AUTOMATED DEFORMATION DETECTION USING REAL TIME GEOMETRICAL MEASUREMENTS FOR QUALITY CONTROL IN A PRODUCTION LINE

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ABSTRACT

Automated quality control systems that filter deformed or defective items are increasingly used in manufacturing environments to improve their efficiency and reliability. With that demand in mind, this research proposes a low cost, programmable deformation detection system using vision based real-time measurements. Our objective is to verify that a finished product conform to a given set of specifications in terms of geometric measurements. Using images of the product captured while the item moves along a conveyor belt, we take several measurements of the item in real-time. Items with defects, and therefore are to be rejected, are identified and guided out of the main stream using a one DOF robotic arm. The proposed design was tested on a simulated production environment with a mix of deformed and non-deformed items passing through the detection unit. In the statistics obtained, our inspection system successfully rejected all the faulty or defected objects. This system can be used to inspect any type of product for defects or presence of alien objects.

Key Words: Online Inspection System, Real Time Measurements, Deformation Detection, Image Analysis

1. INTRODUCTION

Quality control in manufacturing emphasizes the importance of thoroughly examining and testing a finished item against a set of pre-defined specifications of the products. Manual systems reduce the percentage of false negatives (wrongly identified rejections), but fail to detect all the defective items. On the other hand, automated defects detection results in higher throughput (more parts in less time, better planning) and higher repeatability (process safety). Automated visual inspection, noise detection, tracing and scanning are typical implementations of defect detection whereas real time image analysis [4] is used when dimensional precision, color variations, 3D orientation of products are to be examined.

Inspection systems can be divided into two Categorizes; online inspection systems and offline Inspection systems. The online inspection systems inspect the products while they are moving on the conveyer Belt. The offline inspection systems take samples of the product for evaluation. Methods based on machine vision [2] are capable of detecting all the defective items but have a relatively high number of false negatives. **Error! Reference source not found.**Hough transform based image segmentation is another method for this purpose.

In the paper we propose a design for deformation detection system using vision based real-time measurements. The objective is to examine and detect shape deformation errors such as changes in the circumference against given data, dents, bumps, or scratches or any other surface errors present in a finished product. The scope of the project is limited to find dimensional errors on an object (using variations in geometrical measurements), identify this while the item moves on a conveyor belt and elimination of defective items with the aid of a mechanical arm/gate. The proposed design was tested on a simulated production environment with a mix of deformed and non-deformed items passing through the detection unit.

The proposed design can be implemented under any factory environment at a low cost, and can be tailored to detect deformations of variety of shapes by programming the PC interface accordingly. The design being cost effective will be ideal to be implemented on small scale industry.

The rest of the paper is organized as follows. Section 2 introduces the system architecture for the unit while deformation detection process is explained in section 3. Results are presented in section 4 with the concluding remarks given in section 5.

