Design and Development of AI Based Quality Inspection Automation Based on Colour and Size

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Abstract—Automation is need of future. Machines are replacing humans everywhere as they are fast and efficient than humans. Many industries lack in skilled labour and because HSV their efficiency also hampers. Sorting of object is one the basic work done in almost every kind of industry. Physical sorting depends upon colour, shape and other physical attributes of the object. THSV work represents the machine vision-based object sorter. A Camera is used to give machine vision to the project. Camera takes the picture of the object on conveyer belt and passes HSV image to PC for the further processing using python based OpenCV software. OpenCV does the required Colour Processing of the received image using Digital Image Processing Coding. Colour is most important feature of an object. Colour of a living thing holds vital information about quality of object. Here Digital Image Processing is used to get colour related information of the object, shape of the object & seven size of the object. Object sorting and the grading of the object is done based on its colour. Open CV used for colour processing of the image. RGB and HSV colour models along with analysing the colour, size & shape of the image.

Index Terms— Artificial Intelligence, Drives, Machine Vision, Python, Solid works, X-Axis Arm, Y-Axis Arm.

1 Introduction

Digital image processing has a history going back over 35 years and colour has been part of that history for at least 25 years. In Digital image processing images are captured, transmitted, and processed in digital form. Digital image processing is one of division in electronic area where image being modified to pixels, stored in a digital storage and processed by computer. In effect, it reduces cost increasing computational speed, and flexibility.

The core task of digital image processing is storing images and enhances them to the new information structures, so as to provide a better basis for obtaining and analysis of related activities. In addition, digital image processing leads to enhancement of image features" interest and therefore useful information about the scene from enhanced image could be computed. Digital image processing, extract information of an image for processing and analysis task. After taking the digital image from the digital camera, the system transferred to a computer for processing and storage by using different processes such as image capturing, image digitization, noise filtering and feature identification.

Sorting of objects is extensively used in many industries like food processing industries, toy industries, etc to ensure that the quality of the product is up to the mark. This process is simplified using automation. Automation is the use of control systems like computers or robots for handling different process and machineries to replace a human being and provides mechanical assistance. This not only reduces manual efforts, time consumed, gives more time for marketing, but also prevents danger which might occur when human beings work in hazardous environments.

Nowadays industrial area requires demand for automation. Due to automation, human efforts are decreasing since last decade. The object sorting based on color is a difficult task in recent

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days. In the industry field, there is rapidly increasing demands for automation. This project gives us an idea about automatic color sorting. This project gives high accuracy and performance and is easy to operate and construct which reduces human errors. Existing sorting method uses a set of inductive, capacitive and optical sensors to differentiate object color.

The project consists of sensors that detect object color after that sends the information to Arduino Uno which in turn adjusts the DC motor which located just below the object slider to move it left or right and also carries the remaining as it is straight to end bin. Based upon the color detected, the motor will move clockwise or anticlockwise depending on object of color and size. The stations are in red, green and blue respectively. After every object placement, the slide will go back to its default angle position, awaiting the next color object.

Machine vision provides the computer eyes and ears. Eyes are the most critical organs in the human body and our aptitudes depend to a great extent on our capacity to see, distinguish and separate between articles. Most occupations rely on upon our capacity of sight. Machine vision does not mean design and outlining; it is identified with the innovation of vision in manufactured sense. Cameras give PCs or gadgets the capacity to see and distinguish and recognize items or circumstances and to settle on the right choices in like manner. The study and advancement of strategies and methods that permits machines to translate computerized pictures in m/c vision.

A machine vision framework comprises of a few vital segments, from the sensor (camera) that catches a photo for examination, to the processing engine itself (vision apparatus) that renders and conveys the outcome. Alternately, for any machine vision structure to work reliably and produce awesome results, it is key to grasp the coordinated efforts of these sections.

Amid the most recent 15 years, machine vision innovation has enhanced rapidly, getting to be imperative and much of the time, essential apparatus for assembling robotization. Today, machine vision applications are available in numerous commercial enterprises, including semiconductor, pharmaceuticals, bundling, gadgets, car and shopper products.

Generally, machine vision has been exceptionally fruitful in applications where it was coordinated into the creation process. Case in point, managing machines or shutting a control circle. Yet, while vision direction has demonstrated its worth in setting surface-mount segments on printed circuit sheets, most clients would dither before putting resources into a machine vision examination station to catch deficient parts on a current generation line. Nonetheless, persistent enhancements in expense, execution, algorithmic power and convenience have energized vision frameworks' utilization by and large assembling robotization. Further advances in these regions will bring about more vision frameworks on assembling floors amid the following couple of years.

