can be modified. For example, a size range of 1.5 to 2 inches may be appropriate for strawberries, whereas a size range of 2.5 to 3 inches may be appropriate for apples. The measures of the sizes can also be used to classify or grade the fruits according to their sizes, such as large, medium, or small.
2) *Defects:* The fruit's quality and shelf life can be greatly affected by defects including cuts, bruising, mould, and insect damage. Machine vision methods like pattern recognition, edge detection, or neural networks can be used to find the flaws. For instance, computer vision algorithms can be used to examine fruit image data to look for flaws like blemishes, stains, cracks, or insect infestation. Using machine learning models like convolutional neural networks, decision trees, and support vector machines, the faults can be categorised according to their type, size, and severity. Depending on the severity of the defects, the fruits can be classified as premium, standard, or reject using the defect classification. The fruit's defect level can also be used to decide if it has to be sorted, trimmed, or discarded after processing.

In conclusion, size and defects are two crucial quality indicators used for sorting fruits using machine vision on a conveyor belt system. To assess the acceptability, grade, and treatment of the fruit, computer vision techniques and machine learning algorithms can be used to analyse the measures of size and defect. The quality and safety of the fruit for customers and the fruit industry depend on the precision, dependability, and consistency of the size and defect measurements.

C. Data Collection and Analysis

Machine vision can be used to collect data and analyse it in a number of processes to sort fruits on a conveyor belt system, including:

1) *Data Collection:* Gathering image data of the fruits on the conveyor belt is the first step in the data collection and analysis procedure. Cameras or other optical sensors positioned at various angles and places along the conveyor belt can be used to record the picture data. To give a complete view of the fruit, the cameras may take pictures of it from various angles.
2) *Data preprocessing:* The next stage is to preprocess the image data to eliminate any noise, artefacts, or distortions that can compromise the analysis's accuracy. In the preprocessing, the contrast, brightness, or colour of the fruit in the image may be improved by the use of image filtering, normalisation, scaling, or other methods.
3) *Feature Extraction:* The third phase is extracting pertinent features from the image data that may be applied to categorise the fruit according to its quality criteria, such as size and flaws. Convolutional neural networks and other machine learning models like contour analysis and edge detection can be used for the feature extraction.
4) *Data Labelling:* The final stage is to provide a quality label to the image data based on factors like size and flaws. The labelling can be carried either manually or automatically using technologies like supervised learning models or item detection algorithms.
5) *Data Analysis:* To establish the acceptability, grade, and treatment of the fruit, the labelled picture data must be analysed using statistical methods, machine learning models, or other approaches. To find patterns, trends, or anomalies in the data, the analysis may use techniques like classification, regression, clustering, or visualisation.

Overall, a mix of hardware and software tools, as well as knowledge of computer vision, machine learning, and fruit quality criteria, is required for the data collecting and analysis approach for sorting fruits on a conveyor belt system utilising machine vision. The quality and safety of the fruit for customers and the fruit industry depend on the precision, dependability, and consistency of the data gathering and analysis process.

