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Computer Vision-Based Automated Non-Contact Metrology Framework for Mechanical Component Evaluation

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Abstract: ***Machine vision and artificial intelligence have reshaped quality inspection across modern manufacturing. In this project, we designed a non-contact metrology system that uses machine vision to inspect mechanical parts like bolts, nuts, and pinions. The setup relies on a high-resolution camera along with a controlled backlight to grab crisp, clear images of components. We run these images through image processing tools and machine learning algorithms to pull out accurate measurements and spot any defects. This system not only boosts accuracy and consistency, but it also runs in real time and slashes the need for manual labor. Our tests show it's faster and more precise than older, manual methods. It's the kind of upgrade fit for Industry 4.0 and advanced industrial automation.***

Keywords: ***Computer Vision, Non-Contact Metrology, Machine Vision, Mechanical Component Inspection, Dimensional Measurement, Image Processing, Automated Quality Control.***

I. INTRODUCTION

Manufacturers crank out huge numbers of mechanical parts every day. Keeping up with quality checks is tough using only traditional methods—manual inspection drags down production, leads to missed errors, and just can't keep up with high-speed lines. That's where machine vision steps in. These systems bring speed and reliability, using high-res images and smart algorithms to automatically inspect parts. We set out to develop an AI-powered system that measures dimensions and checks for defects in mechanical components. It gets the job done faster, cuts down on errors, and upholds strict quality standards across the board.

II. SYSTEM METHODOLOGY

The proposed system is based on a machine vision approach for non-contact inspection of mechanical components. In this system, the component is placed on a precision platform equipped with a uniform backlight to ensure clear visibility and high contrast. A high-resolution camera captures the image of the component, which is then processed by converting it into grayscale and binary formats for easier analysis. Various image processing techniques such as edge detection, contour analysis, and feature extraction are applied to identify important characteristics of the component. The extracted features, including dimensions, shape, and area, are further analyzed using a machine learning model. Finally, the system compares these results with predefined standards to classify the component as either acceptable or defective.



Fig. 1 Web Cam

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Fig. Hardware Setup Inside the Experimental Setup

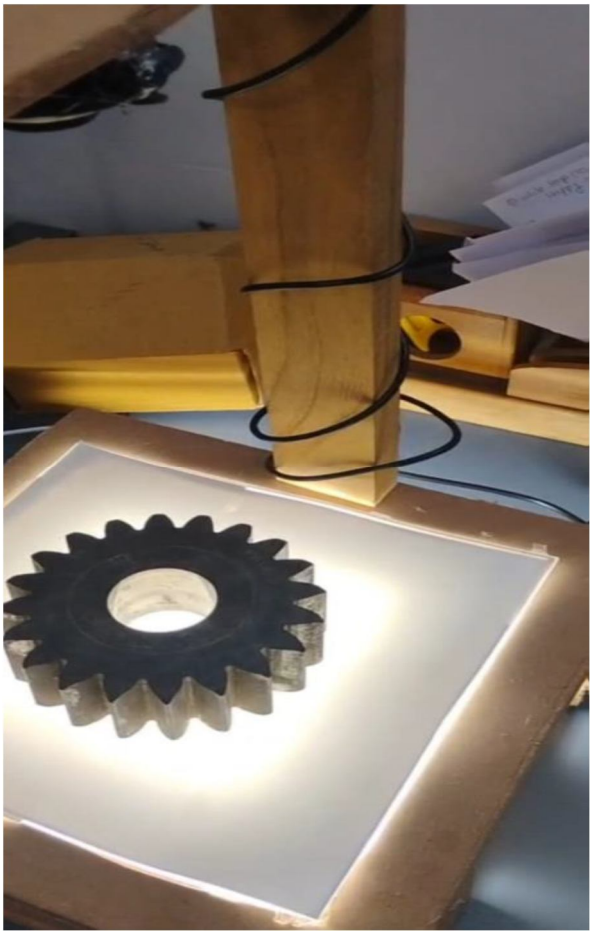


Fig. 3 Mechanical Component (Pinion) is Placed on the Inspection Platform

III. RESULTS

Our system handled bolts, nuts, and pinions with impressive accuracy. The combination of image processing and machine learning nailed the exact measurements and spotted defects consistently. Inspection time dropped sharply compared to doing it by hand, and the system proved reliable during continuous use on the shop floor.

