

QUALITY CHECK ANALYSIS OF GEAR ERROR DETECTION

Dr. Baliram Sambhaji Gayal*1, Aniket Dubbawar*2, Sakshi Uttarwar*3, Om Jadhav*4

*1,2,3,4Dept Of E&TC ,RMD Sinhgad School Of Engineering , Pune-58, India.

Abstract- In traditional sampling methods, manufacturers often inspect only a few items—such as 2 or 3 gears out of a batch of 100—to determine overall quality. However, this approach risks rejecting entire batches due to minor errors in just a few gears. To address this limitation, our project focuses on developing an automated system capable of inspecting every individual gear in a batch. The system incorporates a conveyor belt for gear movement, a high-resolution camera for capturing images, and a backend database containing reference gear parameters. Each gear's captured image is analyzed using computer vision techniques and compared to the stored parameters. If a match is found, the gear is sorted into the accepted lot; otherwise, it is rejected using an automated shooting mechanism. Precise measurement is critical in gear inspection, yet conventional methods are either too slow or costly. Moreover, no single method currently offers the capability to efficiently and accurately measure all gear parameters. Our proposed solution utilizes computer vision to establish a non-contact, rapid inspection system specifically for spur gears. The vision system is calibrated in metric units and validated by comparing measurements of sample gears to their known parameters. This approach yields higher accuracy for smaller gears with minimal deviation, enhancing overall efficiency and reliability.

Index Terms- Matlab, Arduino, Image Processing.

I. INTRODUCTION

Gears are fundamental mechanical elements used extensively to transmit rotational motion and power between shafts. They come in various forms such as spur gears, helical gears, and worm gears, each suited for specific applications based on load and speed requirements. Gear mechanisms are widely implemented in different types of machinery, including automobiles, metal-cutting tools, material handling equipment, rolling mills, and marine engines. A significant advantage of gear-based power transmission is that it exhibits relatively low frictional and transmission losses.

In this work, we utilize the software “MATLAB” to analyze and calculate various gear parameters. MATLAB is a powerful tool often used in engineering and research fields due to its high level of accuracy and wide range of built-in functionalities. It allows for the development of user-friendly programs that prompt users for input values and then perform design calculations to deliver accurate results. The use of such software not only simplifies the gear design process but also enhances reliability and reduces human error.

As industries move toward automation to save time and reduce cost, tasks traditionally performed by human workers—like gear classification and inspection—are being handled by algorithms and computing systems. Manual inspection is often time-consuming and inconsistent, so the integration of imaging devices such as cameras and scanners, along with intelligent classification algorithms, offers a more efficient solution. Using technologies like Digital Signal Processing (DSP) and Digital Image Processing (DIP), gear characteristics such as size, pitch, and tooth profile can be extracted directly from captured images. These modern techniques allow for non-contact, fast, and accurate gear inspection, making them highly suitable for large-scale industrial applications.

II. LITRATURE REVIEW

2.1 Haque Nawaz, Himat Ali, “Gear Measurement Using Image Processing in Matlab”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) This paper focuses on measuring specific features of a gear using image processing techniques in MATLAB. The primary objective is to determine the area of the gear from its image and count the number of teeth accurately. The authors addressed the challenges related to feature extraction from gear images by developing a MATLAB-based tool. This tool successfully measures the gear's area and counts its teeth. For validation, five distinct gear images were analyzed, and the results demonstrated the effectiveness of the approach in feature extraction using image processing methods.

2.2 Cheng Pengfei and Feng Changyong Henan, “Characteristic Value Extraction of Gear Defect Based on Image Processing”, *Journal of Multimedia*, 2013, Volume-8, pp. 198–205

This study explores defect identification in gears using image processing by extracting characteristic values and contrast features. It introduces two image-based expressions of gear defects and utilizes the gray-level co-occurrence matrix (GLCM) for feature extraction. To evaluate the detection of defects such as pitting and wear, a recognition model is constructed using a nearest-neighbor approach. Although the method yields correct outcomes, the recognition accuracy remains an area for improvement. Additionally, eccentricity and circularity values, derived from image morphology, are used as critical indicators of gear condition.

