Design and Development of a Machine Vision System for Part Colour Detection and Sorting

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Design and Development of a Machine Vision System for Part Colour Detection and Sorting

Vedang Chauhan , Saurin Sheth , Bhavesh R. Hindocha , Rushabh Shah , Parth Dudhat , Pratyush Jani

***Abstract*— Nowadays various automation techniques are being adopted & researched for increase in productivity, better accuracy, eliminating the human errors and for safety. Machine Vision is one such advancement in automatic systems. Machine vision performs the tasks that are equivalent to human vision. It helps to automate the systems where there are limitations of human vision like detecting various shades of colors or determining high precise dimensions and thus permitting human employees to serve in more appropriate positions. Now, what happens when the questions turn to "Is this part of correct color?" or "Which parts are blue and which are red?" So in our system, colour based identification of the parts is done and then it is sorted according to different colours. After recognizing the colour of the object, robotic arm will automatically pick & place it accordingly. If the colour of the work piece is not found in accordance to the required one then it will be rejected. The complete sorting system operates on image processing using the MATLAB application & PLC which controls different motors in the system. Machine vision based color concept has found its wide application in the pharmaceuticals industry, agriculture industry and assembly of parts especially in automobile industry. Advances in both machine vision technology and related software tools have enabled manufacturers to apply color machine vision on the factory floor in real time. This technology can solve problems formerly restricted to manual inspections & sorting.**

***Index Terms*— Machine Vision, MATLAB, PLC, Sorting, Colour Detection**

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I. Introduction

MACHINE vision is the application of computer vision to industry and manufacturing. Two important specifications in any vision system are the sensitivity and the resolution. The better the resolution, the more confined the field of vision. Sensitivity and resolution are interdependent. All other factors held constant, increasing the sensitivity reduces the resolution, and improving the resolution reduces the sensitivity. One of the most common applications of Machine Vision is the inspection of manufactured goods such as semiconductor chips, automobiles, food and pharmaceuticals. Just as human inspectors working on assembly lines visually inspect parts to judge the quality of workmanship, so machine vision systems use digital cameras, smart cameras and image processing software to perform similar inspections. Machine vision systems are programmed to perform narrowly defined tasks such as counting objects on a conveyor, reading serial numbers, and searching for surface defects [1,2].

Specifically, manufacturers use colour vision to solve three primary vision applications:

1. Color verification -- Verifying that a certain part's colour matches with what the vision system is programmed to find.
2. Color sorting -- Sorting parts based on colour.
3. Color inspection -- Inspecting coloured parts for defects that greyscale image processing tools can't detect.

II. Design of the System

A. Block Diagram

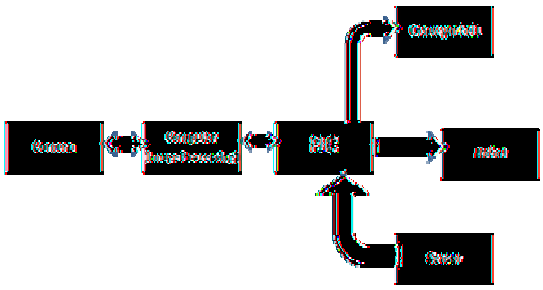

Fig.1 Block Diagram

Working of system is very simple. Initially when product is on the conveyor belt, Sensor detects the presence of the particular product & gives signal to the PLC. Then PLC sends

this signal to the computer by serial interfacing. Image processing software (MATLAB) [9] of the system will send the signal to the camera for capturing the image. Once image is captured, the software processes on the captured image and generates signals according to requirement and which in turn signals back to PLC. Accordingly the PLC will control the conveyer belt & robotic arm. Robotic arm will pick & place the given component according to the color [6]. If color is not matched with a given requirement, the product will be rejected. This cycle will be repeated number of times as per requirement.

