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A Review paper on the usage of Image Processing for Measurements of Gear Parameters

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Abstract - *This review paper aims toward the Image processing which deals with the both digital and optical processing of gear images samples. Since pictures are specified across two or more dimensions digital image processing may be represented in the form of multidimensional systems. This images samples are collected and segregated with the help of various algorithms. This information collected were then validated using the established algorithm and again process out for build-up of noise and distortion during processing using variety of algorithms and maintain up to the threshold for better accuracy and precision over parameters of gears. The results of these research papers concluded that there are many factors such as camera angle, lighting condition for image processing, camera resolution, specifications of cameras, surrounding temperatures, calibration of camera and their lenses with algorithms coordination etc. are affecting the quality and accuracy of gear parameters. This paper also suggested different methodology like machine vision and deep learning for solving image processing algorithms and hardware setup for better sampling of gear images. Testing study demonstrates that the suggested technique has better precision over traditional way of digital image processing, thus it has significant usefulness.*

Key Words: **Image Processing, Algorithm, Camera Angle, Calibration, Resolution, Machine Vision, Deep Learning.**

1.INTRODUCTION

Image processing method is used to measure the dimensions of elements with extremely high accuracy and precision. Under this method, an image of a component to be measured is captured by a camera from some distance above the component. This picture is further processed with the assistance of a program and boundaries or edges of the component are formed. These derived boundaries are then evaluated with necessary dimensions and tolerances. Since picture of the component is split into various number of pixels, dimensions of the elements may be measured with great precision. If a picture consists of a higher number of pixels, dimensions may be assessed with better precision.

The gear must have huge role in the economic development of industrialization as a common power transmission mechanism. Where Gear design has a significant impact on the success of machine tools. As a consequence, throughout the gear production process, product quality must be closely checked and regulated. The measuring procedure to detect defects like grinding gears, losing a tooth, and misaligned gears was difficult owing to the geometric shape of the gear. Furthermore, traditional measurement apparatus, like the 3D CMM and gear integrated fault monitoring equipment, is difficult to build, and the procedure is costly, necessitating the employment of a significant number of personnel to conduct the tests.

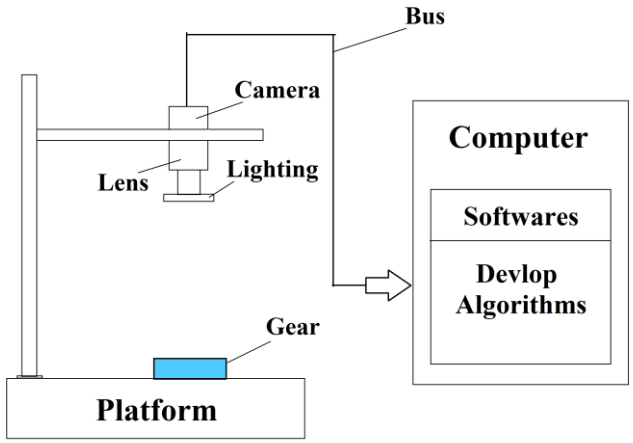

Fig-1: Function diagram image processing setup

The present industrial sector needs a greater rate of issue identification in gear items as well. As a result, a method for quickly monitoring and analyzing gear characteristics during manufacturing is required. Machine learning technology, a novel method to non-destructive test, has progressively proved to be a successful way to monitor quality of the product and identify flaws, and it has shown potential in gears measuring technology. Visual inspection has the benefits of not requiring direct touch, being quick, and having a high anti-interference capability on the job site when comparing to other detection techniques. These benefits lessen the time testing and employees must spend on the task, eliminate subjective aiming and interpretation mistakes, and improve measuring speed and accuracy.

Presently, visual techniques have been extensively utilized in various applications. Image processing systems were first created for quality assurance, but they have since been used as objective monitoring and assessment systems. The creation of gear monitoring system that used a HD camera and data visualization tools to take measurements. They

looked into the precision and the many causes of inaccuracy that were discovered. They found that the measurement precision is equivalent to existing gear tolerance testing techniques. Image analysis measuring devices were also appealing because of their cheap cost and simplicity of use.

2.LITERATURE REVIEW

Uros Urbas et al. [2021] focused their study on technique to acquire full 3D measurements using an optics inspection to overcome present inspection techniques contain just a constrained sample of statistics for gear for particular regions.3D optical scans was used to acquire the measurement data. Using the software that was developed, the collected data were analyzed and evaluated.
This has been tested on an ideal form simulation scan with various geometrical details and afterwards on a simulation scanning with artificial deviations. Their technique were ultimately verified by assessing their gear and use a coordinate-measurement machine & comparing the findings to those obtained using the suggested optic methodology. When compared to the tactile method, the optic methodology provides a more comprehensive strategy with several significant benefits. The activity diagram of detecting and collecting data for future software processing is illustrated in the figure below.

