Visual Inspection of Motorcycle Connecting Rods

Image Processing and Computer Vision Mini Project

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Masters in Artificial Intelligence

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2022 - 2023

1 Abstract

The aim of this mini project is to create an algorithmic solution or software system designed for the visual examination of motorcycle connecting rods, distinguishing between Type A (one-hole) and Type B (two-hole) rods while analyzing their dimensions and positional characteristics. Images depicting connecting rods arranged in the inspection area are captured using the backlight technique. In the first task, the primary objectives involve identifying the rod type, determining position and orientation (modulo π), measuring Length (L), Width (W), Width at the barycenter (WB), and obtaining the position of the center and diameter size for each hole. The rods in these images are deliberately positioned apart from each other and do not make contact. For the second task, the system is tasked to handle images where the inspection area may be dirty due to the presence of scattered iron powder while maintaining similar inspection criteria as in the first task. A combination of median filters and Morphological operations are performed to tackle the noise. Both tasks are executed using OpenCV libraries to facilitate the analysis and processing of the provided images.

2 Task 1

- Thresholding and Connected Component Analysis:

  Initially, the image is read and converted into a binary thresholded image using Otsu's thresholding method (threshold function). This converts the grayscale image into a binary image, highlighting the regions of interest (connecting rods). Invertion of bits of an image is performed, essentially performing a bitwise 'NOT' operation on each pixel. The connected component analysis (connectedComponentsWithStats function) then identifies distinct components or individual regions within the binary image, which correspond to the separate connecting rods.

- Rod Inspection Loop:

  The inspection is carried out for each identified rod. The code iterates through each connected component and processes it separately. It finds contours within the identified region, considering these contours as separate entities within the same connected component.

- Rod Type Identification:

  Based on the number of contours detected within each connected component, the system distinguishes between Type A and Type B rods. Type A rods typically have two contours (one for the main rod body and one for the hole), whereas Type B rods has 3 contours due to additional hole.

- Hole Detection and Analysis:

  For each contour detected beyond the main body contour, the code identifies these as holes. It computes the position of the hole's center and its diameter using contour analysis and geometric calculations (minEnclosingCircle).

- Dimensional Analysis:

  It calculates the minimum area bounding rectangle for the main body of the rod to determine its width, height, and angle of rotation relative to the image axis (minAreaRect).

  The calculate_angle function computes the orientation angle of a rectangle by evaluating the angles formed between two edges of the rectangle, determined using the atan2 function in radians. It then converts these radian angles to degrees. The function corrects negative angles to their corresponding positive values within the range of 0 to 180 degrees, ensuring a consistent representation of the rectangle's orientation angle.

  The centroid of the rod is obtained based on the rod's main body contour(moments). Additionally, it computes the width at the barycenter, which is determined using the distance transform (distanceTransform) around the centroid of the rod.

  The inspection results, including identified contours, hole positions, dimensions, and angles, are plotted and displayed for each rod using Matplotlib subplots.

2.1 Sample Result

Rod 1 is of type A
Position of center of hole and diameter are (179, 68) and 26.5
Rod 1 width at barycenter: 15.18
Rod 1 Angle: 69.64 degrees
Rod 1 Center: (198, 113)
Rod 1 width, height: 39.78, 169.35

