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Automatic Sorting Conveyor with Machine Vision for Agriculture and Industrial Applications

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***Abstract*: We know that to export a product or achieve higher quality packing manual sorting is sometimes very inefficient. Machine vision has progressed drastically over the years and has allowed for faster classification of objects without increasing costs. As such, our paper presents the use of an automated conveyor with sensors which classifies the given product based on shape, color, weight and other characteristics. In the paper we use machine vision and various sensors to classify defective products from non-defective. We hope to find the actual feasibility of the system from collecting the dataset, training the dataset and implementing the full system in an actual test case.**

***Keywords*: Sorting, Product Quality, Classification, Sorting Conveyor.**

1. Introduction

Faster production rate at lower costs is the aim of all manufacturing units. Research and Development in this field has been going on for decades. Use of machine learning and Internet of Things based manufacturing are the latest trends in the field. But adoption of the latest trends means of product packaging is slow mainly due to the higher costs that are involved in the same. Sorting of the final products based on quality of huge importance in maintaining international supply chain standards. Machine vision has come a great depth in classification of objects based on their color, size and other feature. The sorting systems used by bigger supply chains are complicated and not easy to be implemented for smaller consumers. This paper identifies whether it is feasible for small scale industries to use complicated machine learning tools at affordable costs. Furthermore the application also extends to agriculture sector where farmers would be able to package their products faster by avoiding manual labor. In the paper we explore the opportunities and feasibility of a conveyor sorting system based on machine vision and sensors in improving the pre-existing methods.

2. Literature Review

Nasiri et. al. [1] studied the possibility of classification of date fruits based on defectiveness. This was done by the use of deep Convolutional Neural Network (CNN). The study was successful in discriminating between defective and non-defective date fruits with an accuracy of 96.68%. The consolation of study was that the CNN model outperformed the traditional classification methods by a considerable margin. Naphade et. al. [2] proposed a conveyor system for oil packing industries for reducing the error in human inspection. The paper proposed the identification of best and low quality end products with the help of density weight relation. The underlying principle of this classification is identifying the weight of the oil case using a load cell and calculating the volume by considering constant density of oil. The proposed system was accurate and human error and time loss was greatly avoided. Nils Boysen et. al. [3] reviewed the global supply chain with an emphasis on the importance of conveyor systems from an operational research perspective. The paper reviewed the present problems, challenges and the future for research in this particular subject.

3. Existing System

The current systems use the principle of manual comparison. In agriculture sector, fruits and vegetables are sorted by people with experience. In industrial sector weights are manually compared to determine the quality of products. These methods are inefficient financially and can be very time consuming. Conveyor systems are used in many industries but due to the increased complexity involved many have opted for manual labor vs. automated systems.

Fig. 1. People identifying defective products

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4. Proposed System

Our proposed system decreases the complicated process of training object detection models by using tensor flow library. Our system collects data from various sensors such as load cell, camera, and various other sensors and uses the pre-trained model to classify the product. The conveyor system is hence made effective by being compact and as the system is based on open source software, the system can be well maintained.

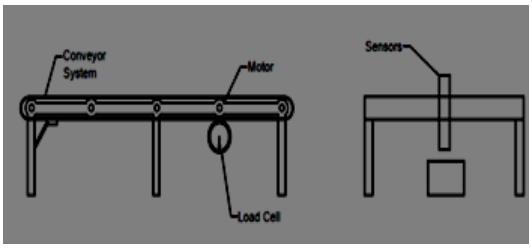

Fig. 2. Concept drawing in 2D CAD

A. System Components

1) Conveyor System (Sprocket, Conveyor Pulley & Belt)

A conveyor system is used for smooth transportation of objects from one point to another. A simple conveyor system is used in our proposed system. It consists of parts such as sprockets (fig. 3), conveyor pulley (fig. 4) and belt.

Fig. 3. Sprocket

Fig. 4. Conveyor pulley

2) DC Stepper Motor

Stepper motor is used for controlling the movement of the conveyor system. Precise speed control is also made possible with stepper motor. A stepper motor is also known as a brushless DC motor.

3) Load Cell

A load cell is a device that converts the given force or weight into corresponding electrical signals. They are quick and precise. When a load is applied on a load cell, minor deformation is formed. This causes a change in resistance in the load cell. This change in electrical resistance can be calibrated for our use. A disadvantage with the use of load cell is constant calibration with each run. However this problem can be solved with using digital weight measuring tools.

Fig. 5. Load cell

4) Microcontrollers

Here we are using a raspberry pi as the machine learning module. The data from sensors are calculated and appropriate action is taken. Here the action is checking whether the product is defective or not.

5. Sensors

1) Camera

This device is used to capture live images of the object moving through conveyor belt. The proposed system uses a 5MP camera module connected to the microcontroller through MIPI data lanes. Camera sensors catches the light and converts it into electrical signals in digital format.

2) IR Sensor

These sensors works by detecting change in the infrared radiation. A change in the resistance occurs with infrared radiation and this translates to the IR sensor acting as a switching or detector. In our proposed system an IR sensor can allow us to detect the object on the conveyor belt and only hence start the conveyor. Power saving is an important aspect related with this module.

3) Linear Actuator

A linear actuator creates motion in a straight line. They are used in industrial machines and computer peripherals. The device works by using hydraulic or pneumatic cylinders to produce linear motion. In the proposed system, we can use a linear actuator to remove the defective product.

4) Dataset

This involves the collection of images having good quality and bad quality products for training the machine vision for recognizing the defective products. A minimum of 600 images of each cases are needed. They can be collected from online datasets. We used self-collected data using mobile cameras and labelled each image manually.

5) Tensor flow

Tensor Flow is an open source platform for machine learning projects. It has a huge eco system of libraries which are easier to build and deploy. Hence tensor flow is a flexible library for object detection and has a huge community support.

6) Coding

We are using python to interface with raspberry pi and sensors. For programming in tensor flow, we are using the default filters given in the tensor flow documentation [4].

6. Results

For validating our proposed system, we trained an object detection model in tensor flow for detecting defective apples and oranges on an image dataset of 600 images each. The average accuracy of the final model was around 85%. We defined a particular weight to consider for each produce to be considered as good and anything lower would be considered defective. First we calculated the average time for existing system using manual labor with 10 apples and oranges. Then we compared the same with the results for automated system. It was found that the automated system average 1-2 minute greater than existing systems as tedious mental calculation and errors from human part was eliminated. We also found that in the existing method, defective produce is identified slowly as time progresses while our system has a smooth process flow.

7. Conclusion

From the findings of the proposed system, we can conclude that the system can excel at improving the production line speed by a considerable margin. The system was designed to reduce the time, cost and provide easier means to package good quality produce. As the system we are proposing does not require huge initial investments and can be setup with relative ease, it can be concluded that the system should be adopted to improve production rate in industries. Naphade et. al [2] concluded that the system has much greater efficiency and longer working periods as compared to human labor. The dataset for training the model maybe captured through ordinary smartphones. The system has hence proven to be effective in reducing the overall time required for sorting defective produce.

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