Low Cost Machine Vision System for Sorting of Mechanical Parts using MATLAB & ARDUINO Embedded Hardware

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Abstract— The main aim of this research work is to design and develop a low cost machine vision system and conveyor belt setup for automatic recognition and sorting of mechanical parts. In this project the algorithm for feature extraction and object detection has been developed and tested in MATLAB software environment. By using low cost web camera the image of the object has been captured. The control system for conveyor belt speed control and sorting mechanism has been developed by using Arduino hardware. From the result it is proved that the proposed system can able to detect, recognize and sorting of parts accordingly as required for the applications.

Keywords—Machine Vision, Object Detection, Web Camera, Sorting, Conveyor, Automation

Introduction

In order to increase productivity, improve accuracy and to eliminate the human error, various automation techniques are being researched, developed and adopted in industries. One of the application of computer vision technology is machine vision. It is mainly focused on image based industrial automation tasks. 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 [2]. A typical machine vision system’s integrates imaging devices with embedded systems to carryout industrial operations. The detailed inspection system of spur gears using machine vision system is presented in [3]. Most common applications of Machine vision system includes, checking the certain requirements of a test piece such as color [6], prescribed dimension, presence of components and serial number etc. Object sorting is one of the machine vision based industrial application. The proposed method includes four different tasks namely object identification, Image processing techniques, object selection and sorting mechanism.

In this project Image processing operations are used to carry out the tasks such as object detection, feature extraction, identification and sorting of objects. MATLAB software is used to carry out the operations, since it includes a lot of image processing functions. In many food processing and packaging industries the object counting and sorting is the very important task that needs to be carry out.

I. MACHINE VISION SYSTEM SETUP

A. Arrangement

The system contains web camera, lighting source, clamping device and PC. The web camera is used to capture the image of the object. The lighting source is used to get the image with good quality.

![Machine Vision System Arrangement](image)

Fig. 1 Machine Vision System Arrangement

B. Conveyor Belt
It is a mechanical transportation system consists of continuous moving belt that carry components, materials from one location to other. In order to drive this system a variable speed dc motor control system is used along with various position sensor’s which are fixed in the conveyor belt system to detect the object presence.

The detailed specifications of conveyor belt system are listed below:

<table>
<thead>
<tr>
<th>Specifications of Conveyor Belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
</tr>
<tr>
<td>Width</td>
</tr>
<tr>
<td>Belt Thickness</td>
</tr>
<tr>
<td>Belt Material</td>
</tr>
<tr>
<td>Number of DC motors</td>
</tr>
<tr>
<td>DC motor type</td>
</tr>
<tr>
<td>Number of position sensors</td>
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</tbody>
</table>

C. Experimental Setup

The proposed project work mainly focuses on object detection and sorting based on its image regional properties. In this project the image of the object is continuously captured by using web camera which is interfaced with PC, the image information captured by the web camera is processed by the image processing algorithm implemented in MATLAB software, based on the result the sorting mechanism in conveyor belt is actuated. The DC motors in conveyor belt are controlled with the use of Arduino embedded hardware. The block diagram of the experimental setup is shown in Figure 2.

II. IMAGE PROCESSING OPERATIONS

A. Histogram Operations

It is a graph showing the number of pixels in an image at each different intensity value found in that image.

![Histogram of Sample Object Image](image1)

B. Thresholding

It is region based image segmentation technique. The pixels are grouped into different attributes based on gray levels. The operation of threshold is explained as:

\[
g(x,y) = \begin{cases} 
0 & \text{if } f(x,y) < T \\
255 & \text{if } f(x,y) > T 
\end{cases}
\]

where \( T \) is threshold, \( f(x,y) \) is input image and \( g(x,y) \) is output image.

The processed image is shown below.

![Result of Threshold Operation](image2)
III. FLOW CHART

The flow chart for object detection and sorting is shown in figure 5.

IV. ALGORITHM

**STEP 1:** Capture the image of the object using web camera

**STEP 2:** Read the image into MATLAB software environment

**STEP 3:** Visualize the gray level distribution using histogram command ‘imhist’

**STEP 4:** Threshold the image data for converting the image into black and white image and tracing boundary.

**STEP 5:** Remove the pixels which are not belong to the object pixels by using morphology functions

**STEP 6:** Fill all the holes in the image, so that it is easier to estimate the area enclosed by each of the boundaries

**STEP 7:** Finding the exterior boundaries

**STEP 8:** Calculate the area and perimeter of each objects. Estimate the metric value to include the circular (roundness) of the object.

Metric = 4*pie*area/perimeter^2

If metric = 1, the object has perfect Circular shape

Set the threshold to indicate the round

**STEP 9:** Send the commands to Arduino motor controller to actuate the sorting mechanism based on the result and move to step 7.

V. INSPECTION RESULTS AND DISCUSSION

Circle and square shaped mechanical parts shown in Figure 6 are used as the test objects. Its diameter is 30mm and dimension is 50mm X 30mm.
The experiment is carried out with several images of test specimens. Based on the test results, the inspection system can efficiently detect round (circle) shaped object with 90% of accuracy.

VI. CONCLUSION
A low cost machine vision system for sorting of mechanical components is designed and developed. The prototype model was tested in real time experiments for the measurements of object dimensions, and the experiment is carried out by taking hundreds of object pictures. From the result it is concluded that the accuracy rate reaches above 90% which means a sorting system with good quality has been built.

REFERENCE