

QUALITY TESTING OF WATER PUMP PULLEY USING IMAGE PROCESSING

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ABSTRACT: This paper presents an efficient implementation of Image processing technique for an object quality testing. The proposed work makes use of the Matlab software for the said work. Using the image acquisition technique in the Matlab software, the images are taken and various operations are performed for the given object which is Water Pump Pulley. Currently manufactured water pump pulley is tested manually using equipments like Venire calliper, Snap gauge, Air plug gauge, Thread ring gauge which is manual process and may not be accurate. Efficient way to test quality of water pump pulley is by testing its parameters such as diameter, total height, grew height using Image processing. The various operations being performed on the object like image acquisition, edge detection, Image Segmentation etc. For testing the parameters. This paper focuses on a model designed for the automation of the measurements processes for the Water pump pulley which is more efficient & accurate than manual process.

Keywords: Image processing, Water pump pulley, Image acquisition, Image segmentation

1. Introduction

In present day the industry has a lot of manually operated processes. There is manufacturing process. This includes welding, cutting, molding of metal job etc. Being specific about the industry we dealing, the parameters testing of the product (job being developed) is completely manual process. Being a matter of quality and precision, there is no chance for any human error to be introduced in the parameters being measured or calculated. The measurements are carried out by the labor using traditional measuring methods such as:

- Vanier calliper
- Snap gauge
- Air plug gauge
- Thread ring gauge
- Depth venire Pressure gaugeetc.

These methods are precise but involve risk of human errors which depend on the skill of labor used. Any minute error in the measurement may result into some major problems in working of the main machine it is part of. This is going to affect the overall production time required to manufacture the jobs. Also, the implementation of labor for the work requires to bare the human needs to be satisfied, which will affect industry officials and the production. Our work strives to develop a technique

which will cancel all the manual process of measurement. This will ease the industry officials from the strenuous techniques of measurement for each and every job. This will surely reduce the work load. The advantages of the project to the industry are :-

- accuracy in measurement
- Reduction in time dedicated to every job manufactured
- Increases the yield.
- Machines work consistently
- Defects are reduced
- Machine vision works tirelessly
- Machine works the work that complies with the standards required for the industry.

The test object (Water Pump Pulley) is our main object for analysis. The work deals with the automation of Water Pump Pulley using Image Processing. i.e. The measurement processes being carried out manually at present will be atomized with the help of Image processing technique.

2. Proposed Work

Owing to the problems faced by the industry in day to day life for inspection of the pump pulley, we are

trying to develop a system that will get these inspection work done automatically..

Our work aims at developing software based model that will measure the job parameters like

- a.) Total height of job.
- b.) Grew height.
- c.) Outer dimension of the job (diameter)
- d.) Centre bore.

The system is all about developing an Image processing tool for the respective Industry based on Matlab software. The proposed system comprises of mainly Cameras for the object image capturing , the light sources for the proper illumination of the object and the personal computer(PC/ Laptop) to which the cameras will be interfaced. Once the object is placed under the camera, with proper illumination from the light sources used, the cameras placed at different places will capture the respective images of the same object from different angles. These captured images will be sent to the PC via interfaced cable.

The Matlab software present in PC will do the necessary processing on the images.

After processing and comparing them with standard image figures stored in Knowledge (data) base, the dimensions of the above mentioned parameters will be displayed. Based on these parameters, the software will indicate for the right /faulty job done.

After the completion of this processes, the authority or responsible can take necessary action regarding a particular Water pump pulley under inspection.

Design

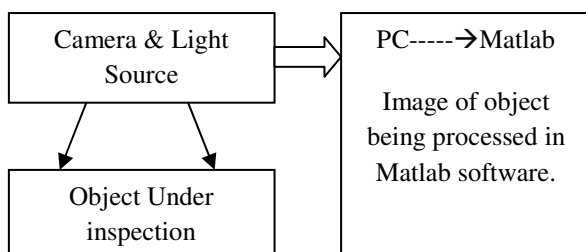


Fig.1. General block of the proposed work.

Figure 1 shows the general block of the proposed work. Idea to place the inspection job (Water Pump Pulley) under a well illuminated light source. Cameras will be used to capture the image of the pump pulley. The same images will be fed to the

Computer / Laptop having the Matlab software and the images will be processed to get the desired results.