2 Literature Survey

Pourdarbani [1] presented a study on an automatic sorting system for date fruits based on different stages of its maturity to meet consumers' demands. The framework embodied a conveyer belt on which the dates were passed and a cam to catch the picture of the dates. The sorting framework was a suitable actuator driven by an engine. Detection rate of the system for Tamar and Khalal was satisfactory. Although the detection rate was insufficient for the Rotab stage, there was not a significant difference between system accuracy and that obtained by the experts. The speed of image processing system was 0.34 s. System capacity was 15.45 kg/h.

Hanmei [2] presented a way of identifying and sorting aquatic products based on machine vision. Machine vision was used to detect the visual quality of fishes, fish filets and some other aquatic products (i.e. shrimp, oyster, and scallop). This review introduced detecting methods based on measurement of size, shape, and colour using machine vision systems. Machine vision systems used for measuring size, shape, and colour was described, including improvements of cameras, illumination settings, image processing and analysis methods, and experimental results as well. With the development in these areas, machine vision technique may achieve higher accuracy and efficiency, and wider application in visual quality detection of aquatic products. Besides, advantages and limitations of these machine vision systems were discussed, with recommendation on future developments.

Zhang [3] presented a vision based control strategy to do pick and place tasks. CCD camera was used to take pictures every time the conveyer moves a small distance. After picture preparing of the photos, position and states of items was dead set and target following technique was utilized to do sorting operation. Target tracking method based on "Servo motor + synchronous conveyer" is used to fulfil the high speed porting operation real time. Experiments conducted on Delta robot sorting system demonstrate the efficiency and validity of the proposed vision-control strategy.

Edinbarough [4] presented a vision inspection system interfaced with a robot based on neural

network. IC lead defects were detected in line by this method. The vision framework utilized dark scale pictures and a solitary layer neural system database for each of the ICs to be investigated.

Wei [5] presented an automatic extraction method of fruit object using machine vision. The method was based on improving threshold algorithm using a new feature in OHTA colour space. The organic product articles were naturally removed with this strategy and the yields were demonstrated as binary pictures. Numerous of experiments show that the automatic extraction method can extract mature fruit from complex agricultural background and the extraction accuracy is more than 95%. The results indicate an effective fruit object extraction method for vision system of fruit picking robot.

Manual sorting is the conventional approach that is preferred by industries which involves visual observation performed by human beings. This is an approach where human labourers are made to work for maximum time to achieve the desired task. When we consider the large-scale industries, segregation of objects that are bulk in number becomes a tedious task for labourers which consume lot of time. Recognizing a particular object and placing it in a required place is a tiring work, wherein one has to sort a bulk of objects with greater weight in quick time. This is slow and non-consistent when the human labourers do it manually. Sometimes humans are restricted to work in the hazardous conditions and it is the place where automation plays a major role.

3 Conceptual Background

Use of machine vision for object separation is not an unknown concept. Detecting objects on transportation is very common industrial problem. Model based recognition methods can be employed if all the objects are same or with few differences. In recycling plants, bottles, plastics and other materials require sorting. To inspect the objects stationary camera mounted above the conveyer belt system is used. One must decide whether a pixel belongs to an object or to the background.

Throughout the years, many people tried to use various ways to program and create intelligence robot in various ways to have respective functions. Some of the claims made have contributed directly or indirectly to the project. This project is developed with the purpose of minimizing the cost, optimizing the productivity and reducing human mistakes.

Colour analysis in this project is based on the RGB Colour Space and HSV colour spaces:

3.1 RGB Colour Space

The RGB colour space is commonly used and human eye can also perceive it. The colour of any object is made from three primary colours these are Red, Green and Blue. Other colours are made from primary colours that is, the mixture of 2 or more primary colour gives the full colour spectrum. RGB colour space based on the primary spectral components of red (R), green (G) and blue (B).