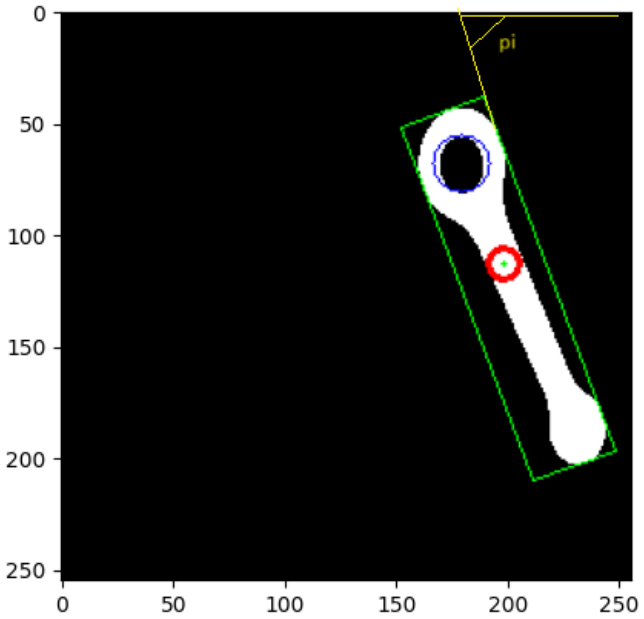
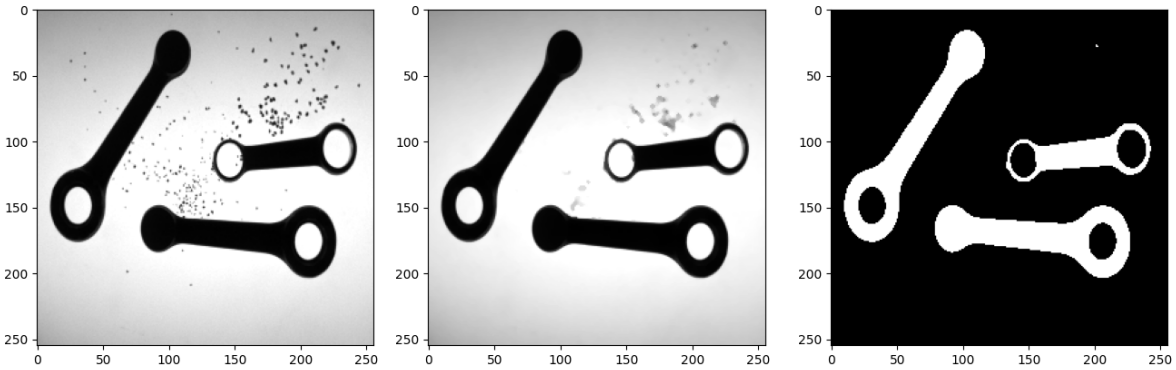


Figure 2.1: TESI00 image rod 3 output (yellow line is only for illustration purpose)

3 Task 2 (Iron dust powder challenge)

In Task 2, the images have undergone additional preprocessing due to potential contamination from scattered iron powder in the inspection area. This process follows the same procedure as Task 1, with a few modifications:

- Three Median filters of kernel size 5 are applied before thresholding to minimize the dust powder noise.
- Morphological opening is performed with a kernel size of 2x2 to remove the leftover white noise followed by a dilatation with the same kernel to enhance the lost edges(white foreground) of the connecting rods.



(a) Original image (b) after median filters (c) binary threshold image

Figure 3.1: Task2 de-noising procedure

Figure 3.1 shows the original image followed by the output of 3 median filters and binary threshold image, which undergoes morphological opening to eliminate noise and dilation to enhance brighter areas.

3.1 Sample Result

Rod 3 is of type A
Position of the center of the hole and diameter are (30, 148) and 29.42
Rod 3 width at barycenter: 17.58
Rod 3 Angle: 118.58 degrees
Rod 3 Center: (58, 104)
Rod 3 width, height: 44.85, 178.62

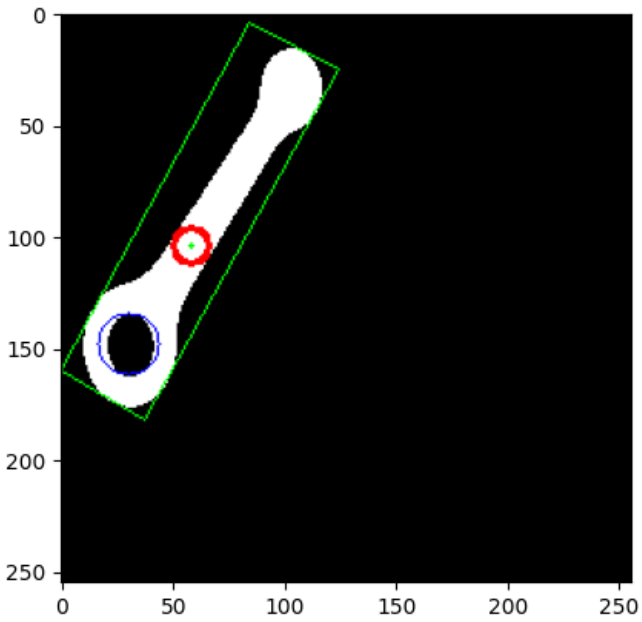


Figure 3.2: TESI92 Rod 3 output Inspection result(with dust powder)