III. Components of the System

A. Electrical Components

1) Sensors

Sensor is a device that measures or detects a physical condition. An electronic sensor converts this measurement or detection into equivalent analog or digital electrical signal. Proximity sensors are used. A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic or electrostatic field, or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Specification of sensor

- Input:10 to 30v
- Type: PNP/(NO)
- Range:10cm

2) Programmable Logic Controller (PLC)

Siemens Logo PLC is used. In project PLC is required to implement the sorting mechanism. PLC controls different motors of robotic arm & motor of conveyor belt according to sorting mechanism. Moreover interfacing of sensor is done with PLC [5]. LOGO Soft is programming software. It makes creating control programs easier, more efficient and more manageable than in the past. The process of creating a program involves positioning and linking up program elements on a "drawing board". One particularly user-friendly feature is the offline program simulation facility, which enables simultaneous display of multiple special function statuses and professional documentation of the programs created.

PLC Specifications

- 12-input port
- 8-output port
- Working voltage-24V

3) Camera System

INTEX-IT-305WC Web came is used to capture an image.

Specifications (INTEX-IT-305WC):

- Image resolution:160x120,176x144, 320x240, 352x288, 640x480, 800x600
- Frame rate:upto30 frames per second
- Camera Controls: Color saturation, brightness, sharpness is adjustable
- Image Quality:RGB24
- Exposure: Auto or manual
- Focus Range:4cm to infinity

B. Mechanical Components

1) Robotic arm and drive motors

As per the weight of the block and distance between the object and the robot calculations are done and the robotic arm is designed [10]. The degrees of freedom, or DOF, is a very important. Each degree of freedom is a joint on the arm, a place where it can bend or rotate or translate. Typically the number of degrees of freedom is the number of actuators on the robot arm. The robotic arm has 3 DOF. DC motors are used in arm. Base motor of our system is of 10RPM. Link motor is of 40 RPM. Gripper motor is of 45RPM.

2) Conveyor Belt

Conveyor belt is nothing but the mechanical apparatus consisting of a continuous moving belt that transports materials or packages from one place to another. Conveyor belts are often driven by variable speed electric motors or by other moving parts in a complex system. They are commonly found in factories, grocery stores, warehouses and public transportation centers. The readily available conveyor belt system of the lab is used for the task.

Specifications

- Length : 900mm
- Width :135 mm
- Thickness : 5 mm

Permanent magnet DC servo motor

- Model : D2415PL20
- SR No : PDD8013
- Torque : 35 kg-cm
- Current Rating: 2.5 Amps
- Voltage : 24 V
- RPM : 80

IV. Algorithm for Color Detection

Image processing software captures the incoming image & processes it according to its color. After that it gives signal to PLC. RGB color space is used. RGB color space uses a rectangular coordinate system with one coordinate axis assigned to each of three color components, red, green, and blue.

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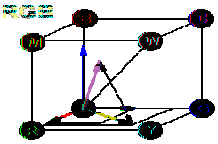

Fig.2 Color Coordinate System

MATLAB software for image processing is used. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation [3].

For detecting the colour the threshold value of particular colours is used. According to that colour software gives results. The threshold for red component should be the least value of the red component found in the region of the red ball. The threshold for green component should be the maximum value of the green component found in the region of the red ball. The threshold for blue component should be the maximum value of the green component found in the region of the red ball [4].

Red colour:
fR= rgb_image(:,:,1); fG=rgb_image(:,:,2);
fB=rgb_image(:,:,3);
I= ((fR>=120) & (fG<=70) & (fB<=70)); (Set the threshold values for red colour)
Blue colour:
I= ((fR<=80) & (fG<=70) & (fB>=110)); (Set the threshold values for blue colour)
Green colour:
I= ((fR<=80) & (fG>=110) & (fB<=70)); (Set the threshold values for green colour)

As per the application the threshold values of the colour can be changed & expected results can be obtained.

V. INTERFACING

Interfacing is a term used in electronics when different electronic devices are attached. Many interface methods have been developed over the years to solve the complex problem of balancing circuit design criteria such as features, cost, size, weight, power consumption, reliability, availability, manufacturability.
Following interfacing is done in the system:

A. Computer to Web camera
B. Computer to PLC
C. PLC to actuators (DC MOTORS)
D. PLC to sensor

As webcam used is a plug and play device, it can be easily connected to computer, via USB port, in which the image processing needs to be done.

