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Gear Defect Detection Using Machine Learning

Tejas Sanjay Desai, Prof. P.G. Kulkarni, Tushar Ajay Magar, Amaan Irshad Shaikh
UG Student, Professor, UG Student, UG Student
Mechanical Engineering,
Pune Vidyarthi Griha college of engineering and technology, Pune, India

Abstract :

Appearance defects inspection plays a vital role in gear quality control. Human inspection is a traditional way to remove defective gears, which is instable and time consuming. In this paper, we develop a machine vision system for gear defect inspection, which can inspect various types of defects on gear covers, such as deformations, rusts, scratches and so on. The proposed system designs a novel image acquisition system to enhance the defects appearances and get controlled image acquisition environment. A series of image processing methods are proposed or utilized to inspect the defects. Especially, for the deformation defects on seal, we find a common rule on the distribution of projection, and design a simple but effective inspection algorithm based on the rule. The proposed system is evaluated and compared with skilled human by the recall, precision and F-measure. Experimental results show that the proposed vision system has high accuracy and efficiency.

Keywords : Defects , Deformations , Machine Vision , Projection

Introduction :

In the industry of machinery, gear are important components that connect different machine parts to reduce frictions. They have been widely used in air conditioners, cars, and many other rotating machines. The quality of gears can directly influence the performance of many machines, and may even cause serious disasters. Bearings are usually mass-produced with high demand of precision, and a lot of inspection measures have been adopted in the production process to ensure the quality of gears. The inspection measures can be classified into three steps: material inspection, assembling inspection and final goods inspection. The material inspection is mainly focused on the dimension and surface inspection of the receiving materials, such as inner rings, outer rings . The assembling inspection is used to inspect the defects that are caused by assembling process, including surface inspection and vibration test. The final goods inspection is mainly focused on the surface defects, giving a full inspection before packing, so the result of final goods inspection can directly influence the product quality. Currently, the inspection of bearings in manufacture mainly depends on skilled human inspectors with

the help of bright lights. The manual activity of inspection is subjective and highly dependent on the experience of

human inspectors, which cannot provide a guarantee of quality. In addition, working under bright lights for a long time is harmful to human's health. Therefore, automatically inspecting the defects of gears becomes an important issue, and the computer vision can play a crucial role in it.

Literature Survey :

Table 1 : Literature Survey

Paper	**Description**
[5]	In this paper, the gear defect is located by a deep learning algorithm, which lays a foundation for more precise quality inspection such as the subsequent dimension measurement. The traditional detection of gear manufacturing defect detection is based mainly on machine vision in which the contour extraction algorithm is often used to extract the image features of a single gear.
[6]	For high speed automatic production lines, using machine vision method,through access to detecting object image quality detection, and machine vision system has simple structure, easy to move, quick and advantages, such as data acquisition, required by the visual sensor module is relatively simple.
[7]	The purpose of lubrication is to ensure an oil film separates the gear teeth at the meshing area . Depending on the lubricant film thickness three different lubrication regimes can be distinguished: Hydrodynamic lubrication, Elasto-hydrodynamic lubrication and Boundary lubrication. Mixed lubrication refers to the intermediate regime between EHL and boundary lubrication.
[8]	For automatic detection of defective gears, we propose the use of deep learning with two kinds of classification approaches, namely the Na¨ıve approach and the fine grained approach. The Na¨ıve approach allows deep convolutional neural networks to directly classify defects and non-defects in gear images,&the fine-grained approach harnesses an image processing technique before using CNN.
[9]	Gear tooth surface fatigue is one of the most common failure modes of gears. Surface fatigue manifests on two principal phenomena, namely spalling and pitting. Spalls are localized cavities on the teeth surface with relatively important depths, whereas pits are distributed cavities on all the teeth surface with small depths.

Proposed Framework :

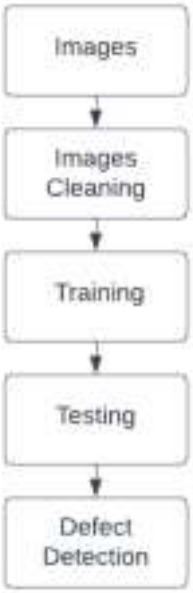

Fig. 1 Proposed Framework

Proposed System:

