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AI Based Quality Analysis of Industrial Products

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Abstract

The project introduces a new method for sampling data from a group, addressing limitations in traditional approaches. It highlights inefficiencies in inspecting only a few items from a batch, potentially leading to the rejection of entire lots due to isolated errors. To counter these challenges, a system is being designed to automatically inspect every gear in a batch. This system incorporates a conveyor belt for gear movement and a camera for analyzing gear parameters. Parameters are compared against those stored in a backend database, with gears meeting the specified criteria directed to the accepted lot and those failing diverted to the rejected lot using a shooting gun mechanism. This automated approach aims to enhance efficiency and accuracy in quality control, eliminating manual inspection and reducing the risk of rejecting entire lots due to isolated errors.

Keywords: Gear, MATLAB, Image processing, Manufacturing industries, Power transmission

INTRODUCTION

The main function of a gear, a mechanical part that is frequently employed, is to transfer power from one shaft to another. There are numerous varieties of these gears, including worm gears, helical gears, and spur gears.

Numerous machines, including cars, metalworking tools, material handling machinery, rolling mills, marine power plants, etc., use gear drives. With this kind of power transmission equipment, friction and other losses are relatively minimal [1].

In this work, gear parameters are determined using a program named "MATLAB." For scientific and research purposes, MATLAB is widely utilized. It is accurate and multifunctional due to its many built-in features. When the software is run, it asks for inputs, completes the required design calculations, and is user-friendly.

In the current era of rapid computation, where time, money, and capital are valuable commodities, computers, algorithms, and computing agents are gradually taking the place of human or semi-human interaction in the manufacturing and processing industries. In industries where gears are necessary, human labor is used to filter and classify the gears, a process that is crucial and is constrained by labor costs and working hours. Imaging tools like cameras and scanners can be used for classification, together with the creation of an algorithm that specifies what should be accepted and rejected [2].

Because it keeps producing great results and advancing technical growth, computer science image processing technology is progressively finding its way into our daily lives. In order to conduct research and develop more sophisticated computer technologies, such as DSP (digital signal

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processing) and DIP (digital image processing), technology plays a crucial role in presenting gear size and measurement. By utilizing these technologies, we will be able to measure the picture object features with ease.

Measuring is a crucial step in limiting the gear to a particular size. The essential work has been done to measure the following, which are its most crucial characteristics, utilizing image processing. a. To determine the addendum diameter, or outer diameter [2].

a. To determine the inner diameter, or diameter of the dendum.
b. To determine how many teeth the gear image object has.
c. To determine the height of teeth.
d. To figure out the gear PCD.
e. To determine the gear module.

To achieve this, we first transformed the original gear image object into grayscale. Next, we counted the gear's teeth using the original gear image's grayscale. This means that we measure the gear teeth in relation to the teeth counted by image processing by applying programming code.

Gears are employed in machinery, and while gear transmissions guarantee the modification of motion through the linear and rotary development of the gear, we know that they can be used to change a machine's motion property. It is outdated technology, and sophisticated gear transmission was created at the time of invention.

Taking into account the number of gear teeth and quantifying the gear object complexity of transmission. Commercial cars' gear gearboxes are measured using this geometry. This section provides a technical overview of basic gear. On the other hand, a rudimentary understanding of the gear is required for its proper use and design [3]. According to the research, the Gear teeth could be measured using specialized tooth calipers. Various gear kinds are available in the market based on their intended uses. It implies that the profiles of the gears vary. As a result, these vary in size and have an odd or even number of teeth. Both an odd and an even number of teeth profiles could be present in the gear. As a result, measuring the gear parameters will be easier, quicker, and require less effort.

LITERATURE REVIEW

Haque Nawaz, Himat Ali, “[1]. Gear Measurement has been carried out by focusing on two features of gear image object. The problems are to measure the features of gear image object, in the sense the measurement of the Area of the gear image object and as well the teeth of the gear will be counted. We have used MATLAB tool and development code which overcome these problems and measure the area as well as teeth of the gear image object counted. To accomplish this task we measured five different gear image objects area and counted the teeth by using image processing.

Cheng Pengfei and Feng Changyong Henan, “[2]. Based on the two different image expressions of defect forms, this paper abstract defect are ratio as well as the characteristic Journal of Multimedia, 2013, Volume 8, pages 198–205, "D on Image Processing." This paper's abstract defects are ratios, characteristic values, abstract contrasts, and grey co-occurrence matrices as picture characteristics, based on the two distinct image representations of defect shapes. To validate the abstracted picture feature for assessing pitting and wearing effectiveness, we build our cognition model using the neighboring technique and examine the gathered image samples. While the outcome is accurate, there is room for improvement in the recognition precision. Based on the morphological features of the image, atlas, eccentricity ratio, and circularity are abstracted as characteristic values. Digital image processing uses a specific algorithm to analyses and analyses images on a computer. Image processing techniques are currently being successfully used and investigated in many different fields. Image transformation, image intensification and restoration, image segmentation, image analysis, picture recognition, and other technique branches are the several subcategories of digital image processing. One type of high-

level computer language that finds widespread use in digital image processing is MATLAB, which possesses strong data processing capabilities.