3.2 HSV Colour Space

The HSV that is hue (H), saturation (S) and Value (V) gives the colour description in terms that are practical for human interpretation. Hue, Saturation and Intensity of the colour objects are perceived and described by human eye. Hue gives the measure of distinct colour of the spectrum such as red, green, yellow etc. Saturation is a measure of the degree to which pure colour is diluted by white light that is richness of pure colour. Intensity is the brightness subjective descriptor and impossible to measure. The Intensity of HSV model decouples the intensity component from the colour carrying information (hue and saturation) in a colour image. HSV is the gives the best results compared to RGB colour system because in RGB colour system it provides three separate coordinates RED, GREEN and BLUE which is not efficient for colour perception and image processing than compared to HSV mode where only hue (H) can give the colour perception.

3.3 Components of Machine Vision

A camera and vision software are essential with many other components in a machine vision system. Illumination is very important component of machine vision. For the camera to capture images in a proper way a light source must be provided. If light is not proper object's parameters like colour, length, area, shape, etc. may be interpreted incorrectly by the vision system and hence after image processing the output may be the undesired one. Thus, a proper light source is kept to provide luminance to the vision system. LED lamps are much preferred. Other light sources can also be used. Right intensity and correct direction of light is required.

Cameras are the eye of the machine vision system. The capture the images and send it to the computer system for processing. Various types of cameras can be used in a machine vision system according to the requirement. A charge coupled device (CCD) is an integrated circuit scratched onto a silicon surface framing light sensitive component called pixels. Photons striking on this surface create charge that can be perused by electronic circuits and transformed into an advanced duplicate of the light examples falling on the gadget. Photons striking a silicon surface create free electrons as well as holes through the

photoelectric effect. If nothing else is done the hole and the electron will recombine and release energy in the form of heat. Small thermal fluctuations are very difficult to measure, and it is thus preferable to gather electrons in the place they were generated and count them in some manner to create an image. This is accomplished by positively biasing discrete areas to attract electrons generated while the photons come onto the surface. Other types of cameras include line scan camera and CMOS camera.

Extent to which a camera can view the real-world image in a time instant is known as field of view. After image acquisition, several processing steps are to be done on the images so that the image can be analysed. Removing noises by filtering, controlling brightness, contrasts, sharpness, converting into binary images, etc. are various ways of processing the image. For example, in case of edge detection, the image to be analysed must be an 8-bit image. Thus, from a 32-bit RGB image acquired by the camera, the RGB plane is extracted to convert it into an 8 bit image. Similarly, pixel counting is most common image processing method. It involves counting of light or dark pixels in the image. So, it can be analysed by histogram that shows the grayscale distribution in an image another processing technique is thresholding which is the process of dividing the image into segments. It is used for creating a binary image from a grayscale image.

4 Proposed Method

4.1 Components of the system

A Cartesian coordinate robot is an industrial robot whose three principal axes of control are linear and are at right angles to each other. The three sliding joints correspond to moving the wrist up-down, in-out, back-forth. Among other advantages, this mechanical arrangement simplifies the Robot control arm solution. This chapter contains the components used to assemble the Vision Cartesian Robot.The design includes 5 major assemblies:

1. X-Axis Arm
2. Y-Axis Arm
3. Conveyor System
4. Camera Stand System
5. NEMA17 Stepper Motor

4.1. 1. X-Axis Arm

The design of the X-axis arm includes a NEMA-17 Stepper motor which is widely available throughout the world is connected to a screw rod via a coupler. The Screw rod is then connected to a carriage plate which is bolted on to the support rods so that the carriage moves as the screw rod rotates with the stepper motor.

This carriage is then bolted onto the Y Axis arm so that both the arms move with the X Axis with the right timing and the required distance with minimal deviation with the required timing.

The main component of X axis arm are as follows:

1. Two support rods of diameter 10mm
2. Screw rod of diameter 8mm
3. Two Couplings on the support rods
4. X Axis Carriage
5. NEMA-17 Stepper Motor with Support Plate
6. Two Support Rod and Plate Coupler
7. Stepper motor to Screw rod Coupler
8. Screw Rod to Carriage Coupler

4.1.2. Y-Axis Arm

The design of the Y axis arm includes a NEMA 17 Stepper motor which is now connected to a timer pulley which in return is then connected to a belt and on the other end the belt is wrapped around an idler pulley. There is a carriage placed onto the support rods and it is connected to the belt so it moves with the belt as the timer pulley rotates by taking the input from the microcontroller. This in return moves the carriage which is then interlocked with the X axis arm. This is done in order to minimize the difference in the theoretical timing and the actual timing. The specifications are the same as mentioned above as we use the same NEMA-17 Stepper motor. The end actuator is attached to the end of the Y axis arm as it is used to move the work piece around when the micro controller gives the input.