IV. BLOCK DIAGRAM

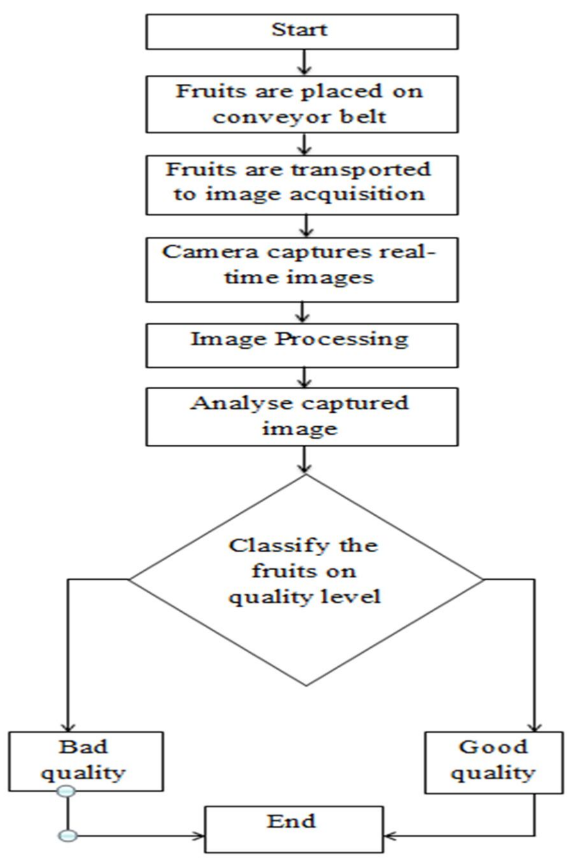

Figure 1. Block diagram of system

The process begins with the placement of the first fruits onto a conveyor belt. The fruits are transported to the picture capturing stage via a conveyor belt. Real-time photos of the fruits are taken during the image acquisition phase. The stage of image analysis is then given the collected images. The recorded images are processed to extract pertinent data and features during the image analysis stage. The fruit quality classification stage is where the processed photos are forwarded after that. The photos are assessed to establish the fruit quality at the classification stage for fruit. Fruit is divided into two categories based on quality: poor quality or good quality. Finally, the classification of fruit quality produces an outcome.

V. WORKING

A. *Conveyor Belt Control*

1) A microcontroller serves as the system's main controller and controls the conveyor belt motors.
2) The conveyor belt's motors receive commands from the microprocessor to start, stop, or modify its speed.
3) The microprocessor provides an instruction to the motors to turn on when the system is turned on, which starts the conveyor belt moving.

B. *Fruit Placement and Infrared (IR) Sensing*

1) Fruits are put on the conveyor belt as it begins to run.
2) The technology makes use of an IR sensor that is placed during the image acquisition process.
3) As fruits get closer to the time for image acquisition, the IR sensor is intended to identify their presence.

C. *Conveyor Belt Stoppage*

1) The microprocessor instructs the motors to stop the conveyor belt after receiving the signal from the IR sensor.
2) In order to ensure that the fruit is still during the image acquisition stage of image capture, the conveyor belt stops.

D. *Real-Time Image Capture*

1) At the image acquisition stage, the conveyor belt is paused while a camera takes a real-time picture of the fruit.

E. *Image Analysis and Processing*

1) The collected image is then subjected to various image processing techniques for processing and analysis.
2) To extract important information from an image, such as colour, texture, and shape aspects, image processing techniques are used.
3) These algorithms can improve the image's clarity, reduce noise, and pinpoint the fruit's essential traits.

F. *Fruit Classification*

1) Fruit categorization is done using the features that were extracted from the processed image.
2) Fruit is categorised as either good quality or bad quality using feature mapping approaches, which may incorporate machine learning or deep learning algorithms.
3) To determine the classification, the algorithm compares the features that were retrieved from the analysed image with pre-defined patterns or training data.

G. *Output and Further Actions*

1) The system decides whether a fruit is categorised as excellent quality or bad quality based on the results of the fruit classification.
2) Depending on the fruit quality, this data may be utilised to initiate additional processes, categorise the fruits into other groups, or issue alerts or notifications.

VI. RESULTS

A. *Classification of Good Quality*

1) When a fruit is labelled as "good quality," the system has successfully identified that it satisfies the required quality requirements with an accuracy of 80–85%.
2) The best maturity, ideal size, appealing colour, and general good condition are likely to be present in these fruits.

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3) According to the categorization accuracy of the system, 80–85% of fruits categorised as "good quality" are actually of a satisfactory quality.

B. Classification of Poor Quality
1) When a fruit is labelled as "bad quality," the system has accurately identified it as not meeting the required quality requirements with an accuracy of 80–85%.
2) These fruits could display unfavourable traits like over- or under-ripeness, bruising, damage, or other flaws.
3) According to the categorization accuracy of the algorithm, 80–85% of fruits categorised as "bad quality" are actually of subpar quality.