Parallel communication is used to interface PLC with computer. According to its colour MATLAB gives one signal out of three from parallel port in form of 5V.This 5V is converted into 24V because PLC is working on 24V. So step up circuit is used. From step up circuit 24V will be given to PLC as input. Refer fig. 3.

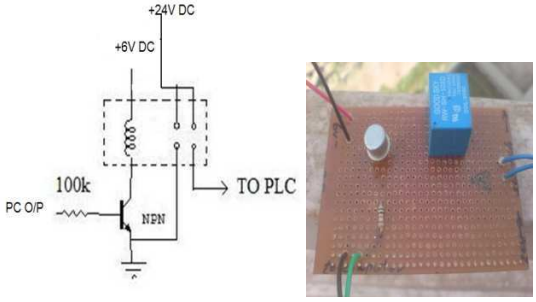

Fig.3 Step up Circuit

Simple relay circuit is used to control the motors of the system. Both forward & reverse motions are needed of the three motors of the robot. So six relays are used (Two for each motor).

Sensor to PLC connection is done as per show in fig.4. Sensor gives 24V when object is detected. And after reducing these volts to 5V, this Voltage will be given to computer via serial port. Finally camera captures the object image

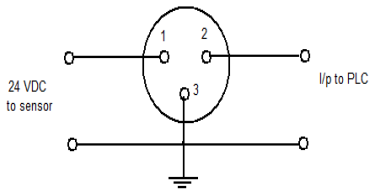

Fig.4 Sensor interfacing circuit

Processing time to sort one object is approximately 25 to 28 seconds. So system can sort 120 objects per hour. Efficiency of the system is 80%. If the resolution quality of camera & the processor speed of computer is increased then high accuracy, repeatability & sorting speed of the system can be obtained. Sensor & motors are also essential factors for the efficient system.
The complete system is as shown in fig.5 and fig.6.

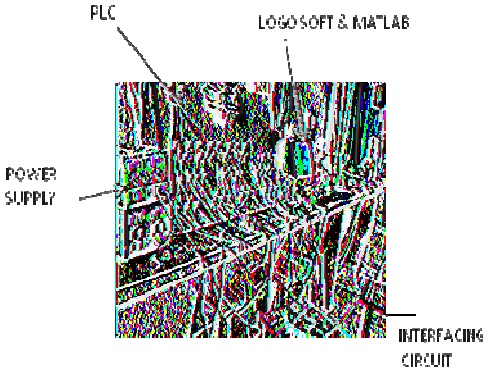

Fig.5 Complete System

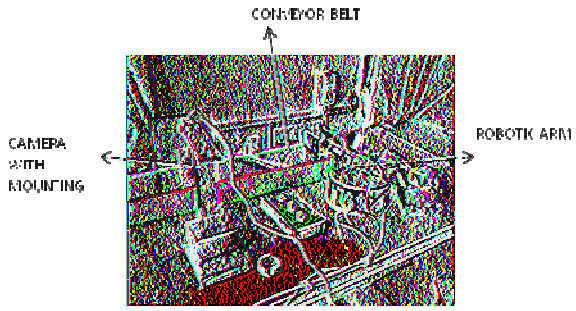

Fig.6 Complete System

VI. Conclusion and Future Scope

Simple web camera is used in the system. If vision camera with external trigger was used system would be more efficient. The machine vision camera obviously have better resolution, zooming capacity and clarity and moreover an inbuilt circuitry for external triggering. So it will save the circuitry used for interfacing the sensor with computer as the sensor output will be directly made available to the camera so it will also save the time as computer will not be in the connection at all.

Only part sorting is done but in future by some modification following can be included;

- Number of parts are sorted
- Number of parts passed
- Checking label on the part
- Check the crack or dent on the part
- Measuring dimension

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