2.1 How it will work

Once the images are captured by the cameras, images are fed directly to the PC. The image is then opened in the PC using Matlab software. The Image Acquisition Toolbox in Matlab is used for the various operations on the captured images. These techniques are applied in a step wise manner and the desired results are obtained. The process can be divided into various stages after the image capturing. These stages involve,

- Image Acquisition
- Image Processing
- Image Segmentation
- Feature Extraction
- Classification.

These steps are further explained in detail.

2.2 Steps in the operation

1. Image Acquisition

This step is the very basic step in which the camera /cameras are interfaced to the PC/laptop. And then they are made to capture the image directly from the Matlab software. It means that the captured image is opened straight way in the software. Any preloaded image can also be worked upon in the same manner.

2. Image Processing.

In this step, the image captured by the camera is opened into the Software. This is the step where actual working on the image of the Water Pump Pulley starts. Image is processed in order to reduce its size for further operation. For this , the color image is transformed to a 'grayscale' image.

All further operations will be carried out on the gray scaled image and not on the original image.

Experimental result for ‘Image Processing’



Fig.2 Top view and Side view of pulley .

Image being converted to Gray scale.

3. Image Segmentation

In general terms, image segmentation means dividing a given image into smaller parts. This helps in accurate processing of every details in an image. Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. In image, partitions are different objects which have the same texture or color. The image segmentation results are a set of regions that cover the entire image together and a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristics such as color, intensity, or texture. Adjacent regions are

considerably different with respect to the same individuality. The different approaches for image segmentation are:

- by finding boundaries between regions based on discontinuities in intensity levels,
- thresholds based on the distribution of pixel properties, such as intensity values, and
- Based on finding the regions directly.

Thus the choice of image segmentation technique depends on the problem being considered.

Feature Extraction

The feature extraction technique can be understood in the following steps which include:

- Edge Detection
- Top view diameter measurement of major and minor bores
- Measurement of total height and grew height of water pump pulley.

4. Edge Detection

The edge representation of an image significantly reduces the quantity of data to be processed, yet it retains essential information regarding the shapes of object. An image is easy to incorporate into a large amount of object recognition algorithms used in an artificial vision along with other image processing applications. The major property of the edge detection technique is the ability to extract the exact edge line with proper orientation .

There are different Edge detection techniques .Each technique differs from the other by the way in which it finds or differentiates the edges of an image being taken.

- a) Edge detection using Sobel Operator
- b) Prewitt Operator
- c) Roberts Operator
- d) Canny Operator.

a) Sobel Operator working

-1	-2	-1	+1	+2	+1
0	0	0	0	0	0
+1	+2	+1	-1	-2	-1

Gx

Gy

The operator for Sobel consists of a pair of 3x3 convolution kernels. Kernels are nothing but the ‘information available’. These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these Gx and Gy). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient . The gradient magnitude is given by:

$$(mod G) = \sqrt{(Gx)^2 + (Gy)^2}$$

Typically, an approximate magnitude is computed using:

$$(mod G) = (mod Gx) + (mod Gy)$$

which is much faster to compute.

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\text{Theta} = \arctan (Gy / Gx)$$

b) Robert's cross operator

-1	0
0	+1

Gx

0	-1
+1	0

Gy

The Roberts operator performs a simple, 2 dimensional spatial gradient measurement on a given image. Pixel values at each point in the output show the estimated absolute magnitude of the spatial gradient of the image input at that given point. The operator consists of a pair of 2x2 convolution kernels. These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each

of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these Gx and Gy). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$(\text{mod } G) = \sqrt{(Gx^2) + (Gy^2)}$$

an approximate magnitude is computed using:

$$\text{mod } G = \text{mod } Gx + \text{mod } Gy \text{ which is much faster .}$$

The angle of orientation of the edge giving rise to the spatial gradient is given by:

$$\text{Theta} = \arctan (Gy / Gx) - 3\pi / 4$$

c) Canny Operator

Canny's Edge detector is preferred over all other edge detection techniques. It is because this technique filters the noise present in the given image in more efficient way. The edges detected by the canny algorithm are more clear with minute details of the image.

