ISSN (e): 2250 – 3005 || Volume, 13 || Issue, 6|| Nov.-Dec. – 2023 ||
International Journal of Computational Engineering Research (IJCER)

Design and Development of Product Sorting System Using Machine Vision

Deepashri K M[1]*, Shubha V Patel[2], K K Nandish[3], Bharath R[3], Amit M Khode[3]
[1]Assistant Professor, Department of Artificial Intelligence &Machine Learning,
Bapuji Institute of Engineering and Technology, Davangere-577004, Karnataka, India.
[2]Assistant Professor, Department of Electronics & Communication Engineering,
Bapuji Institute of Engineering and Technology, Davangere-577004, Karnataka, India.
[3]Department of Electronics & Instrumentation Engineering,
Bapuji Institute of Engineering and Technology, Davangere-577004, Karnataka, India.
.
Corresponding Author: talk2deepashri@gmail.com

ABSTRACT

In view of the problems of inefficiency and quite expensive traditional manual sorting used in the existing logistics industry and other fields, a vision-based robotic sorting system is proposed. The automatic sorting robot uses vision to identify the target, locate the target, grab the target, and sort the target. After the robot vision technology is combined, the sorting is more efficient, stable and safe. The lack of sorting exists. Therefore, the vision-based robot sorting system has high application value. The sorting system realizes the automatic sorting function of the object and has a good application prospect.

KEYWORDS: Sorting, machine learning, robot, actuator, training

---

Date of Submission: 16-11-2023 Date of acceptance: 03-12-2023

I. INTRODUCTION

Operations like Machine part sorting, Product sorting, Logistics sorting is an important part of any modern Industry. In this paper, an auto-sorting system is proposed based on Computer vision. In the proposed system, an industrial object detection network combined with a robotic system is designed to automatically and efficiently complete object sorting. The major role of a vision system can be implemented in a facility, which Punches out multiple parts from a single work piece. This kind of process is an efficient choice for producing multiple pieces in a single operation, but it should be noted that the parts should have to be sorted later. A vision-based robot can be employed to do this kind of sorting efficiently. An example for such an industry would be the automotive Industry. With the rise of Machine learning, Deep learning and Artificial intelligence, an advanced sorting algorithm can be implemented at a solid waste management facility, to identify and sort different wastes like plastics, papers, metals etc. through a single robotic operator. Currently, techniques like IR spectroscopy (mainly to identify plastics) are used at these facilities, which are expensive to implement in developing countries.

II. LITERATURE REVIEW

From classifying products at the end of an Industrial process to differentiating solid waste in a recycling plant, sorting plays an important role in this modern era. The manual sorting techniques existed as long as the dawn of Human civilization, but with increase in product output and identification complexity, the manual sorting system is very taxing on human psychology and can lead to slower production rates. The manual sorting systems will slow down an entire industry, due to limitations of humans.

As reviewed by Tadhg Brosnan, Da-Wen Sun [1] in fields like food processing facilities, Raw materials like fruits have to be sorted, before they can be processed to the next unit. Handling this kind of task where an individual has to look up on every fruit to check whether it is good for production or starting to rot can be a hard task. Implementing a manual sorter is good for a very small production, but is not a valid choice when it comes to large production facilities which might operate 24x7. Thus, an automated system is necessary. Sorting is also a major task in Logistics. Due to the rise of e-commerce, the complexity of handling the packages has also become sophisticated and special sorting mechanisms are introduced in their respective fields. A barcode system might be used to sort packages based on their destination, which is encoded inside barcode, and a vision system can be used to sort the packages based on their dimension for an efficient packing density, while shipping.

The major role of a vision system can be implemented in a facility, which Punches out multiple parts from a single work piece. This kind of process is an efficient choice for producing multiple pieces in a single operation, but it should be noted that the parts should have to be sorted later. A vision-based robot can be employed to do this kind of sorting efficiently. An example for such an industry would be the automotive Industry. With the rise of Machine learning, Deep learning and Artificial intelligence, an advanced sorting algorithm can be implemented at a solid waste management facility, to identify and sort different wastes like plastics, papers, metals etc. through a single robotic operator. This concept is reviewed by Dilan Bonello *et al* [3].

Currently techniques like IR spectroscopy [5] (mainly to identify plastics) are used at these facilities, which are expensive to implement in developing countries. Manufacturers favor machine vision systems for visual inspections that require high-speed, high-magnification, 24-hour operation, and/or repeatability of measurements. Frequently these tasks extend roles traditionally occupied by human beings whose degree of failure is classically high through distraction, illness and other circumstances. Human eyes are sensitive to electromagnetic wavelengths ranging from 390 to 770 nanometers (nm). Video cameras can be opted for desired wavelengths and can be used in respected environments. Some machine-vision systems function at infrared (IR), ultraviolet (UV), or X-ray wavelengths.