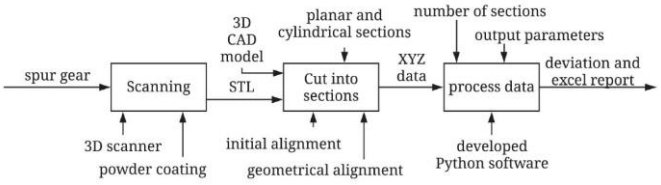

Fig-2: Operation diagram of collecting and processing the data for subsequent software analysis

The research is mainly focused on a,
I. A methodical development including its technique for optical gear inspections for a customized strategy for alignment and before the processing the quantitative measurements and unique program was developed for handling and assessing the measured data. an innovative method for calculating the parameters to leading contour distortion and runout variation was developed and utilized.
II. A randomly selected measurement for scan procedure was obtained, which has been used in evaluating the likelihood of finding the correct quality grading. As close the outcome contour of the region includes, then higher the possibility of it being erroneously calculated. The suggested method would be in a worst situation 9 percent which is to identify the erroneous relative to the CMM. The optic approach to examining the entire gear, that allows missed significant flaws low probable and This was discovered and technology is appropriate for assessing injections molded gears.
Dejun Xi et al. [2020] this article reviews a novel vision measuring methodology based on a customizable vision detected algorithm where the mask area convolutional neural network using the acquired data set of more than 1400 gear pitting photos, an efficient deep Mask R- convolutional neural network has been constructed for the data study of gear pitting. The functional tooth area & pitting were both detected at the same time, therefore the pitting area ratio was computed by dividing them. Various indices was utilized to assess the detection and segmentation performance of deep Mask R-CNN utilizing three scenarios: multi-level pitting, multi-illumination & multi-angle. Empirical findings suggested technique has better precision than conventional computer vision methods, indicating that one has a broad variety of applications. The following is a schematic representation of the quantitative detection of gear pitting implementation procedure from start to finish.

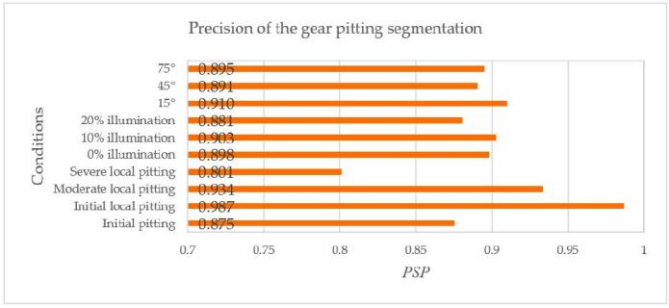

Chart -1: Effects of different conditions on Precision of the gear pitting segmentation

After the analysis they concluded that,

I. This technique detects pitted and Tooth Surface concurrently and quickly, enabling pitting and tooth surface to be effectively separated. The gear pitting area ratio is readily determined using segmented pitting and TS. The ability of the suggested approach was tested by evaluating three situations utilizing multi-level pitting, multi-lighting, and multiangle, and better illumination and shooting angle were achieved.

II. The current technique has substantially better Precision of the gears pitting segmentation (PSP) for the collected gear pitting picture series, with a mean PSP of 88.2 percent. As a result, the suggested technique may be utilized to properly evaluate gear pitting in order to develop an appropriate maintenance program for gear transmission systems. the computation effectiveness and measurement range of its will be enhanced by discovering a new deep Mask arrangement of R-CNN.

Yongzuo Wu et al. [2019] worked towards Using computer systems and video equipment, tooth of a acquired gear pictures were deconstructed by algorithms and the amount of tooths are tallied. The diameter and modulus of addendum circle was gathered to calculate the diameter of the base circle. After calculating the middle point at where base circle & tooth profile met primarily on base circle, the equations of its tangent line tangent to a tooth profile were produced. the procedure is required to determine gear teeth count and standard lengths using image recognition technology rather than human intervention. This recorded photo had comprised of a succession of computer vision using OpenCV

combined with the technique, using this dimension was calculated, that is helpful for gear accuracy.

After the analysis they concluded that,

experimental findings show the technique does correctly compute gear tooth counting, however few mistakes arise in computation of gear common normal line. There's many causes for such like camera accuracy resemble with lack in calibration, this all cumulatively contribute to errors in the experimental findings. The next stage is to modify the cameras such that there would be less effect of lens distortions on the picture captured.