A. Highlights

1) Precise dimensional measurements every time
2) Dramatically shorter inspection cycles
3) Solid consistency and repeatable results
4) Fewer errors compared to manual checks

IV. FUTURE SCOPE

There's plenty of room to make this system even smarter. Integrating deep learning can sharpen defect detection and pattern recognition. Adding IoT capabilities will let people monitor and even control inspections remotely, in real time. If we tie in automatic sorting, defective items could be pulled off the line instantly—no lag. Using multiple cameras or advanced sensors will give the system the edge to handle even more complex parts with better accuracy.

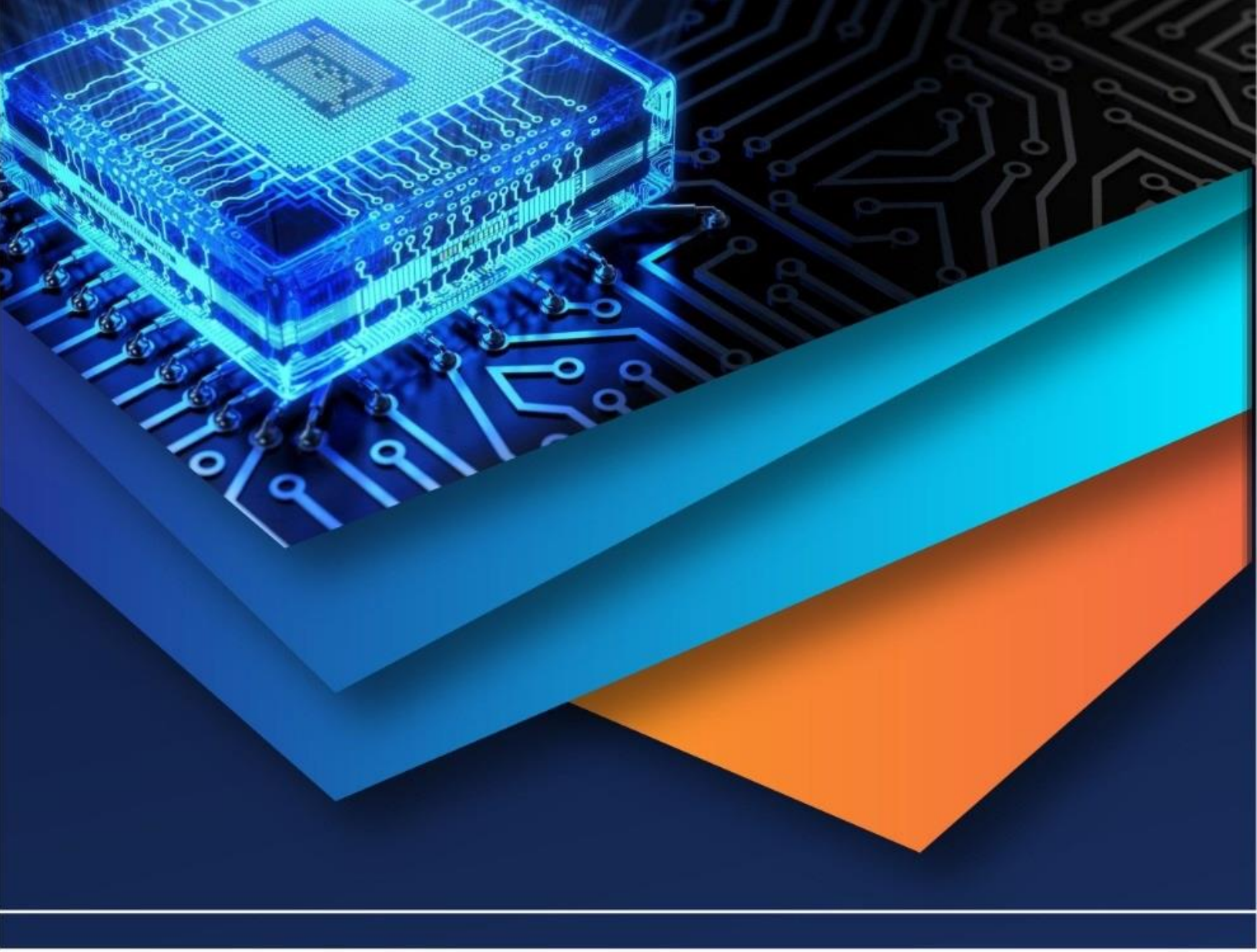
V. CONCLUSION

This machine vision-based system offers manufacturers a reliable and efficient way to automate inspection. It cranks through parts quickly and accurately, dodges the common pitfalls of human error, and keeps quality standards locked in. By cutting down dependency on manual labor, it helps spot rejects right away, reduces waste, and boosts overall process efficiency. It's a step forward for industrial quality control and paves the way for smarter, automated manufacturing.

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