2.3 Zhang Jing, “The Research on the Application to Digital Image Technology in Hypoid Gear Contact Zone Detection”, *Journal of Computers*, 2011

This paper highlights the growing application of digital image technology across various fields, particularly in detecting contact patterns in hypoid gears. It emphasizes the need for the development of advanced, intelligent, and integrated detection systems that incorporate cutting-edge technologies such as computer systems, digital signal processing (DSP), and image analysis. The integration of these technologies forms the foundation of modern image-based gear inspection, which contributes significantly to technological advancement and automation in gear analysis.

III. METHODOLOGY

In this work, an image processing-based methodology was implemented using MATLAB to automate the measurement and analysis of spur gear parameters. The objective was to accurately extract essential geometric features such as the number of teeth, gear area, outer and inner diameters, pitch circle diameter (PCD), module, and tooth height—parameters critical to gear design and quality inspection.

The process initiates by importing the gear image in RGB format, which is then converted to a grayscale image to simplify further processing by reducing color redundancy. A suitable threshold value is calculated for the grayscale image, which is then used to binarize the image. This transformation distinguishes the gear object from the background, with the gear represented in white (foreground) and the background in black (background). To enhance the quality of the binary image, small artifacts and noise are eliminated using morphological operations. Subsequently, internal holes within the gear object, which may result from inconsistent lighting or surface texture, are filled to restore the gear's complete geometry. This ensures accurate boundary detection and surface area computation.

The binary image is then analyzed to measure the area of the gear object. Region properties such as centroid, bounding box, and orientation are extracted using built-in MATLAB functions. Convex hull algorithms are applied to the segmented gear regions to simplify complex boundaries and enhance contour accuracy.

To detect and count the teeth, the convexified regions are further processed and highlighted using visual overlays. These overlays, typically rendered in red and yellow lines, correspond to the teeth boundaries and serve as reference points for tooth count estimation.

The developed MATLAB code was tested on five distinct gear images by altering the file names within the same script. For each sample, the system successfully computed key gear parameters, including addendum (outer) diameter, dedendum (inner) diameter, PCD, module, tooth count, and tooth height. The results, validated through visual annotations and numerical outputs, demonstrate the system's reliability and repeatability.

This automated approach significantly reduces human involvement and enhances inspection efficiency. The integration of digital image processing in gear measurement provides a rapid, non-contact, and cost-effective alternative to conventional mechanical methods, making it suitable for industrial applications requiring precision and speed.

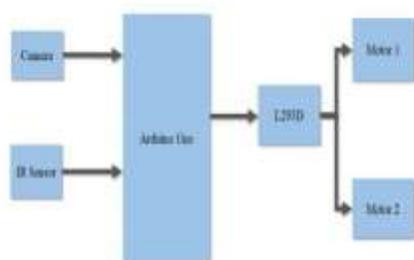


Figure 1: System Architecture

IV. WORKING

MATLAB-based image processing approach was developed to analyze and extract key geometrical features from spur gear images. The process begins with reading the original gear image and converting it into a grayscale format to simplify further analysis. A threshold value is then computed from the grayscale image, which is subsequently used to convert the image into a binary format. This binarization step effectively differentiates the gear object from the background.

Following this, small unwanted objects and noise present in the binary image are removed using morphological operations. To ensure completeness of the gear shape, any internal holes within the gear object are filled. This step is essential for accurately identifying the gear boundary and calculating its surface area.

The next phase involves computing the region properties of the gear object using MATLAB's built-in functions. After identifying the object regions, convex hull algorithms are applied to smoothen the gear contours and approximate the polygonal boundaries more accurately. These processed regions are then transformed into regions of interest (ROI), where the gear teeth are highlighted using red and yellow boundary lines. This visual overlay assists in the detection and counting of gear teeth.

The developed code was tested on five different gear samples by modifying only the input image names, demonstrating the reusability and scalability of the approach. Experimental results validate the effectiveness of the method in accurately computing essential gear parameters, including the outer diameter (addendum diameter), inner diameter (dedendum diameter), pitch circle diameter (PCD), module, number of teeth, and tooth height.

The outcomes, presented in the results section, confirm the capability of the system to perform automated, non-contact gear inspection, offering a reliable and efficient alternative to traditional manual measurement methods.