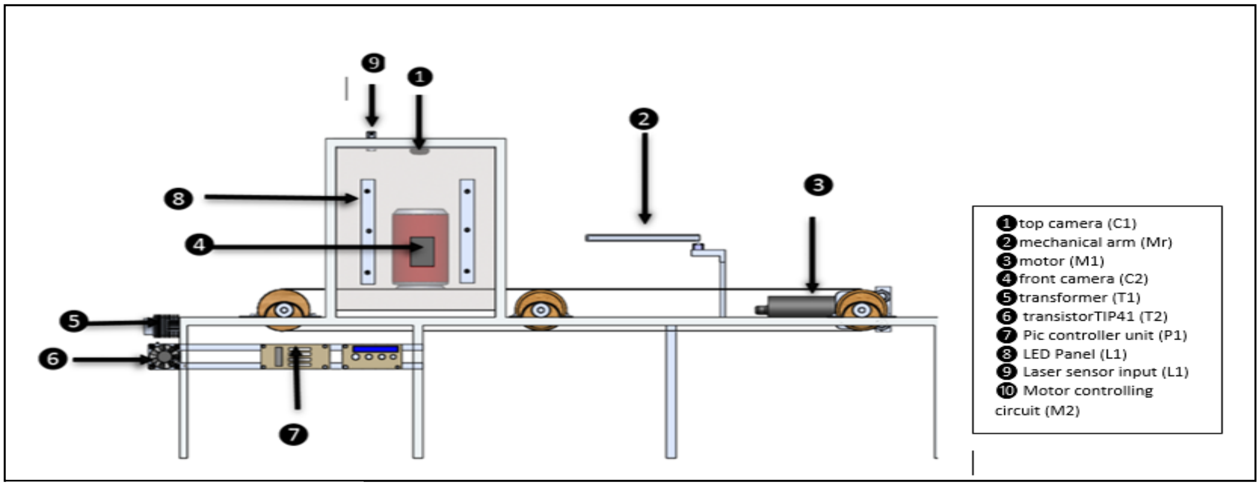


Figure 01: System Architecture

2. DESIGN AND IMPLEMENTATION

The prototype is designed (Figure 01) for inspection of dimensional errors in an empty cylindrical can with standard dimensions. Initially two dimensions are measured; mean diameter and surface area. Measurements are taken while the object is moving along the production line and is eliminated from the line itself using the mechanical arm. When the object just passes L1 it triggers C1 and C2 to take a snapshot. This is done via serial port communication. Necessary sensor value calculation is given below. (Eq.01)

Table 01: parameter specification

V-Supply Voltage	5V
R1-Resistance of the LDR in dark	300Ω
R2-Resistance of the LDR in light	$1.5\times10^{6}\Omega$
R-Load resistor	2140Ω

$$\frac{d}{dR}\left[\left(\frac{R1\times V}{R1+R}\right)-\left(\frac{R2\times V}{R2+R}\right)\right]=0 \qquad \text{[Eq 01]}$$

Camera positioning was done using trial and error method. Camera angle is decided such that it could provide an image with the full height of the object (sample object is an empty can.)

3. PC INTERPHASE AND PROCESSING

Once the image being captured PC Interphase does the inspection for dimensional errors by analyzing the dimensions. Signal through the serial port from M1 triggers the camera. Then, background filtering and conversion to binary RGB .image is then converted to grayscale and then, the image data are exported to a separate background matrix and is subtracted from the original matrix. Then the contrast level is adjusted and the threshold for the binary conversion is defined using ‘gray thresh’ function. Based on the threshold defined the image is then converted to binary using ‘im2bw’ function. Isolating the object of concern is done based on the area and connectivity.

