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Gear Error Detection Using Image Processing

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Abstract— A sampling method of gathering representative data from a group. For example, a manufacturer might check only 2 or 3 gears from a batch of 100 gears. Due to which the whole lot gets rejected if any gear in between has error in it. Thus, we need to check each and every gear in the batch but manually this process is time consuming. In our project we are designing and manufacturing a system which will be checking each and every gear. We use a conveyor belt for movement of gear, a camera for capturing and checking the gear parameters for its error by comparing the parameters stored at the back end. If the parameters are matched with the stored parameters, then it goes to the accepted lot otherwise with the help of shooting gun it goes to the rejected lot. Precision measurement of gears plays a vital role in gear measurement and inspection. The current methods of gear measurement are either time consuming or expensive. In addition, no single measurement method is available and capable of accurately measuring all gear parameters while significantly reducing the measurement time.

Index Terms— **Gear error detection, image processing.**

1. Introduction

Gear manufacturing, an indispensable element of machinery production, is an intricate process that underpins the functionality of countless mechanical systems, from automobiles and industrial machines to marine vessels and power plants. However, the gear production industry faces a critical real-time challenge: ensuring the quality and precision of gears while managing the ever- increasing demand for efficiency and cost- effectiveness.

Traditional methods of gear inspection, often reliant on manual labor, are not only time-consuming but also prone to human error, potentially leading to the rejection of entire batches of gears due to a single fault. In response to this dilemma, our project emerges as a solution that bridges the gap between the need for meticulous gear inspection.

2. Literature Review

Jia-Xian Jian and Chuin-Mu Wang [2] In this paper the authors address the issue of expensive gear defect detection equipment that many small and medium-sized enterprises cannot afford. Recognizing the critical need for affordable yet effective solutions, they propose a novel method that leverages artificial intelligence (AI) technology for detecting gear defects, focusing on gear tooth profiles, tooth pitches, and central holes. The authors outline a comprehensive four-step process, integrating deep learning models to improve the detection accuracy and overall efficiency of the inspection process. The first step involves ResNet, a convolutional neural network, used for image completeness classification, which ensures that the images fed into the system are intact and free of anomalies. In the second step, YOLOv4, a state-of-the-art object detection model. The third step involves the use of UNet, a deep learning model designed for image segmentation, which helps segment the areas of interest from the detected target regions for further analysis. Lastly, data augmentation techniques are employed to increase the diversity and quantity of the training dataset, ultimately enhancing the model's generalization ability. various industrial settings.

3. Methodology

1) The design of a gear profile error detector for a specific application involves several steps.
2) The first step is to consider the design of the conveyor belt, taking into account operational conditions and intended applications.
3) The next step is to analyze the conveyor belt design using ANSYS software for both static and dynamic conditions.
4) Theoretical comparisons of the basic operational parameters of the gear profile error detector can then be made.
5) One potential solution for detecting gear profile errors is through the use of imaging technology and computer-aided MATLAB algorithms.
6) The basic idea is to capture an image of the gear, convert it to grayscale, and simplify the colors using a median filtering algorithm.
7) After then, the picture is transformed to black and white pixels, with just the white pixels indicating the gear.

A. Circuit Diagram

First, we will design gear profile error detector suitable to our application. We need to design the conveyor belt taking into consideration the applications and operational conditions. Then we will analyze the design in ANSYS for static and dynamic conditions. Theoretically we will compare basic operational parameter of designed gear profile error detector. By using MATLAB software, we will do the programming of the error detector. Digital image processing processes and evaluates images through computer with particular algorithm. At present, image processing techniques have been applied and researched

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in various fields with great achievement. Digital image processing can divide into: image transformation, image intensification and restoration, image segmentation, image analysis, image recognition and other technique branches. MATLAB as one kind of high-level computer language, it has a powerful data processing ability that obtains widely application in digital image processing. This paper takes advantage of MATLAB image processing for gear defect detection. Gear shows different defect forms during the using process Corrosive pitting and attrition.