Condition monitoring of helical gears using automated feature and sensor selection is described by H. Alkhadafe, A. Al-Habaibeh, and A. Lotfi in Measurement (2016) [3].

In order to create a monitoring system that is efficient in diagnosing gearbox faults, this research presents a novel implementation of the Automated Sensor and Signal Processing Approach (ASPS) [1].

One of the most important aspects of rotating machinery is the agearbox system, which is widely 41tilized in many industrial applications to transfer power and speed to other power train components.

This covers wind turbines for renewable energy applications as well as industrial machines operating at high efficiency. Numerous variables can negatively effect the functioning of a gearbox system, including incorrect installation, inadequate lubrication, material stress, wear and catastrophic breakage damage.

One crucial element of modern smart manufacturing systems (SMS) is quality inspection. Their popularity is a result of manufacturing businesses' goals to: i) produce high-quality goods; ii) encourage brand loyalty; iii) adhere to laws; and iv) reduce resource waste (including waste materials and staff and machine time) in order to maximise profit. Numerous different quality checking systems are in use on the store floor using a variety of technologies, including as image-based systems, high-fidelity sensor systems, and human operators. The later, contemporary image-based quality inspection systems and procedures are the main emphasis of this work.

The research on the use of digital image technology for hypoid gear contact zone detection was published by Zhang Jing [5].

Computer picture technology is being used more and more in every aspect of life, producing positive outcomes while also successfully advancing technical advancement. Research and development of a more sophisticated, intelligent, and integrated digital detection system that integrates with today's cutting edge science and technology (computer technology, digital signal processing technology, image processing, and precision instrument technology) is required because the current gear contact pattern detection is a crucial component of technology (Figure 1).

ALGORITHM

1. *Determine the Conveyor Belt Needs:* Based on the industrial process and the qualities of the product, ascertain the conveyor belt's unique requirements. Take into account elements like the suitability of the material, the load capacity, the operating conditions (temperature, humidity, chemical presence), and the necessary movement (horizontal, vertical, inclined) [6].
2. *Choose the Right Conveyor Belt Type:* Using the information gathered from the investigation and assessment, choose the conveyor belt type that best satisfies the stated needs.
3. *Conveyor Belt System Design:* When designing the conveyor belt system, take into account the needs for product flow, inspection stations, and production line architecture. Ascertain which parts of the conveyor system are required, including the motor, pulleys, rollers, and controls.
4. *AI-Based Quality Analysis Integration:* Locate the inspection stations on the conveyor belt where the products' quality attributes will be evaluated by AI algorithms. Make sure that the movement of the conveyor belt and the functioning of AI-based quality analysis systems are properly synchronized. Incorporate data gathering tools and sensors to gather pertinent information for quality assessment.
5. *Testing and Validation:* Test the integrated conveyor belt system to make sure it operates without a hitch and complies with quality analysis specifications. Verify how well the AI algorithms evaluate the quality attributes of the products as they travel along the conveyor belt.

6. *Optimization and Fine-Tuning:* Using testing data and input from quality analysis, optimize the conveyor belt system settings and AI algorithms. In order to increase productivity and accuracy in product inspection, optimize the conveyor belt's speed, acceleration, and deceleration [7].
7. *Maintenance and Monitoring:* To guarantee the conveyor belt system's continuous dependability and performance, set up a maintenance program. Install monitoring systems to find any anomalies or problems with the conveyor belt system or AI-based quality control.
8. *Continuous Improvement:* To take advantage of new technology and enhance performance over time, periodically assess and upgrade the AI algorithms and conveyor belt system. To further enhance the system, get input from operators and quality control staff.
9. *Training and Documentation:* For future reference, record the conveyor belt system's design, installation, and operating methods, as well as the AI-based quality analysis. Operators and maintenance staff should receive instruction on how to operate, debug, and maintain the integrated system.