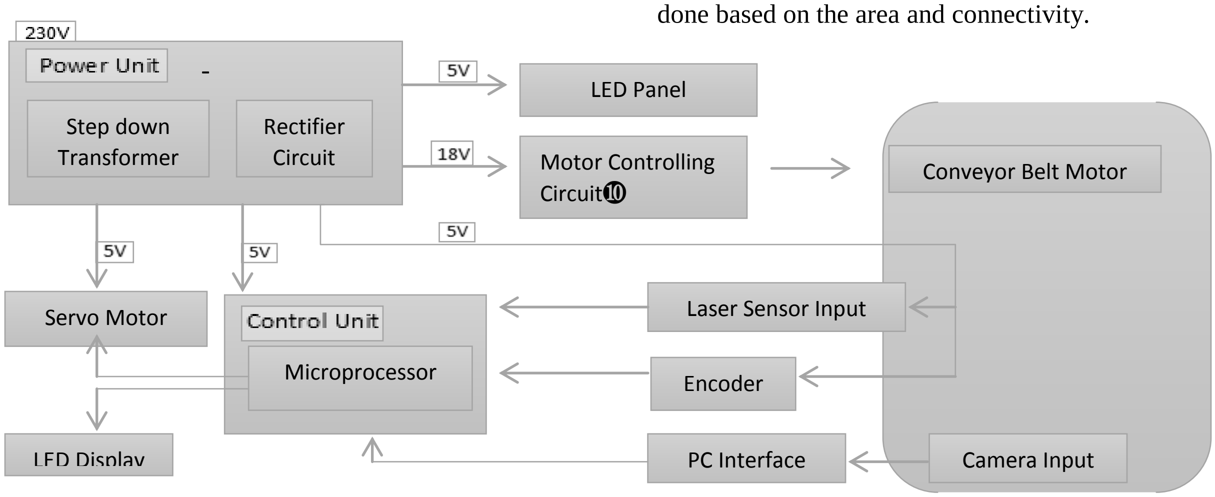


Figure 02: process flow diagram

Table 02: image specifications

Resolution & Image type	320*440 RGB
Software	Mat lab® ® 2013
Toolbox	Image Processing Toolbox, Instrument Control Toolbox
Extension	exe
Modules	UART

The basic logic behind is that our object of concern should be the largest. From the binary image produced objects with small areas are removed using the 'bwareaopen' function. The threshold for removal is obtained from the GUI inputs. Using different field types of Mat lab® inbuilt 'region props' function the dimensional calculations are basically done. Only the properties of objects showing pixel connectivity specified in the GUI are determined.

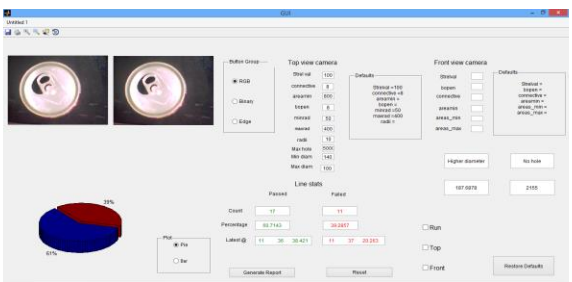


Figure 03: sample GUI view

The front camera determines the hole size (taking the difference between area of the binary image with the image hole filled and unfilled.) and the area of the largest object. The diameter of the lid is calculated using the top camera from boundary pixels of eight directions (check for any unusual folds in it). The difference between filled area and total area of the object is calculated to determine the hole size. For edge tracing we use **canny method [7]** because it has high precision. The Mat lab® 'imdistline' tool is used to measure the distance from the boundary pixels to the center.

hole size is greater than or less than the sizes specified or the equivalent diameter is lesser than the diameter specified or if the diameters calculated from the 8 directions are not approximately equal the program classifies them as defect full and a signal is sent to the arm to remove them while displaying the errors, counts and updating the GUI. If the area of the object is less than or greater than the values specified or if the hole size is not in the range specified the object is classified defect full and a signal is sent to the arm to remove them while displaying the errors, counts and updating the GUI as shown in the figure 03.Associated Mat lab® inbuilt functions for the main code (excludingGUI):

serial,set,fopen,fscanf,fclose,delete,clear,str2double,videoinput,getdata,rgb2gray,start,stop,imopen,strel,imadjust,graythresh,im2bw,bwareaopen,bwconncomp,regionprops,struct2cell,cell2mat,max,edge,imshow,find,imdistline,iptgetapi,zeroes,length,getDistance,setPosition,for,while,diff,axes,clock,bar,pie,etc..And other basic Mat lab® manipulations.

4. DEFORMED OBJECT REMOVAL

This is essentially by a mechanical assembly.in this prototype a simple arm/gate is employed such that it will eliminate defected objects from the path itself. The mechanical arm consists of "SG90" servo motor (S1), Since it can only turn a total of 180° a neutral position of the motor should be defined as the position where the S1 has the same amount of potential rotation in both clockwise and anti-clockwise direction. When S1 is commanded to move, it will move up to a position depending on the width of the pulse sent and hold the position. If an external force is applied against S1 it will resist changing its current position. The resistance for the movement can be increased by repeatedly instructing the pulse width to S1 using a *variable delay method*.