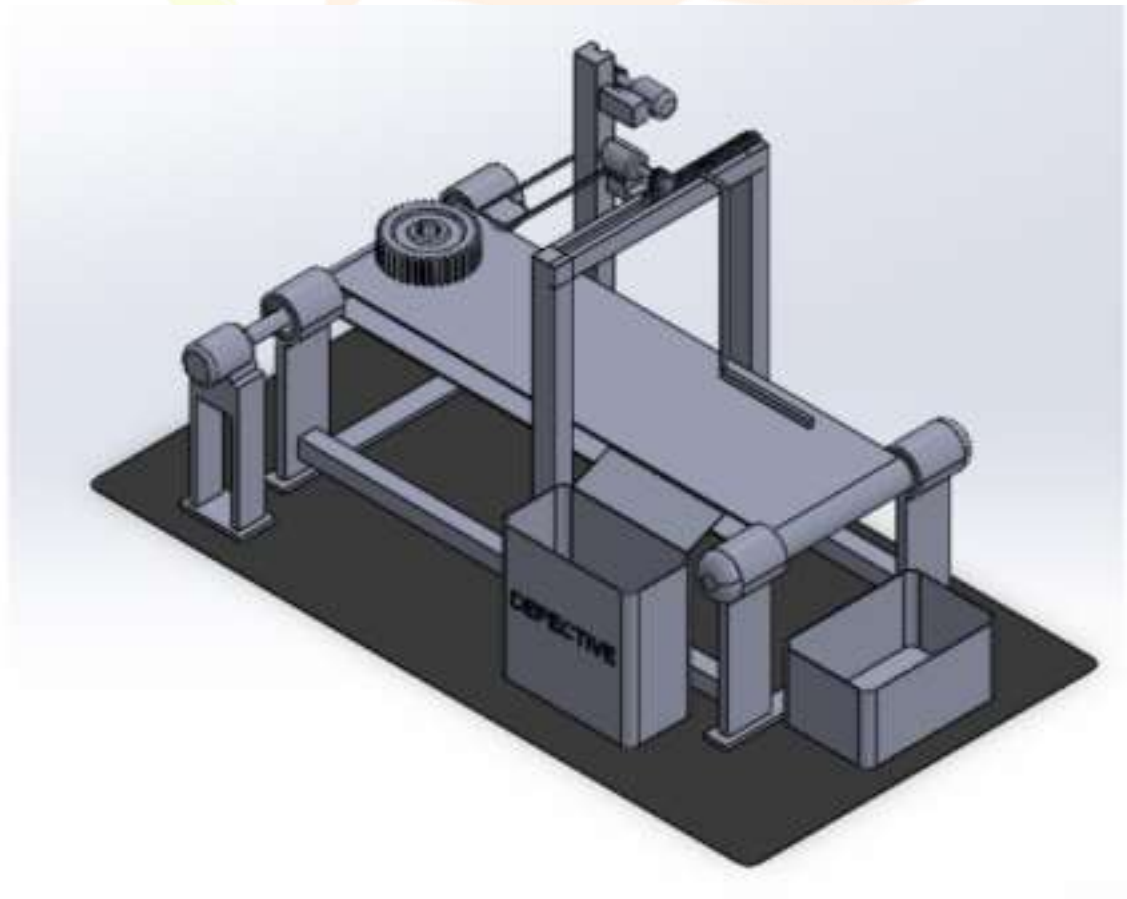

Fig. 2

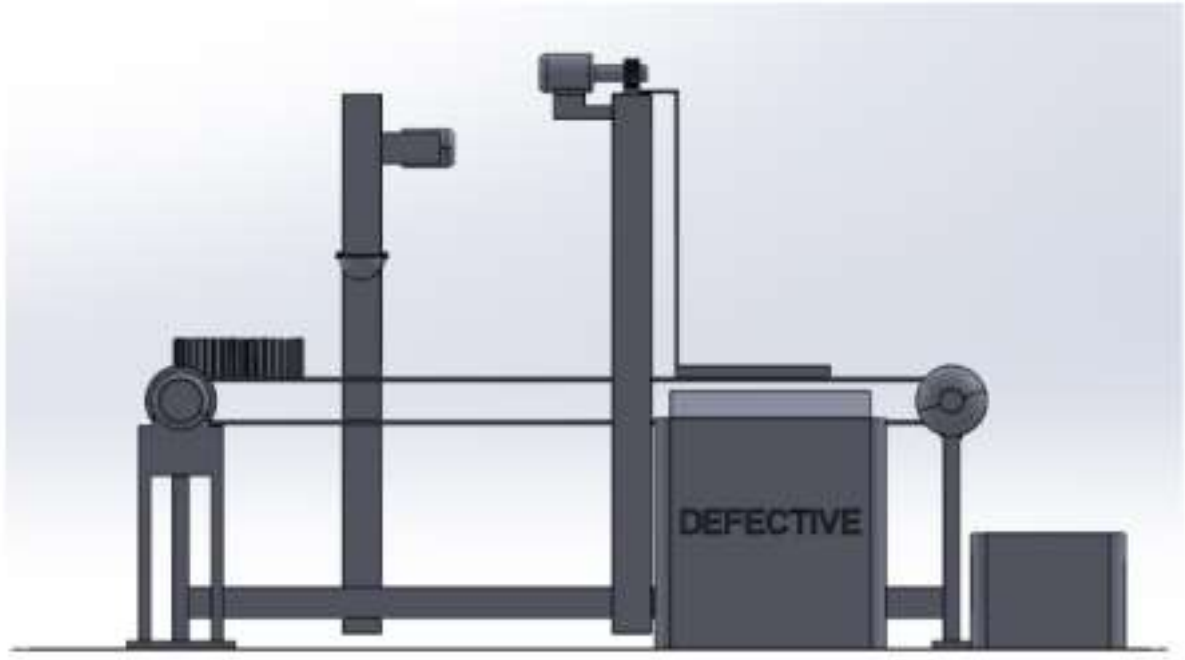

Fig. 3

Methodology :

In this project we are going to study the inspection of the manufactured gear with the help of Machine Learning Process , where data is collected in the form of pictures and then further analysed.The model is manufactured by assembling the various components and then the testing is carried out & result & conclusion is drawn.

A) Data Preparation :

Bilateralfilter :-

The bilateral filter method is a popular image filtering technique used in image processing and computer vision applications. It is a non-linear, edge-preserving, and smoothing filter that can be used to remove noise from an image while preserving its edges and details.

The bilateral filter works by convolving an image with a kernel that takes into account both the spatial distance and the intensity difference between neighboring pixels. The kernel has two parameters: a spatial parameter, which controls the size of the filtering window, and a range parameter, which controls the strength of the filtering effect.

The bilateral filter method is widely used in many applications, such as image denoising, edge-preserving smoothing, and tone mapping. It is a powerful tool for image enhancement and can produce high-quality results with relatively little computational cost.

MedianBlur :

Median blur is a commonly used image filtering technique in image processing and computer vision applications. It is a non-linear, edge-preserving filter that can be used to remove salt and pepper noise or impulse noise from an image while preserving its edges and details. The median filter works by replacing each pixel in an image with the median value of its neighboring pixels in a filtering window. The filtering window is usually a square or rectangular region of the image centered around the pixel being filtered. The size of the window is an important parameter that affects the quality of the filtering result.

Canny :

Canny edge detection is a widely used edge detection algorithm in image processing and computer vision applications. The Canny edge detection algorithm produces high-quality edge maps with low error rates and is widely used in various applications such as object detection, image segmentation, and robotics. However, the algorithm can be sensitive to the choice of the threshold values and the size of the Gaussian kernel used for smoothing, which may require some experimentation to achieve optimal results.

Findcontours :