The algorithmic steps are as follows:

- Convolve image f(r, c) with a Gaussian function to get smooth image f^(r, c).

$$f^{\wedge}(r, c) = f(r, c) * G(r, c, 6)$$

- Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtain as before.

- Apply non-maximal or critical suppression to the gradient magnitude.

- Apply threshold to the non-maximal suppression image.

As stated earlier, Canny operator is not that susceptible to noise as compared to the Sobel, Prewitt, or Robert's operators.

d) Prewitt Operator

Prewitt's operator uses a 3x3 convolution kernel. Prewitt detection is slightly simpler to implement than the Sobel operator, but it tends to produce somewhat noisier results. Hence, the use of Edge detection techniques depends upon the application.

-1	-1	-1
0	0	0
+1	+1	+1

-1	0	+1
-1	0	+1
-1	0	+1

-1	-2	-1
0	0	0
+1	+2	+1

3. Experimental Results

3.1 Experimental results for the above Operators

The above detection techniques are applied on the water pump pulley image and the results are obtained.

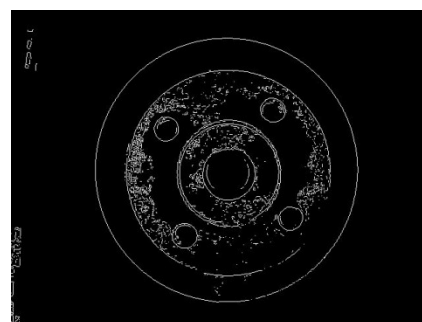


Fig.3. Edge Detection of pulley using Sobel Operator.

This is how the edges will look after being operated using Sobel operator on the given test image.

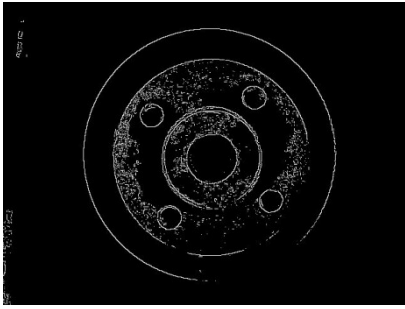


Fig.4 Edge Detection of pulley using Robert's Operator.

This is how the edges will look after being operated using Robert's operator on the given test image.



Fig 5. Edge Detection of pulley using Canny Operator.

This is how the edges will look after being operated using Canny's operator on the given test image.

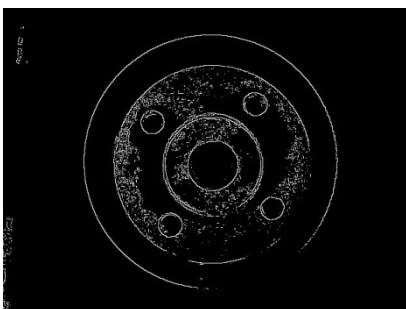


Fig 6 Edge Detection of pulley using Prewitt Operator.

This is how the edges will look after being operated using Prewitt operator on the given test image.

3.2 Diameter calculation for the upper bores on the water pump pulley

For diameter calculation of the diameter the major and minor bore on the top part of the pump pulley, the top view camera image is used. Once this image is converted to gray scale, the main task is to determine the number of circles or bore present on the top of the pulley. This detection is carried out by the technique known as 'Circular Hough Transform'.

How Circular Hough Transform works

In Circular Hough Transform technique, the number of circles on the top of the pulley is determined by overlapping 'dummy circles' on to the bores of the pulley. These dummy circles indicate the presence of exact number of circles. It also calculates the radius and thus diameter of these circles detected. It accomplishes this by finding the center point of the detected circles. By the use of this technique, we accomplish our goal to calculate the said 'outer bore and inner bore' parameter for the pulley. It should also be noted that, all these calculations are affected by light intensity. So, the calculations tend to vary with the intensity of available light.