Table 02: Technical specifications

Torque	1.3Kg/cm at 5V
Volts	3v-6v
Weight	9g

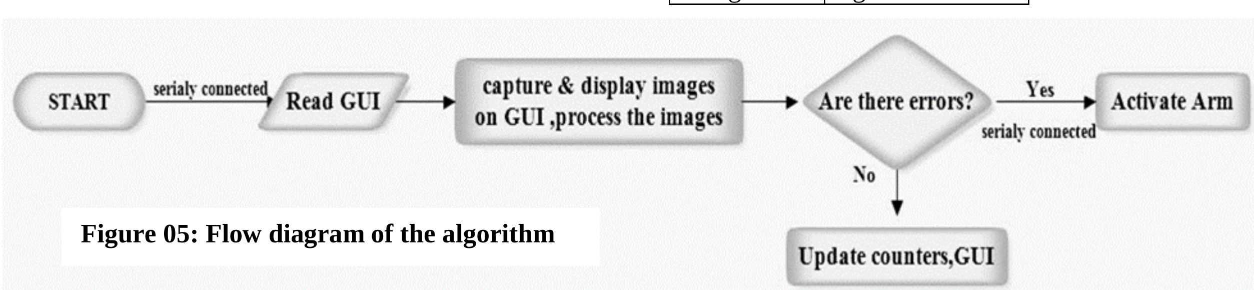


Figure 05: Flow diagram of the algorithm

T1* is used to obtain 18V AC power supply and converted to DC. 18V DC power is directly supplied to M1 *and it is reduced to 5V and supplied for P1*, L1 *and L2* via R1* (regulator 7805).When 18V DC voltage is supplied toM1*, it initially generates 3.8A and drops down to a range of 3.6A-3.5A.L1 requires a constant current 2.2A.since it is impractical to generate this current along with the 5V supply an external current supply is used only for L1.There's a power loss of 13I (total current); conversion of18V to 5V via R1*. In order to compensate the heat loss, heat sinks are used there by reducing the damage that could impact on the power supply circuit. A manual speed controlling system is used. Therefore we use (LM317) M2 *for the motor controller circuit. Since M1operates in a low current range (mA), 3.8A current required for the operation is obtained by an emitter follower circuitT2 *(TIP41).There's a considerable heat generation that would cause a damage to T2* due to amplification of current ranging mA to A. Heat sinks are used to minimize the heat impact.(*referring to the figure 1 and figure2)

5. RESULTS

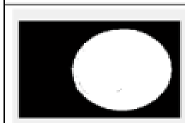
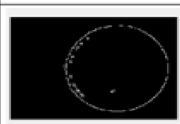
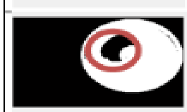
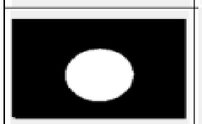
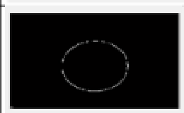
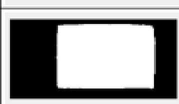
Binary image	Edge tracing	results
		Standard size without holes
		Standard size with holes on the surface
		Low diameter with no holes
		Different shape

Figure 06: comparison of sample

Table 03: sample image result specifications

Maximum diameter deviation	±16 units pixels
Standard can diameter	198 units pixel
Maximum hole size deviation	±35 units pixels.
Standard can hole	0 units

5. CONCLUSION

This paper proposes a deformation detection method for any object on an automated production. The most critical challenge was detection rate since this is online inspection. We were successful in developing our algorithm to proceed within a considerable time and to come up with reliable results as discussed in the latter. The proposed method fails to detect faults in an irregular object. Hence the future work is to develop the algorithm to identify defects in an irregular shape by increasing the no of cameras and coordination of the mechanical arm once the faulty objects being identified. The proposed method is rather feasible and cost effective than existing methods of fault detection and is applicable in most of the manufacturing fields.

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