Desmond K. Moru et al. [2019] This paper reveals the study research of creating an improved vision-based algorithm to detect the exact measurement of motor gears, bring down to sub - pixel level, mainly with potential to raise quality standards, avoid delays, and streamline the testing phase Vision2D was previously created to gather and assess recorded pictures to conduct the operations like measurements and inspections limit of 0.059 pixel. The examination result indicates an advancement in the algorithms of the Vision2D application system in comparison with the prior conventional systems.

After the study they finally concluded that,

The tests are done out through various gears samples show demonstrate the effectiveness of the established Vision2D software keeping in mind not only the real tolerance as well as the estimated uncertainty of the operation. Several key elements were included to significantly contribute to the improvement produced by program, as stated below

I. Through the telecentric lens uses.

II. A better camera arrangement and setup.

III. A larger quantity of proofs performed on an increasing sample count of gear checks.

IV. A substantially low tolerance to improve a limited glitch free method for enhanced product testing assessment.

V. A systematic examination including its ambiguity related to operation.

The authors are also suggested based upon analysis for obtain results for future work Numerous difficulties frequently afflict the calibration procedure owing to various factors including such cameras and sensors config design, illumination effects, ambient temp, camera resolution, and the condition of calibration plate. above all factors may affect random errors, efficiency, and sensitivity of the computer vision system. However, additional study could also done to obtain a calibrating error of a smaller degree.

Shinn-Liang Chang et al. [2017] analyzed and develop a measuring system for the spur gears using the image processing technology. where, almost all of the commercialized image measuring devices can only detect the point, line, and fillets of the work-piece. If the systems are used in the gear measurement, it can only measure the outer and root diameters. The profile deviation and pitch error cannot be determined owing to the gears complex shape. Throughout this work, a novel technique of comparative edge detection is used to evaluate the spur gear. It may have a greater quality of the boundaries curve to enhance the accuracy of measurement. Thus, the proposed system may be used in the measurement of the essential parameters and estimate the accuracy of gear tooth profile, etc. In order to verify the created system, an immediate contact measurement is often performed. This created technique provides a good and powerful way to test the spur gears and also the findings may also be used to the other kinds of planar gears like non-circular gears.

They concluded after the study that,

I. Image processing technique is created to measure the characteristics and accuracy levels of spur gears. The experimental findings and comparisons indicate that the proposed method is practical and helpful to test the spur gears using smaller module.

II. The proposed method may also be used in the measuring of non-circular gear. The limits of non-circular could be determined using the suggested comparative edge detection technique. Furthermore, the tooth profile errors requires to compare the ideal tooth profile with observed profile. Due to the various contours of the tooth, the assessment of profile faults is still a difficult task in the industry.

W. Lotze et al. [2001] have investigated the evaluation of gear measurement points by use of a three-dimensional replacement gear model including various geometrical elements of the gear edges. The advantage of this three-dimensional assessment model and the associated software is that measurement sites may be chosen up wherever on the gear edges, without any restrictions on defined cross-sections or measuring planes. Thus, the novel numerical technique and the software permit gears to be measured as easily as every geometric component by way any of Numerically Controlled- or manually driven CMM equipped with a mechanically as well as optical probe.

This approach enables us to pick up measurement points anywhere upon flank and also to compute gear parameters beyond conventional gear standards. Thus no need to scan profile, lead and pitch precisely at the specified lines. A additional benefit of the universal replacement gear type is the increased measurement and assessment precision. It enables us secondly, to guarantee the traceability of involute gear measurements.

They concluded that after analysis of results;

The conventional quality monitoring of gears has been progressively transformed it into domain use of the co-ordinate measurement method. Because of the relatively traditional gear standards and testing guidelines the assessment software frequently employed replicates only the normal and mostly two-dimensional testing methods. When the more comprehensive 3-dimensional analytic modeling of geometric components is used, gear assessment is based on replacement helical involute flanks and ultimately on a 3-dimensional substitute gear model. This provides considerably more freedom for measuring and assessment of gears using CMM. There is no need now to evaluate profile, lead or pitch precisely at specified flank lines or flank locations.

E.S. Gadelmawla et al. [2009] The purpose of this research study is to use object recognition technology to create a quasi, fast measurement device capable of accurately measuring and validating the majority of spur gear specifications. The imaging system was created at the metrology lab and helpful to collect pictures for measuring and inspecting gears. Gear Vision is a software program that analyzes recorded pictures and performs measurements and checks. The given vision system had been calibrated for both millimeter & pixel units previously. After calibrating, the system was validated by testing 2 distinct gears and comparing parameter estimations to real actual gear parameter values.