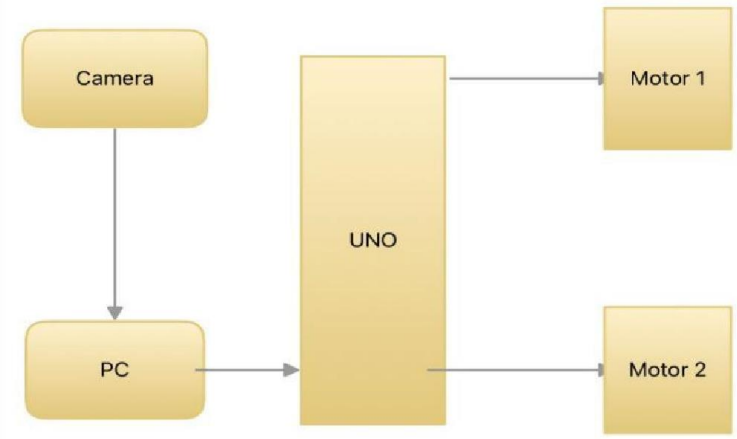

Figure 1. Block Diagram of UNO.

PROJECT DESIGN

We have used a conveyor belt in our project design. A conveyor belt is a crucial component in industrial processes, facilitating the movement of products within manufacturing facilities. These belts, made of rubber, fabric, or metal, transport materials horizontally, vertically, or on an incline. They streamline production, automate handling, and reduce product damage and contamination risks. In projects like yours focusing on AI-based quality analysis, conveyor belts play a key role (Figure 2). They transport products past inspection stations where AI algorithms assess quality attributes. Proper selection of conveyor belts considers factors like material compatibility, load capacity, and operating environment. Overall, conveyor belts are vital for integrating AI technologies into quality analysis systems, enabling efficient and precise assessment of industrial products [8].

COMPONENTS

Camera

- *Resolution:* 1920x1080p
- *Image sensor:* 5 MP with RGB colour filters
- *Pixel size:* 2.2 microns(H) x2.2 microns(v)

Shaft

- *Material:* Mild Steel

IR Sensor

- *Detection Range:* The distance within which the sensor can detect objects or heat signatures.
- *Sensitivity:* How effectively the sensor can detect infrared radiation.

Rejection System

- Rack and Pinion Mechanism

Motor

- 12V DC motors with Gearbox
- 30RPM base motor.
- No-load current=60 mA (Max), Load current=300 mA (Max)
- *Motor weight:* 100gms

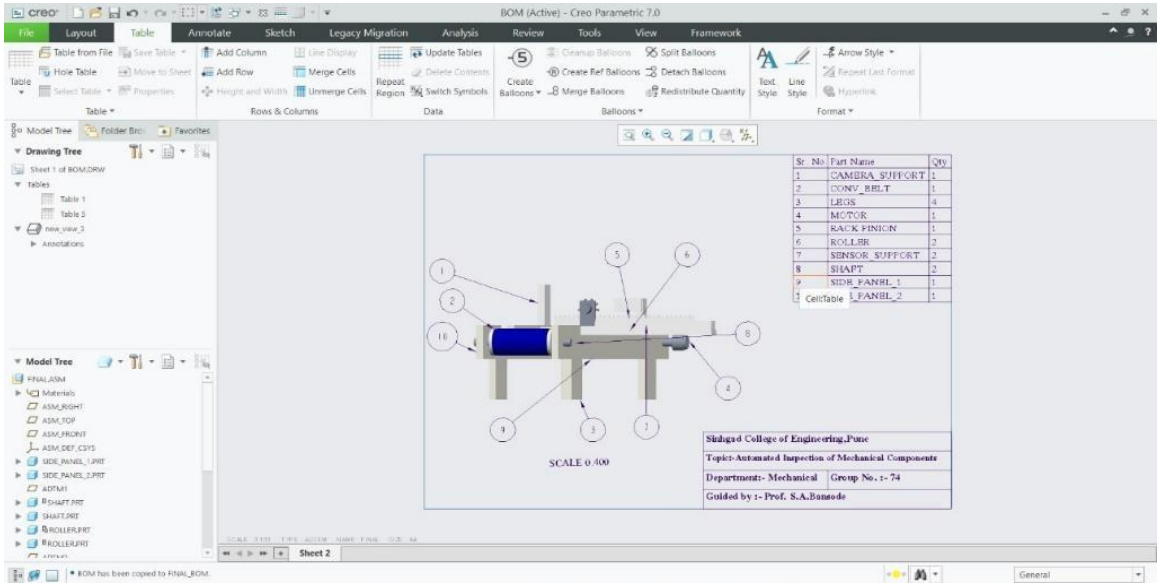

Figure 2. Project design.

The automated inspection system outlined uses computer vision technology to provide a quick, non-contact measurement method that can evaluate the majority of spur gear parameters with increased precision and responsiveness(table 1). It combines sensors, Arduino, and different mechanical parts to create a mechanical system that can identify gears according to their specifications and reject those that don't match the necessary requirements. There are several benefits to using an Automated Surface Detection System using MATLAB for precisely and quickly detecting surface flaws. Known for its usefulness in technical computing, MATLAB offers several crucial characteristics that support this effectiveness() Figure 3). Strong image processing capabilities, adaptability and customization, a quick environment for creation and prototyping, and smooth interaction with other technologies are noteworthy features [9].