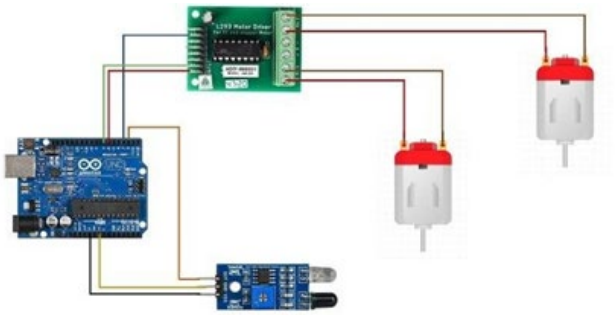

Fig. 1. Circuit diagram

B. Flow Chart

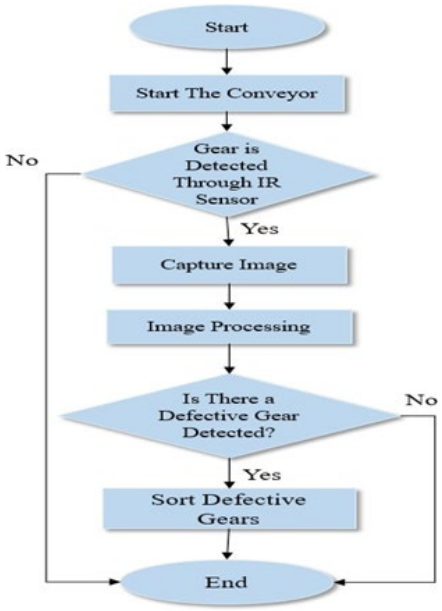

Fig. 2. Flowchart

This project's workflow involves several key stages. It begins with the acquisition of high-resolution gear images using strategically placed cameras. After image preprocessing to enhance quality, relevant features are extracted from the gear images. Image processing algorithms are then applied to detect defects on gear profiles, and a classification model assesses defect types and severity Based on this assessment, decisions are made regarding gear acceptance or rejection. The entire process is implemented in real-time, ensuring efficient inspection as gears move along the production line. A user-friendly interface provides insights into detected defects, statistics, and visual representations for further quality control. This project combines image processing.

4. Tools and Technology Used

1. DC motors
2. L293D motor driver
3. IR sensor
4. Camera
5. MATLAB

A. Applications

i. Manufacturing Industry
ii. Quality Control
iii. Automotive Sector
iv. Customized Gear Manufacturing

B. Advantages

i. Provides accurate measurements, ensuring reliable detection of gear errors or defects.
ii. Enables immediate inspection during manufacturing, reducing manual labor and time.
iii. Reduces costs associated with manual inspection processes, minimizing human errors.

5. Results and Analysis

The gear profile error detection project culminates in a comprehensive system capable of accurately identifying and inspecting gears for defects. Through meticulous integration of components such as IR sensors, Arduino Uno circuits, cameras, MATLAB software, and microcontroller ICs, the system streamlines the inspection process with precision and efficiency. Upon gear detection, the Arduino Uno circuit orchestrates motor speeds and delays, while MATLAB employs sophisticated image processing techniques to analyze captured images. By calculating gear parameters and discerning defects, the system ensures meticulous inspection, enhancing quality control measures. The microcontroller IC governs motor operations, initiating conveyor movement or halting as dictated by MATLAB's assessment of gear quality.