III. PROPOSED DESIGN

A sorting process is a necessary step in many Industries, and the process of sorting products by manual labor has its limitations, thus many large Industries employ automated systems for such tasks. These automated solutions come with a hefty price. The developed system is relatively cheap and capable of performing the sorting task with a machine learning model deployed on the edge device. A machine learning approach is chosen, since it can be configured and trained easily compared to some of the other vision-based techniques. The methodology for the prosed system is shown in the figure 3.1.

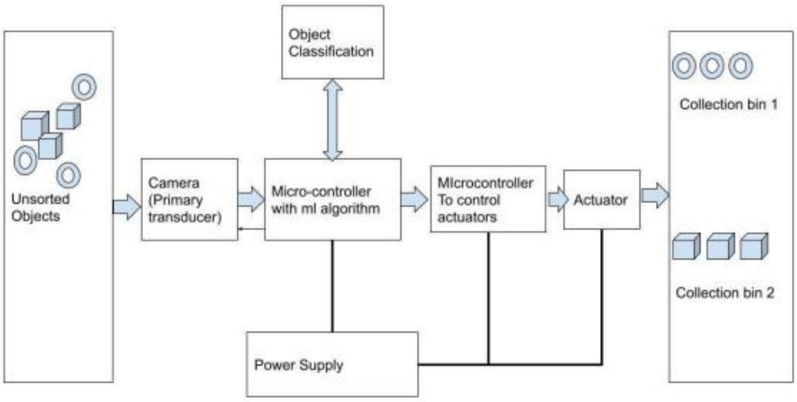


Figure 3.1: Block diagram of a proposed system

The tasks related to machine learning and the actuators are processed by two ESP microcontrollers. An ESP32 camera module-based controller is used for processing the machine learning tasks and also handling some of the basic I/O functions. The ESP8266 on the other hand is used to generate necessary instructions for the servo movement and some other actuators. The communication between two ESP devices is exchanged through an ESP. Now wireless protocol. The stepper motors are driven by an A4988 driver IC, the driver IC handles all the necessary stepping voltages for the stepper coils. It requires only a step signal and a direction signal as its input. A brushed geared DC motor is also used to generate necessary motion for a conveyor system; the conveyor is used to carry the products necessary for sorting.

The machine learning model is pre-trained with 96X96 resolution images taken from the ESP32 camera module itself for better accuracy. The transfer learning method with a tenser Flow lite workflow is employed for generating the necessary ml model. Images are both trained and processed in grayscale to reduce memory consumption and cut-down the time it takes for running the Inference on each Image. In practice, when the machine is switched on, the cartesian system performs a homing sequence and the conveyor starts moving. Products that need to be sorted are placed on the conveyor, when the conveyor reaches the camera module, the ultrasonic sensor measures the distance of the object from the horizontal endpoint of the cartesian system and the camera captures images for Inferencing.

Image Processing unit:

- Image processing consists of the ESP32 camera module and some input functions.
- The ESP32cam consists of an OV2640 CMOS camera cable of capturing images of up to 2MP.
- An ultrasonic sensor is used as Input for the camera module and serves as a trigger for capturing the Image.
- The exposure for OV2640 is very low, and thus a lighting setup consisting of 12V LED strips is used to compensate for the lighting.
- The camera captures images of RGB color depth; these images are converted to a grayscale depth using the image utilities functions provided by the ESP library.

Actuator control system:

- In the developed sorting system, it consists of stepper actuators which are responsible for the cartesian movement and a vacuum motor paired with a solenoid valve, used for the gripper.
- The ESP8266 microcontroller is the heart of the actuator control system. It runs the control Instructions along with the esp. Now network tasks in the background.
- The steppers are controlled with the help of an accel stepper library; the library is useful to fine tune the acceleration, position and speed of each motor. It also provides a multi-stepper feature, which can be used to drive up to 10 steppers simultaneously.

IV. RESULTS AND DISCUSSION

The implemented prototype of product sorting machine is shown in figure 4.1. The designed machine is capable of identifying multiple objects on the conveyor with the help of machine vision and trained machine learning models and thus capable of sorting multiple objects. The screen shot of the results displayed on the serial console is shown in figure 4.2.