Experimental results for Circular Hough Transform

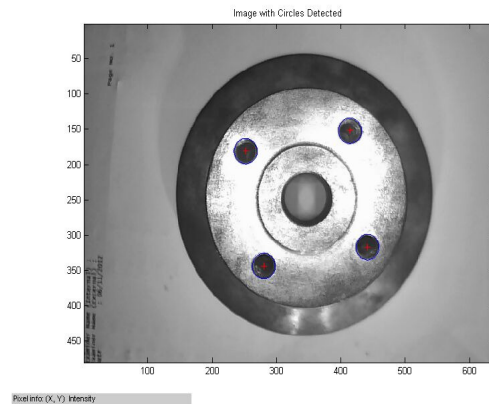


Fig 7. This shows the implementation of Circular Hough Transform technique

From figure 7, it is seen that, the circular Hough transform technique detects the top view circles by overlapping the 'dummy' circles onto it.

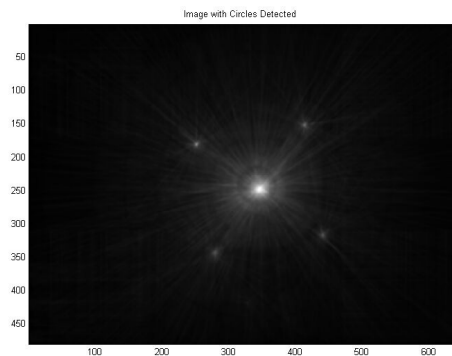


Fig.8 This shows the implementation of Circular Hough Transform Technique and detection of circles (bore)

3.3 Height calculation of the Water Pump Pulley

For the measurement of the remaining parameters of pulley , i.e.

- Total Height
- Grew Height

a) Total Height

We make use of the second camera interfaced to the PC. All previous steps are carried out here as well. After the gray level conversion of the acquired image, code for height measurement is written in Matlab. We achieve our measurements in an opposite way . It means that, we write code for the 'distance measurement ' between two points. Now for us, these two points serve to be the two extreme points of the height of the Pump Pulley. With this code for distance measurement, we can calculate the distance between two points. i.e. the height in case of our pulley.

For this height measurement or (distance measurement) , we can implement this measurement either by defining two points manually by a mouse pointer or a second method with automatic distance calculation.

For this prototype work, we have done this measurement with manual defining of two points on the pulley.

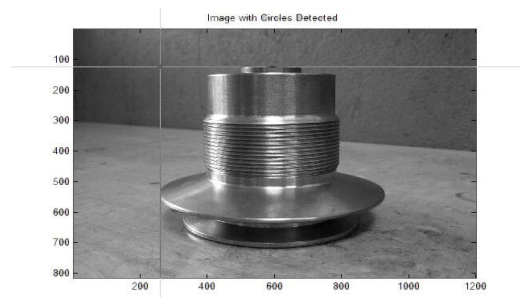


Fig:9 Total & Grew Height calculation

b) Grew Height

For the grew height measurement, the simple method used is to subtract the part of height from the total height, which will give us the required grew height for the object

With the calculation of the total height and grew height, we accomplish the measurement of all the required parameters. After this step, a Knowledge base is developed . This knowledge base will contain the accurate values of the reference water pump pulley. Based on these values , a given test object will be determined whether it's a 'Faulty object' or 'OK object'.

The above detection techniques are applied on the water pump pulley image and the results are obtained.

Advantages

- The very basic need for atomization is to ease the human being from tedious work. This software based system serves the same purpose.
- It generates almost accurate and timely results for the application being used.
- This is nothing but the Machine Vision used for the inspection.
- It can tirelessly perform without complaining.
- It is highly efficient compared to the human labour as their counterpart.
- As the time necessary for every work piece to be measured is reduced, can surely increase the production yield.
- Doesn't require continuous attention for inspection. Once started, it can operate for hours without even bothering the human labour associated with the given task.
- The Water pump pulley dimensions need to be accurate at micron level.
- The production is done nearly equal to this .
- This minute measurements are possible only with the software technique being implemented.

Limitations of this technique

- Parameters that need to be considered while designing the system are in great number.
- So small change in the same can alter the motive for which it is designed.
- Proper alignment of cameras is necessary for capturing sharp job image.

- Sufficient light intensity is required for capturing correct image

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Conclusion

This paper focuses on method of code being developed to test the quality parameters of a Water Pump Pulley & also provides detailed information about steps involved in the Quality testing of the given object. The same can be used for other objects as well. Which would prove this Quality testing using Image Processing an universal way for automation of industrial work. So this atomization will be more beneficial to industry than a manual work which will be more precise & accurate as it eliminates human errors in testing.

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