In summary, the strengths of this Automated Surface detection System leveraging MATLAB lie in its potent image processing capabilities, adaptability for customization, rapid development environment, and seamless integration with complementary technologies. These qualities empower engineers to develop and deploy precise defect detection systems for diverse applications, spanning quality control, manufacturing, and inspection processes.

Table 1. Expected result and discussion.

Comparison Parameter	**Manual gear checking system**	**Automated gear checking system**
1. Time required	Time required is more because gears are checked manually	Time required is less because gears are checked automatically
2. Cost	More man power is required hence cost is more	Less man power is required hence cost is less
3. Production rate	Production rate is less	Production rate is more

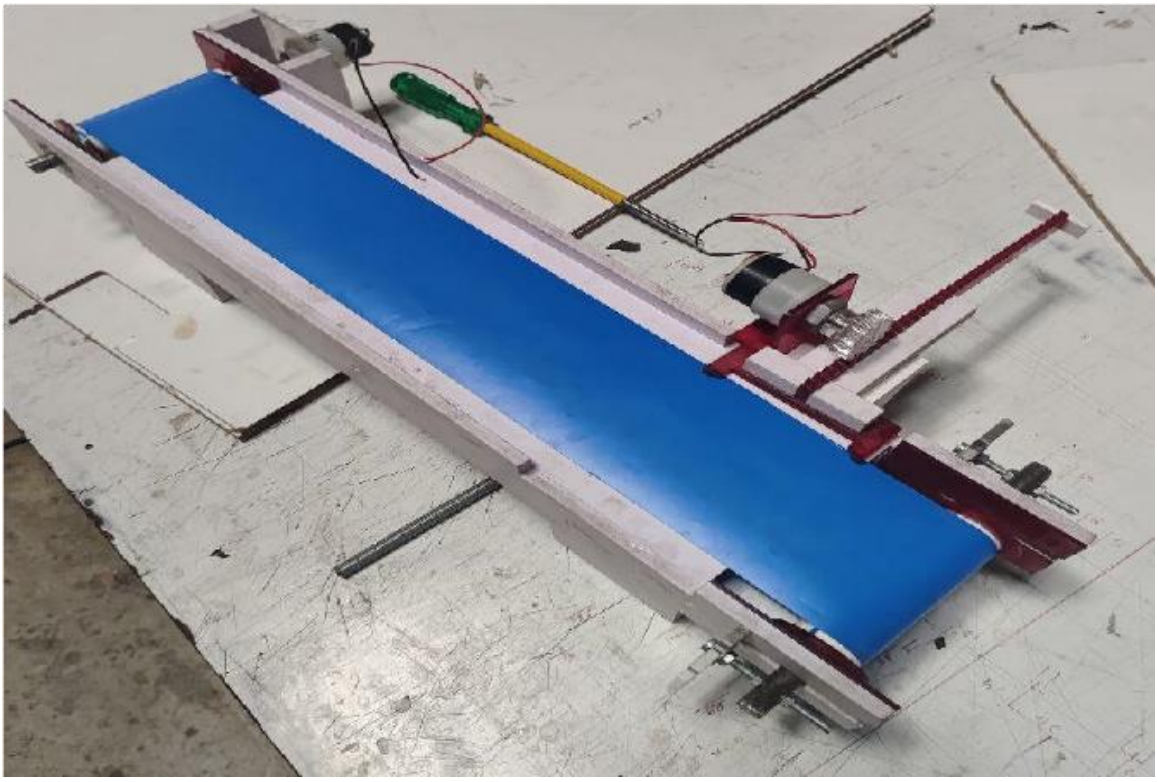

Figure 3. Hardware result**.**

CONCLUSION

In summary, this study successfully illustrates the use of sensors for gear surface flaw assessment. We have proven that infrared sensors and a camera with a microcontroller can identify and measure surface flaws like pitting and cracking on gear surfaces through a thorough literature review and the building of a test rig for data collecting. We have constructed a predictive model based on sensor data for defect detection and identified crucial sensor parameters influencing detection accuracy by using statistical analysis techniques like regression and correlation. This model has the potential to be used in actual industrial environments, allowing for automated gear quality control and inspection. All things considered, our project makes a substantial contribution to mechanical engineering by offering a unique, highly accurate, non-destructive, and non-contact method of gear inspection. The possible advantages of this technology the possibility for even more advanced gear inspection and monitoring approaches to be discovered through further research in this area could lead to improvements in manufacturing quality assurance procedures.

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