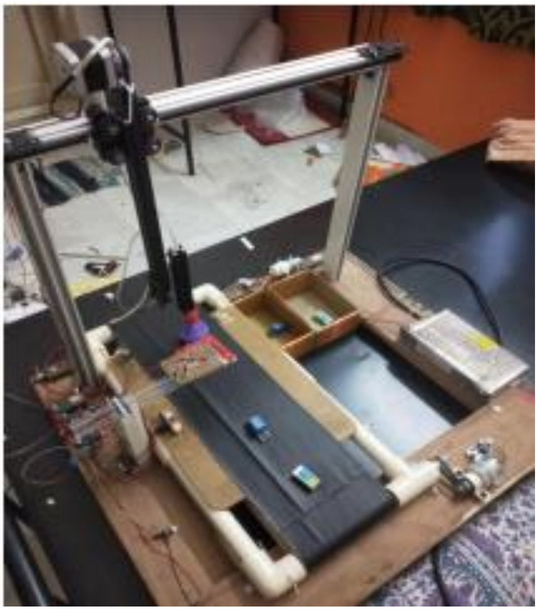
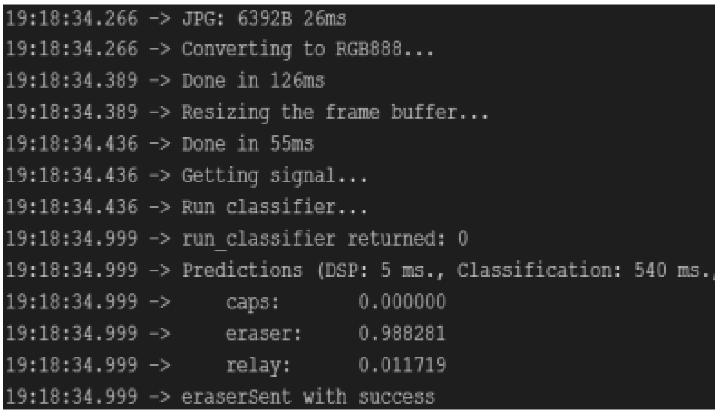


Figure 4.1: A prototype of product sorting machine



```
19:18:34.266 -> JPG: 6392B 26ms
19:18:34.266 -> Converting to RGB888...
19:18:34.389 -> Done in 126ms
19:18:34.389 -> Resizing the frame buffer...
19:18:34.436 -> Done in 55ms
19:18:34.436 -> Getting signal...
19:18:34.436 -> Run classifier...
19:18:34.999 -> run_classifier returned: 0
19:18:34.999 -> Predictions (DSP: 5 ms., Classification: 540 ms.,
19:18:34.999 ->     caps:       0.000000
19:18:34.999 ->     eraser:     0.988281
19:18:34.999 ->     relay:      0.011719
19:18:34.999 -> eraserSent with success
```

Figure 4.2: Screenshot of output from the serial console

The tests are carried out on three objects (capacitors, relays and an eraser) mixed together. The system was able to sort them into their respective bins efficiently. Currently, the gripper size is limited and it can lift and sort objects with very smaller dimensions.

V. CONCLUSION

The developed system can sort the objects as proposed. The system isn't perfect at present due to hardware limitations of the ESP32 camera module. It can classify at most two objects at a time. This limits the machine's sorting capabilities a lot.

VI. SCOPE OF FUTURE WORK

The future scope of the project is to resolve the image classification limits. This can be implemented by utilizing a low-cost Single board computer like Raspberry Pi Zero. SBCs are scarce due to chip shortages in the movement. By upgrading to an SBC, the system can also perform live distance measurements off the captured image instead of utilizing a sensor to measure the pickup distance like in the present implementation.

REFERENCES

[1]. Improving quality inspection of food products by computer vision—a review Tadhg Brosnan, Da-Wen Sun, Journal of Food Engineering, January 2004

[2]. Machine vision system: a tool for quality inspection of food and agricultural products Krishna Kumar Patel & A. Kar & S. N. Jha & M. A. Khan, J Food Science Technology, April 2012

[3]. An exploratory study on the automated sorting of commingled recyclable domestic waste Dilan Bonello, Michael A. Saliba, Kenneth P. Camilleri, Procedia Manufacturing 2017

[4]. Sorting: Possibilities, Limitations and Future – H.R. Manouchehri, Published 2003

[5]. The Application of FT-IR Spectroscopy in Waste Management-Ena Smidt, Katharina Böhm and Manfred Schwanninger , Published April 1st , 2011

[6]. Analysis and Improvement of an Assembly Line in the Automotive Industry-, P.Dias F.J.G.Silva R.D.S.G. Campilho L.P.Ferreira T.Santos , Procedia Manufacturing , June 2019

[7]. Universal robotic gripper based on the jamming of granular materialEric Brown, Nicholas Rodenberg, John Amend and Heinrich M. Jaeger, September 17, 2010

[8]. Accelstepper-the-missing-manual- a hackaday article on AccelStepper , December 2021

[9]. ESP-NOW Networking APIs - ESP- IDF Programming Guide

[10]. Openbuilds Gantry designs for the Cartesian robot.