Figure 2. Trained Image


Figure 3. Live Image

The above two figures show a trained image and a live image. The live image captured by the camera when compared to the trained image gives us the result that the quality is bad, because the features of live image do not match with the trained image according to the threshold given. Our given threshold is 300000, if value of the live image is less then the threshold the result is good quality and vice versa. Thus, for the result above the value of live image was greater than threshold thus the result given was that the quality was bad.

VII. ADVANTAGES

Using machine vision to sort fruits on a conveyor belt system has a number of benefits over manual sorting. Some of the main benefits are as follows:
1) *High Accuracy and Consistency:* Unlike manual sorting techniques, the machine vision algorithms utilised in the sorting system can reliably and consistently categorise the fruits based on their quality parameters, such as size and flaws. Higher product quality and a lower chance of human error can both result from this.
2) *Enhanced Productivity:* By processing a lot of fruits quickly, the sorting system can boost productivity and lower labour costs in the fruit manufacturing process. The system can work continuously without rest breaks or tiredness, which can increase the industrial process's efficiency even more.
3) *Greater Safety:* The fruit sector could be safer thanks to the sorting system, which can lower the danger of accidents and injuries related with manual sorting techniques. The technology can also identify and discard faulty or infected fruit, enhancing the consumer safety of fruit-based goods.
4) *Cost-effectiveness:* By eliminating the need for manual labour, the sorting system can lower labour costs and increase the overall cost-effectiveness of the fruit production process. The technology can also decrease waste and increase fruit yield, both of which can increase the cost-effectiveness of the production process.
5) *Scalability:* The sorting system is easily scalable up or down based on production needs, which can give the fruit business more flexibility and adaptability. The system may also be modified to fulfil the unique sorting specifications of various fruit types, which can increase its adaptability and usefulness to the fruit business.

Overall, employing machine vision to sort fruits on a conveyor belt system has a number of advantages over conventional manual sorting techniques, which can enhance the fruit manufacturing process' quality, efficacy, safety, cost-effectiveness, and scalability.

VIII. FUTURE EXTENSION

The use of machine vision to sort fruits on a conveyor belt system has a number of potential future extensions. As part of these extensions, additional sensors like cameras, lasers, or spectroscopy are integrated in order to offer more thorough and precise data about fruit quality criteria. The system can sort fruits more effectively and dynamically if real-time feedback control techniques like actuator control, decision-making algorithms, or robotic arms are used. The technology may divide fruits into several groups or grades based on their quality parameters by automating the grading process. In the sorting system, predictive maintenance methods like vibration analysis, acoustic monitoring, or thermal imaging can save downtime and prevent equipment breakdowns. Utilising cloud computing platforms can increase the sorting's scalability, flexibility, and affordability. The sorting system can be made more flexible, scalable, and cost-effective by utilising cloud computing platforms. These additions can improve the system's precision, effectiveness, and dependability while lowering the labour costs, waste, and environmental impact of the fruit sector. Overall, machine vision extensions for fruit sorting on a conveyor belt system have enormous potential to transform the fruit industry.

IX. CONCLUSION

In conclusion, machine vision fruit sorting is a promising technology that can raise the calibre, security, and effectiveness of the fruit sector. To identify the fruits according to their quality criteria, such as size and flaws, the sorting system can make use of a variety of hardware and software resources, such as cameras, sensors, algorithms, and machine learning models. Fruit sorting data collection and analysis comprises a number of phases, including feature extraction, data preprocessing, data labelling, and data analysis. The sorting system's precision, dependability, and consistency are crucial for guaranteeing the fruit's quality and safety for both consumers and the fruit industry. Future improvements in the effectiveness and scalability of the system for sorting fruits using machine vision include the integration of multiple sensors, real-time feedback control, automated grading, predictive maintenance, and cloud computing. Overall, utilising machine vision to sort fruits on a conveyor belt system is a promising innovation that has the potential to revolutionise the fruit business and benefit producers, consumers, and the environment.