The main component of Y axis arm are as follows:

1. Two support rods of diameter 8mm
2. NEMA 17 Stepper motor with support plate
3. Timer pulley
4. Idler Pulley
5. Support coupling on the support rods
6. Y axis carriage
7. Belt connector
8. End arm actuator

4.1.3. Conveyor Belt

The conveyor is powered using the NEMA17 stepper motor which is connected to a roller. The camera stand is mounted outside the base plate to allow easy adjustment of the camera for to find out the ideal place which gives us the best results. The working length of the belt is 370mm.The conveyor rollers are made with PLA and the conveyor is supported using the bearing which is in the support clamp used to place the conveyor. The camera which captures the image and feeds it into the microcontroller is placed right on top of the conveyor so that it captures the top view of the work piece to determine the qualities of the current work piece being tested. Fig 1. Shows the top view of the Vision Cartesian Robot and Fig .2 shows the 3D view of the Vision Cartesian Robot.

The main component of conveyer system are as follows

1. Two conveyor Rollers
2. Conveyor Support Clamps
3. Roller Bearing
4. Roller Connecting Rod
5. NEMA 17 Stepper motor With Support Clamp
6. Camera Stand

4.2 Design of Control System

Robot control systems consists of 3 major sections:

1. Mechanical structure of the robot
2. Controller & Drives
3. Control Software

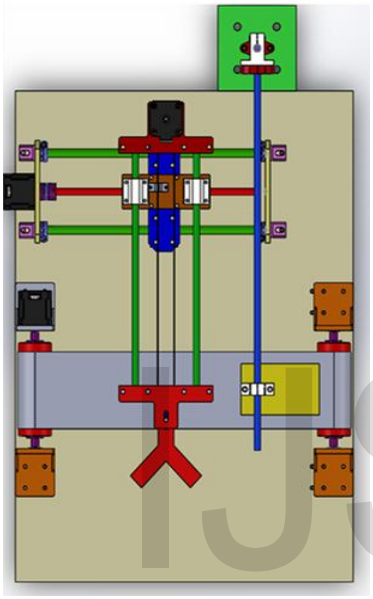


Fig 1. Top view of the Vision Cartesian Robot

Mechanical section includes, all mechanical parts such as Stepper motors, linkages, Supports, bearings, pulleys & belts, screw rod & guides rods etc. Controller Drives incudes, Microcontroller & Stepper Drives used to control the movements & positions of Robots. Control Software is interfacing software used to teach the positions of the robot & Applications based on the requirements.

This project involves two major Software Parts:

1. Arduino Programming
2. Python based Control Software

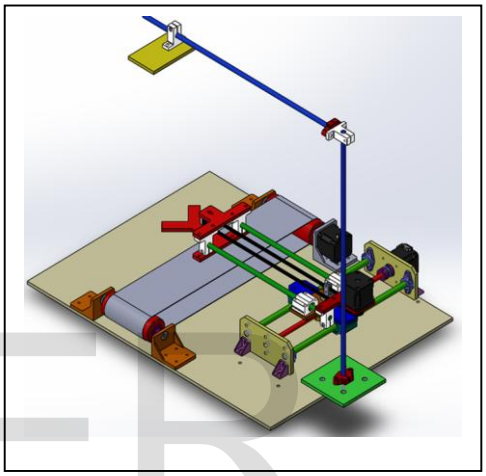
4.2.1 Arduino Programming:

The main control system of the project is the Microcontroller which controls the movements of the robot by driving Stepper motors with respect to the robot kinematics. Arduino Microcontroller board is used in this project which is programmed in such a way that robot can move depends on the input received from the python-based control software from PC.

The hardware components which are used are programmed by means of the software tools. The various software which are included are presented briefly. The software used to program the microcontroller is Arduino IDE.

4.2.2 Python based Control Software

This the User interface software which guides the robot to move to required position based on the kinematics of the robot by sending x, y & z position commands to Robot.



5. Conclusion

AI will impact manufacturing in ways we have not yet anticipated. With the adoption of AI if companies can keep inventories lean and reduce the cost, there is a high likelihood that the manufacturing industry will experience an encouraging growth. Quality inspection is becoming an important cost factor in manufacturing (and later in service costs). Now that many production tasks are already automate.

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