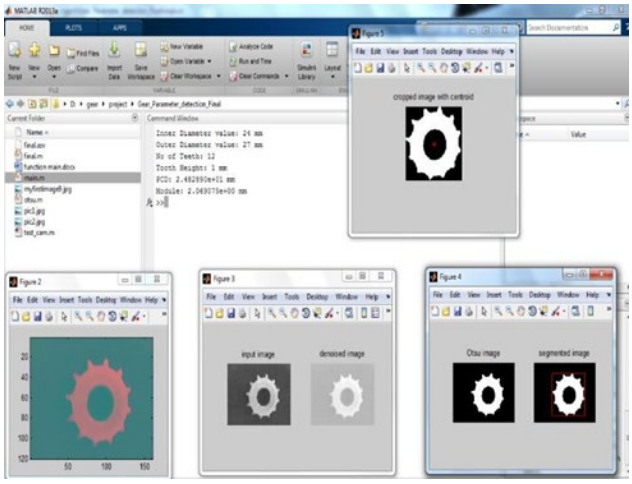

Fig. 3. Right gear result

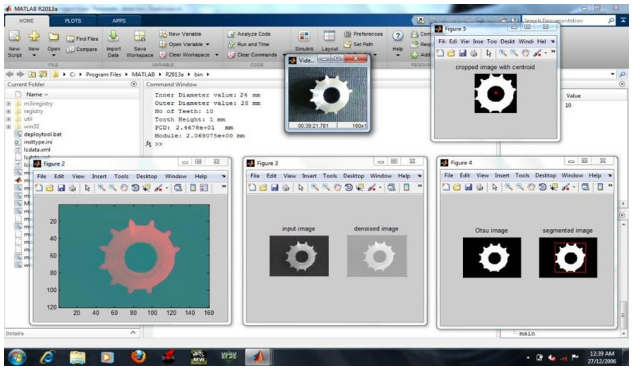

Fig. 4. Defective gear

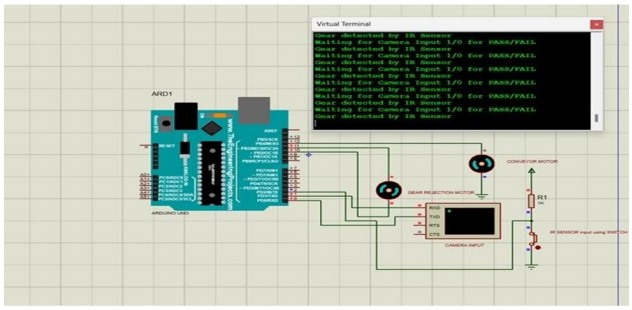

Fig. 5. Simulation

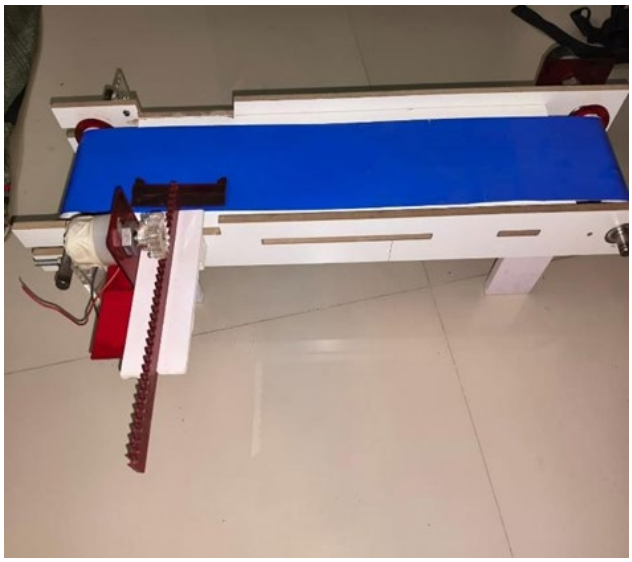

Fig. 6. Output

6. Future Scope

It is utilized in nut and gear manufacturing industries. This technology is commonly implemented in quality control departments across various industries. It finds applications in gear manufacturing units for efficient error detection. The automobile industry extensively utilizes this technology for error detection and quality assurance. It facilitates comprehensive error checking, ensuring high-quality production standards.

7. Conclusion

The utilization of image processing techniques in MATLAB has proven to be instrumental in gear inspection, facilitating efficient measurement of gear area and teeth count. Through the developed MATLAB code, gear objects from five different images were processed, revealing varying area values and teeth counts. This approach not only enables swift gear inspection but also finds applications across diverse industries such as nut and gear manufacturing, quality control departments, automobile manufacturing, and both small and large-scale industries. The versatility of this technology extends beyond gear inspection, encompassing fields like space exploration, medical research, remote sensing, and computerized photography. In conclusion, image processing technology holds significant potential for enhancing productivity and accuracy across various industrial sectors and scientific domains.

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