V. RESULT

5.1 Analysis of the Right Gear

The MATLAB platform was utilized to extract and analyze the key geometric parameters of a properly manufactured gear, designated as the "Right Gear." This process involved applying several image processing techniques, with the outcomes displayed in different MATLAB windows and the Command Window.

Command Window Output: The gear characteristics calculated include:

Inner Diameter: 24 mm **Outer Diameter:** 27 mm **Number of Teeth:** 12 **Tooth Height:** 1 mm

Pitch Circle Diameter (PCD): 24.828 mm

Module: 2.069 mm

Figure 2: Presents an enhanced and filtered image of the gear, facilitating clearer visualization of its shape and edges.

Figure 3: Shows a comparison between the original input image and its denoised version, where noise reduction has improved feature clarity.

Figure 4: Illustrates the segmentation results:

The **Otsu thresholded image** separates the gear from the background.

The **segmented image** outlines the gear boundary in red, assisting in precise edge detection.

Figure 5: Displays a zoomed-in image of the gear with its centroid marked in red, useful for alignment and further analysis.

Figure 5.1 captures the complete results of this right gear assessment, including all relevant visual outputs.

5.2 Analysis of the Defective Gear

The analysis was also performed on a gear identified as defective. The same image processing workflow was applied to detect abnormalities.

Command Window Output: The computed parameters are:

Inner Diameter: 24 mm **Outer Diameter:** 28 mm **Number of Teeth:** 10 **Tooth Height:** 1 mm

Pitch Circle Diameter (PCD): 24.67 mm

Module: 2.067 mm

The decrease in tooth count along with the increased outer diameter suggests wear or damage to the gear.

Figure 2: Shows an enhanced image highlighting the defective gear's structure and edges.

Figure 3: Compares the original image and the noise-reduced version, improving the visibility of the gear's features.

Figure 4: Includes:

The **Otsu thresholded image** used to isolate the gear. The **segmented image**, where the gear boundary is highlighted in red, revealing any structural defects or irregularities.

Figure 5: Shows a cropped image of the defective gear with its centroid marked in red for further geometric examination.

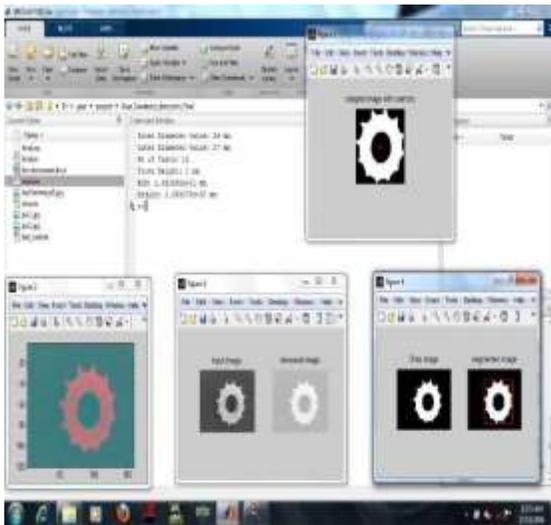


Fig 4.1.1 Right gear result

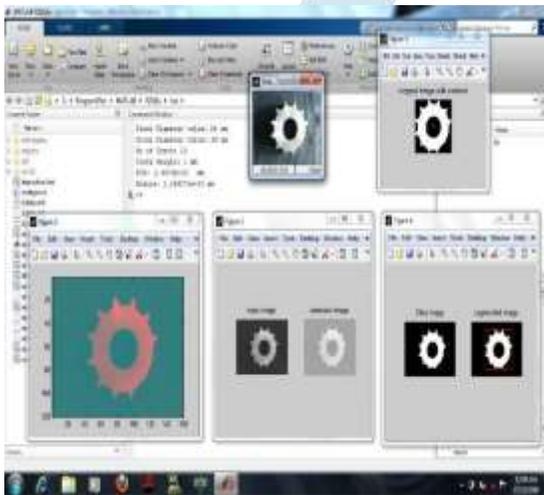


Fig 4.1.2 Defective gear result

VI. FUTURE SCOPE

1. Suitable for use in nut and gear manufacturing industries.
2. Can be implemented in quality control departments across various industries.
3. Applicable specifically within gear production units.
4. Utilized in the automotive sector.
5. Enables comprehensive error detection.
6. Effective for both small-scale and large-scale industrial operations.
7. The results can be effectively applied in mechanical engineering as well as automotive fields.
8. Offers a cost-efficient method for error inspection.
9. Applicable to all types of gears.
10. Capable of testing various circular components.
11. Widely used in automotive manufacturing.
12. Also applicable in medical facilities.

