Final Year Project Showcase Batch-2020
Year 2024

Department: Industrial & Manufacturing Engineering Programme: Industrial & Manufacturing Engineering	
1	**Project Title:** AI Vision-Based Inspection System for Quality Control of Products
2	**Project Idea:** The project is interfacing, linking the two domains of Manufacturing Engineering and Quality Engineering. Mainly, it sets out to develop an AI-based 3D scanning system taking advantage of computer vision technologies in visual inspection of manufactured objects. The significance of this project lies in its ability to automate visual inspection with an assortment of AI and computer vision technologies. Currently, inspecting by manual means is costly and requires more time. Our system will help fight common manufacturing problems. It spots and sorts flaws systematically, results in high product quality. Also, it cuts labor costs related to manual checkups, boosts productivity, and helps adhere to industry rules and compliance. Another cool thing, it doesn't need CAD models, a common inspection hurdle. Instead, it scans real, tangible products. This capability promotes waste reduction, minimizes human error, and adapts to diverse product types, all while elevating customer satisfaction, minimizing product recalls, boosting operational efficiency, and improving manufacturer's profitability and reputation in the competitive market.
3	**Process:** The methodology adopted can be divided into the following things: ➢ **Literature Review**: A thorough assessment of the literature will involve reviewing research papers, patents, journals, standards etc. to comprehend the prevailing academic trends and identify research gaps with special emphasis on the novelty of the proposed method. ➢ **Design and Acquisition of Components**: The design of a body/frame will be CAD modelled and printed if necessary. The procurement of essential components such as a HD camera, DLP projector, controllers and their integration to control the entire system will be carried out. ➢ **Construction and Integration:** All components will be meticulously integrated. The systems training will entail the utilization of ML algorithms with datasets containing high-definition images of the products to be scanned. Employing an ensemble approach, the model will be fine-tuned by integrating personalized hyper parameters to achieve a sustainable and precise- model for product inspection. Following the training phase the system will acquire the capability to derive dynamic features against every individual product there by aiding future predictions and the inspection processes. ➢ **Validation:** Thorough validation will ensue to measure the accuracy and reliability of the system by testing its performance across a wide range of items (simple, moderate & complex). Analysis will draw comparisons against obtained metrics to define the efficacy of the model. ➢ **Documentation & Reporting:** All the findings and procedures will be accurately documented and published within the final year project report. The comprehensive report will clarify the systems design configurations and adherence to industry standards culminating in an upgraded solution for product inspection. Finally, the progress of the project will be demonstrated during the mid and final semester

	presentations.
4	**Outcome:** The project's core objective was to develop a system capable of scanning mechanical parts, generating a point cloud, and comparing this data with a pre-scanned ideal model. By leveraging ML algorithm, the system effectively processes and analyzes the point clouds to determine whether the scanned parts fall within acceptable tolerances. Key achievements of this project include: **1. Efficient 3d scanning system:** The structured light 3D scanner has been developed using a cost-effective components such as DLP projector, Industrial camera, controllers and computer systems. An Open-source software, based on structured light and stereo vision, was used to scan and collect data from the objects. The specific needs addressed by this system include: accuracy, ease of use, and affordability. **2. Effective Point Cloud Analysis:** The system can accurately compute distances between points in different clouds, identify deviations, and calculate statistical measures like; Mean distance b/w point clouds, Standard Deviation, Percentage Deviation, density of point clouds, which are crucial for quality assessment. **3. Robust AI Integration:** The use of Iterative Closest Point (ICP) Algorithm Combined with Machine Learning allows for advanced pattern recognition and feature extraction from point clouds, enhancing the system's ability to detect deviations and anomalies.
5	**Evidence (Theoretical Basis):** Our system is based on 3d Image acquisition technique named as **Structured light 3d scanning.** It is the process of projecting a known pattern (often grids or horizontal bars) on to a scene. The way that these deform when striking surfaces allows vision systems to calculate the depth and surface information of the objects in the scene, as used in structured light 3D scanners. During this process, a camera, positioned at a known distance from the projector, concurrently captures a sequence of images of the illuminated object. The captured image undergoes distortion based on the surface shape being scanned in relation to the flat reference surface utilized for calibration. Leveraging the principles of geometric triangulation, the XYZ coordinates for each point on the scanned object's surface can be computed. The resulting point cloud data is then utilized to construct a detailed 3D model of the scanned object's surface. An in-depth analysis of 3D scanning data allows for the determination of crucial information, including surface area, volume, shape, contour, and feature size of the scanned object. The 3d data files than can be fed into the source code which consist of ML algorithm for the statistical analysis of distances an deviations between point clouds. Combined with the computation of point cloud density and spread, provides a comprehensive assessment of the inspected parts. Based on the comparison and tolerance checks, the AI system decides whether to accept or reject the scanned part. Parts that fall within the acceptable tolerance range are accepted, while those that exceed the tolerance limits are rejected.
6	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market

	share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence
a	**Attainment of any SDG: '** AI Vision-Based Inspection System for Quality Control of Products' aligns with Sustainable Development Goal SDG#9, (**Industry, Innovation, and Infrastructure**). By automating defect detection and enhancing quality control, the system contributes to efficient manufacturing processes by ensuring consistent product quality, reduces human error, and minimizes production waste. Regionally, it bolsters economic competitiveness, conserves resources, and fosters skill development. Its implementation modernizes infrastructure, positioning our region as forward-thinking and attractive for investment.
b	**Any Environmental Aspect:** The Smart 3D Inspection System not only enhances the efficiency and accuracy of quality control processes but also plays a crucial role in promoting environmental sustainability. ➢ Reducing material waste by eliminating non-destructive testing. ➢ The automated nature of the AI-based system significantly reduces energy consumption, contributing to overall energy conservation. ➢ Accurate and efficient inspections lead to higher-quality products with longer lifespans, reducing waste and resource consumption ➢ Increased productivity and efficiency result in lower energy usage per unit of output, contributing to a more sustainable production process. ➢ Improved inspection processes enable the reuse and refurbishment of consumer goods, supporting circular economy principles. As industries continue to evolve, the adoption of such innovative technologies will be essential in driving both economic and environmental benefits.
c	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process:** Quality assurance is the main concern in the fast-changing world of manufacturing. Today, there is more demand than ever before of high product quality. Yet the traditional ways of inspecting the quality of a product often fail, with reliance on manual inspection processes that are prone to human error and inconsistency and material waste. Other that the systems which are using computer vision technologies often rely on CAD models for comparing with the manufactured part. The significance of this project lies in its ability to automate visual inspection with an assortment of ML and computer vision technologies so as to reduce human errors as well as it eliminates the use of CAD models and instead, it scans real and tangible benchmark product for acquiring 3D data for inspecting manufactured parts which help in reducing the defect rates significantly.
7	**Target Market:** One of the most compelling benefits of our AI Vision-Based Inspection System is the flexibility that it can offer in different manufacturing environments and product types. The system is made in such a way that it can be tailored to exactly meet the varied dimensional inspection requirements of industries and applications, such as for automotive components, electronic devices, and consumer goods. This makes it versatile as an asset for any manufacturer interested in stepping up their capability of quality control yet remaining flexible and scalable in any operation.
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10	**Video (If any)**	https://drive.google.com/drive/folders/1Dq0iyerTKeXkzrJF46V55SKhFCu67Wmz?usp=drive_link

Picture (to be pasted below)