findContours is a function in OpenCV, a popular computer vision library, that is used to detect and extract contours from an image. Contours are simply the boundaries of objects or shapes in an image, and they can be used for various purposes such as object detection, recognition, and tracking. The findContours function takes an input image as an argument and returns a list of contours detected in the image. The function can also take additional arguments such as a contour retrieval mode, a contour approximation method, and a hierarchy of contours if they exist. The findContours function is a powerful tool for extracting and manipulating contours in images, and it is widely used in various applications such as object detection, tracking, and recognition.

approxPolyDP:

approxPolyDP is a function in OpenCV, a popular computer vision library, that is used to approximate a contour with a simpler polygonal curve. This function takes an input contour as an argument and returns a simplified approximation of the contour. The approxPolyDP function is based on the Douglas-Peucker algorithm, which is a recursive algorithm that approximates a curve by recursively subdividing it into simpler segments. The algorithm works by selecting two points that define the maximum distance from the approximating line, and then subdividing the curve at this point. The process is repeated recursively until the desired approximation is achieved.

The approxPolyDP function is often used in image processing and computer vision applications to reduce the complexity of contours while preserving their shape and size. This can be useful for tasks such as shape matching, object recognition, and feature detection. drawContours: drawContours is a function in OpenCV, a popular computer vision library, that is used to draw contours on an image. This function takes an input image, a list of contours, the index of the contour to be drawn, and other optional parameters as arguments, and then draws the selected contour on the image. The drawContours function is a useful tool for visualizing contours in images, and it is widely used in various applications such as object detection, tracking, and recognition.

convexHull:

Convex Hull is a mathematical concept used in computational geometry, and in computer vision, it is used to find the smallest convex polygon that can contain a set of points. In OpenCV, the convexHull() function is used to find the convex hull of a set of points. The convexHull() function is useful in various computer vision applications such as object recognition and shape detection. It can be used to extract the shape of an object by finding its convex hull and then comparing it to a known shape or using it as a feature for object recognition.