VII. CONCLUSION

The gear area was calculated and the number of teeth was counted using image processing techniques implemented in MATLAB. This study involved processing five different gear images through a custom-developed MATLAB code, with each gear exhibiting distinct area values and varying numbers of teeth. All measurements were obtained consistently using the same MATLAB program. MATLAB's image processing capabilities enable precise measurement of gear objects by applying specialized algorithms to digital images. Digital image processing involves analyzing and manipulating images using computers based on specific algorithms. In the future, these image processing techniques hold great potential for application across diverse fields. Digital image processing encompasses several branches, including image transformation, enhancement and restoration, segmentation, analysis, recognition, and other related methods. MATLAB, as a high-level programming language, offers robust data processing features that make it highly suitable and widely used for digital image processing tasks. In conclusion, image processing technology proves to be highly effective and valuable across multiple industries such as manufacturing, automotive, aerospace, medical and biological research, remote sensing, and digital photography. Experiments can be performed on a personal computer with a configuration: Intel (R) Core (TM) i7- 2120 CPU @ 3.30GHz, 8GB memory, Windows, MySQL backend database and Jdk 1.8. The application is web application used tool for design code in Eclipse and execute on Tomcat server.

ACKNOWLEDGEMENT

The gear area was calculated and the number of teeth was counted using image processing techniques implemented in MATLAB. This study involved processing five different gear images through a custom-developed MATLAB code, with each gear exhibiting distinct area values and varying numbers of teeth. All measurements were obtained consistently using the same MATLAB program. MATLAB's image processing capabilities enable precise measurement of gear objects by applying specialized algorithms to digital images. Digital image processing involves analyzing and manipulating images using computers based on specific algorithms. In the future, these image processing techniques hold great potential for application across diverse fields. Digital image processing encompasses several branches, including image transformation, enhancement and restoration, segmentation, analysis, recognition, and other related methods. MATLAB, as a high-level programming language, offers robust data processing features that make it highly suitable and widely used for digital image processing tasks. In conclusion, image processing technology proves to be highly effective and valuable across multiple industries such as manufacturing, automotive, aerospace, medical and biological research, remote sensing, and digital photography.

REFERENCES

- [1] E.S. Gadelmawla 'Computer Vision Algorithms For Measurement and Inspection Of Spur Gears', Measurement 44(2011) 1669-1678.
- [2] Amandeep Mavi, Mandeep Kaur 'Identfy Defects In Gears Using Digital Image Processing' ISSN:2278-067X, Volume1, Issue 6(June2012)
- [3] MD. Hazrat Ali, Syuhei Kurokawa, Kensuke Uesugi 'Vision Based Measurement System For Gear Profile' IEEE 2013
- [4] MD. Hazrat Ali, Syuhei Kurokawa, Kensuke Uesugi ' Camera Based Precision Measurement In Improving Measurement Accuracy' Measurement 49(2014) 138-147.
- [5] Sanjana HK, Soniya MG, Sunitha NR, Vismitha PV 'Quality management Of Mechanical Parts Using Image Processing' ISSN:2229-6093(2017)
- [6] Shipley E. E., "Gear Failures", Penton Publishing Co., Clevelenad, Ohio, 1967.
- [7] Decker H.J., "Gear crack detection using tooth analysis", NASA-TM2002-211491, 2002
- [8] Loutridis S. J., "Gear failure prediction using multi- scale local statistics", Engineering Structures, 30 (2008), 1214–1223.
- [9] Samuel P. D., Pines D. J., "A review of vibration- based techniques for helicopter transmission diagnostics", Journal of Sound and Vibration
- [10] Lei Y. G., Lin J., Zou M. J., He Z. J., "Condition monitoring and fault diagnosis of planetary gearboxes: a review", Measurement, 48 (2014).
- [11] Haque Nawaz, Himat Ali , "Gear Measurement Using Image Processing in Matlab", 'International Journal of Innovative Technology and Exploring