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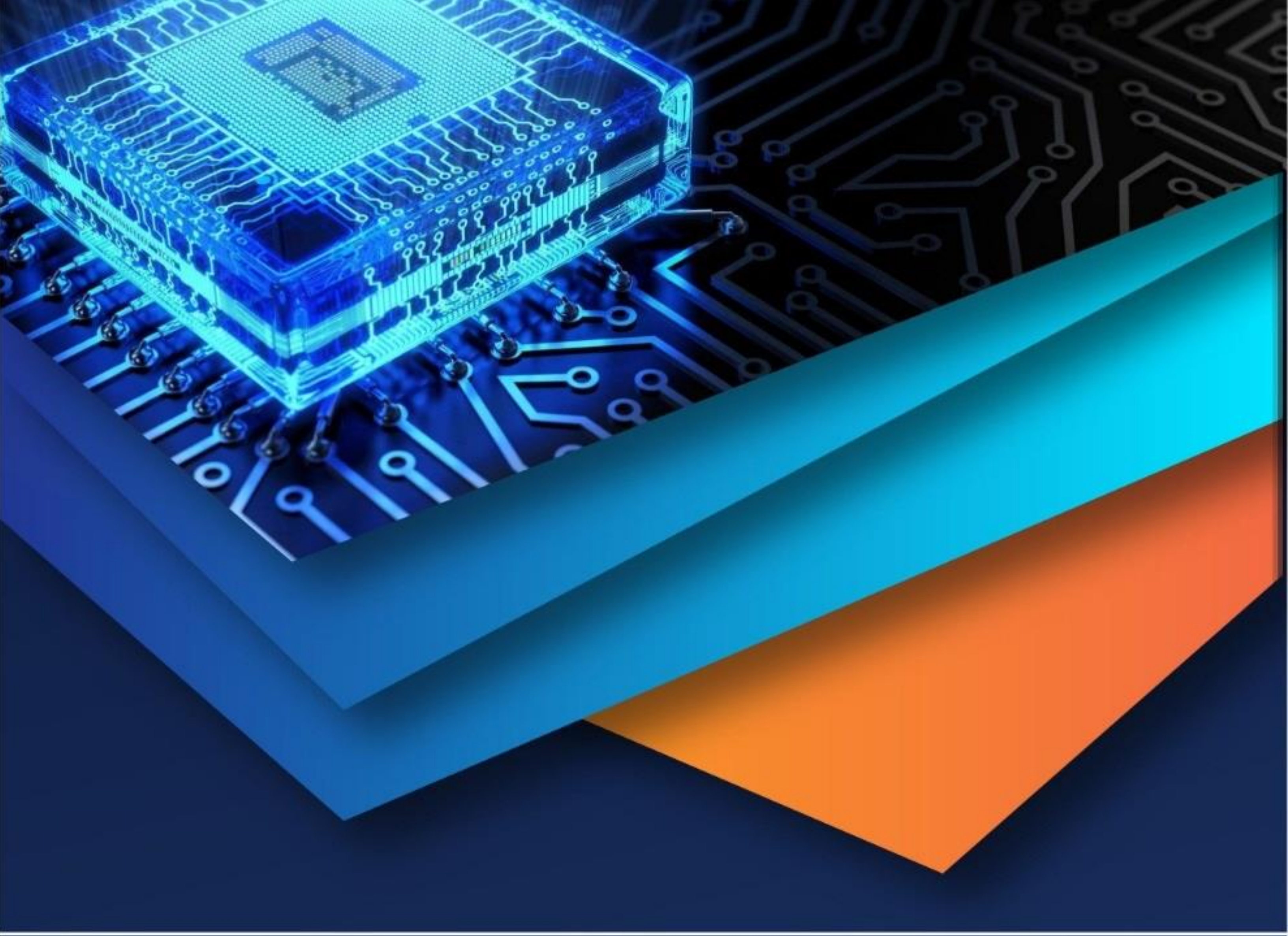

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