Design:

CAD Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used. Its use in designing electronic systems is known as electronic design automation (EDA). In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions. CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space. CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation

for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry. The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD)

Uses:

Computer-aided design is one of the many tools used by engineers and designers and is used in many ways depending on the profession of the user and the type of software in question. CAD is one part of the whole Digital Product Development (DPD) activity within the Product Lifecycle Management (PLM) processes, and as such is used together with other tools, which are either integrated modules or stand-alone products, such as:

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1] Computer-aided engineering (CAE) and Finite element analysis (FEA).

2] Computer-aided manufacturing (CAM) including instructions to Computer Numerical Control (CNC) machines.

3] Photorealistic rendering and Motion Simulation.

4] Document management and revision control using Product Data Management (PDM).

CAD is also used for the accurate creation of photo simulations that are often required in the preparation of Environmental Impact Reports, in which computer-aided designs of intended buildings are superimposed into photographs of existing environments to represent what that locale will be like, where the proposed facilities are allowed to be built. Potential blockage of view corridors and shadow studies are also frequently analysed through the use of CAD. CAD has been proven to be useful to engineers as well. Using four properties which are history, features, parameterization, and high-level constraints. The construction history can be used to look back into the model's personal features and work on the single area rather than the whole model. Parameters and constraints can be used to determine the size, shape, and other properties of the different modeling elements. The features in the CAD system can be used for the variety of tools for measurement such as tensile strength, yield strength, electrical or electromagnetic properties. Also its stress, strain, timing or how the element gets affected in certain temperatures, etc.

Result:

This study develops a machine vision system for the inspection of gear surfaces. In the system, a novel inspection algorithm is proposed for the inspection of defects on gear surfaces.

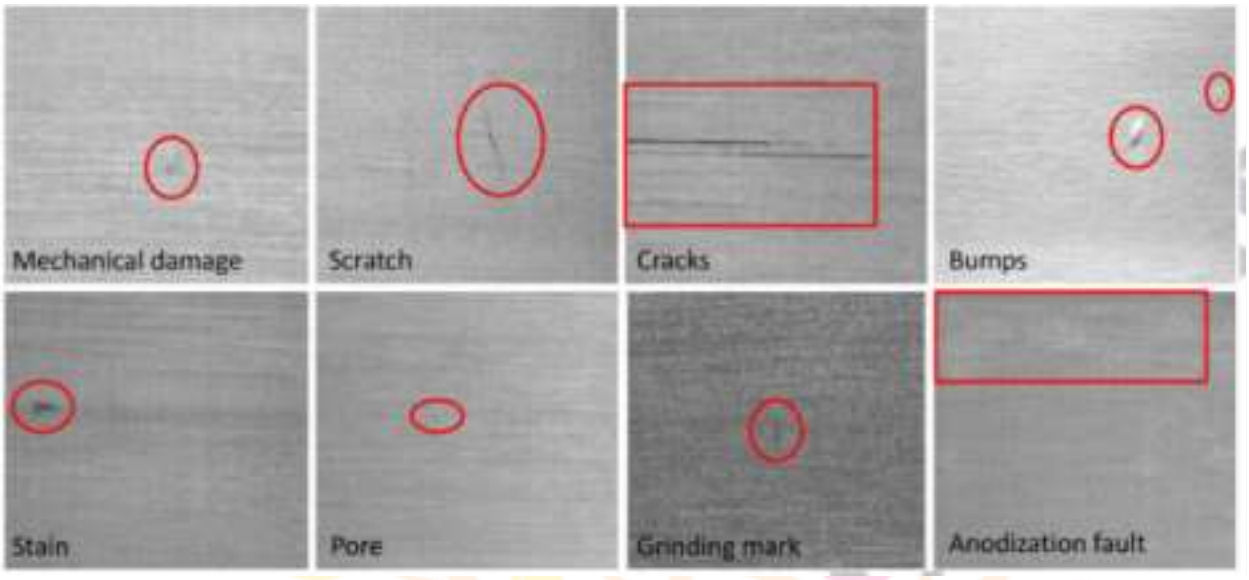

Fig. 4

Fig. 5

The number of counters that were found in the image above was 1, and there were 29 teeth.

Conclusion : This study develops a machine vision system for the inspection of gear surfaces. In the system, a novel inspection algorithm is proposed for the inspection of defects on gear surfaces.

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