After the experimentation they concluded that,

Image processing system has been proposed as a novel contactless mensuration technique for measuring and verification of spur gears utilizing their stored pictures. A program designed to study the collected pictures and conduct the measure mensuration and inspection procedures by number of different image processing algorithms.

H. H. Shahabi et al. [2008] In this study author examined the nose radius wear of cutting tools and roughness profiles of the machined components during lathe operations investigation. The nose radius wear computed from the workpiece's mean line was utilized to determine the flank wear width. When the maximum flank wear width calculated from the roughness profile was compared to the maximum flank wear width measured using a toolmaker's microscope, a mean difference of 5.5 percent was observed. This study shows that by providing the tools and machining settings are known, flank wear may be predicted fairly accurately from its workpiece roughness profile.

From the experimental study they found that,

I. The profile detection technique using respective coordinates is effectively utilized to assess the nose radius wear & flank wear across the nose region, flank wear width, using a 2-D picture of the machining tools. The flank wear also was evaluated through workpiece mean line at such an increasing feed rate.

II. This research indicates that flank wear the nose area flank wear width would have a more substantial effect on the micro surface profile and thus on the workpiece roughness.

Wencheng Wang et al. [2015] Throughout this research, a new technique for gear parameter measurement is provided based on image processing. by creating the physical architecture of a systems and the core idea of the computer programs. after that concurrent to it they examine the concepts of digital machine vision by image data extraction, and image analysis and also analyzes the specific methods,

This technique is straightforward and does not requires edge detection and Hough transformation. Experiments indicate that the system is convenient and that it can meet the criteria of gear parameter measurement, replacing conventional monitoring in actual production. After studying and analyzing they discovered that,

I. By capturing pictures with a camera, that were sent to the system. Researchers accomplished contactless evaluation for gear characteristics by integrating the significant data processing capability of computer using machine learning techniques. The testing showed why electronics framework is simple, robust, and reliable and works with tremendous efficiency and great precision.

II . The constructed system process is useful for evaluation of gear parameters by completing all the criteria of traditional process of evaluation by automation of really high efficiency and a fast speed.

M J Robinson et al. [1995] focused their study on the development of an involute spur gear examination program inside which measurements are done utilizing a cameras and image recognition methods. Overall measurement accuracy achievable with low-cost CCD cameras being studied, as well as probable reasons of error. the research further shows that the measurement accuracy is similar to that of current methods for tolerance inspection of spur gears and also the cheap cost and easy perceived usefulness make image processing process models an appealing option.

After study it is also concluded that,

I. The greatest contributor for a inaccuracy in the test environment and system was the effect of the inter-line transfer array at References least 50 percent and, for some cameras, almost 80 percent of the CCD area is unresponsive to lighting. Therefore, a low-resolution frame transfer camera will, in most situations, function better than any high-resolution inter-line transfer camera.

II. Framestore time fluctuation is a largest source to inaccuracy and therefore a camera sensor in which the Analog to Digital Converter is synchronized with the pixel clock would be better than a regular video connection. However, the performance gain will be modest unless other parameters are also improved in particular total improvement is less than 20 percent if another pixel-synchronous camera includes an inter-line transfer array.

3. PROPOSED METHODOLOGY

I. Problem Identification for parameter of gear you want to resolve using system development.

II. Literature Survey on research done on this topic till date.

III. Study of Image Processing and Process Variables to obtain required results.

IV. Develops an algorithm for Image Processing and to detect an Involute gear profile.

V. Gather the quality Gear image for Image Processing.

VI. Find out the Measurements and Errors.

VII.Implement the required changes in the algorithms.

VIII. Develop setup hardware consist of Camera, different lenses, light source, backlighting table, customizable stand, etc.

IX. Validate the solution by experiments.

X. Results and discussion.

4. CONCLUSION

This review paper identifies the various factor that affect the image processing process from image capturing to developing of algorithms for experimentations for finding out gear parameters. Mainly for camera angle while taking images of gear sample, surrounding lighting conditions to reduce noise in quality of gear image, calibration errors in the system algorithms. The room temperature, camera resolution, and the quality of calibration plate. All of these factors potentially influence measurement errors, accuracy, and precision of the machine vision system. The accuracy of the system is affected by the size of the gear to be measured. Hence, the gap between the predicted parameters and the actual values may be minimized by monitoring small gears. The biggest contribution to the unreliability in the test system was the effect of the inter-line transfer array at References least 50 percent and, for some cameras, almost 80 percent of the CCD area is unresponsive to lighting. Therefore, a low-resolution frame transfer camera will, in most situations, function better than any high-resolution inter-line transfer camera.

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