Project Proposal

Name: Dhananjay Sharma; Student ID: 12230006

Title: Comparison of Machine Vision between CAD and real-world images

Course: 194.147 Interdisciplinary Project in Data Science

Abstract

This proposal outlines the project focused on validating the correct use of clamping devices in manufacturing, which is crucial due to the diversity of parts involved. The project, conducted in collaboration with the Institute of Production Engineering and Photonic Technologies (IFT) at TU Wien as part of the 194.147 Interdisciplinary Project in Data Science, aims to ensure the appropriate clamping device is selected based on the CAM (Computer-Aided Manufacturing) process. Traditionally, machine vision systems used for this purpose depend on training data captured from physical objects, which can disrupt production.

To minimize these disruptions, this project seeks to generate synthetic training images from 3D models using CAD software, specifically Siemens NX. By utilizing its API and Python scripting, the project will create accurate 3D models of various clamping devices and develop an automated software tool to generate 2D images from these models under different angles, sizes, and lighting conditions. These images will then be used to train an open-source machine vision application. The second phase involves testing and verifying the application using real-world images and evaluating its performance. The ultimate goal is to enhance the accuracy and efficiency of clamping device validation, enabling more streamlined and automated manufacturing processes.

1. Motivation / Problem Statement

In manufacturing, ensuring the correct clamping device is used for each specific part is critical for both safety and operational efficiency. Given the wide variety of parts produced, this validation process is essential but can be time-consuming and prone to errors. Validation relies on machine vision systems that require large sets of training images captured from physical objects. However, obtaining these images often interrupts production, leading to inefficiencies.

The primary motivation for this project is to develop a method that allows for the creation of training data without the need to physically capture images from the production line. By generating synthetic images from CAD models, we can train machine vision systems more efficiently, reducing downtime and improving the accuracy of the validation process. This approach aligns with the need for more automated, reliable, and streamlined manufacturing processes.

2. Methodology

The methodology includes the following steps:

2.1 Requirements Gathering

- Collaborate with IFT to define the specific requirements for clamping device validation.
- Determine the types of clamping devices and the corresponding CAM processes that need to be validated.
- Identify the necessary configurations for 3D modeling and image generation using Siemens NX.

2.2 3D Model Preparation

- Use Siemens NX to work with the existing 3D models of various clamping devices, ensuring they accurately represent the physical devices, including dimensions, shapes, and materials.

2.3 Automatic Image Generation Tool

- Develop an automated software tool that integrates with Siemens NX to generate 2D images from the 3D models.
- The tool will automatically adjust angles, sizes, and lighting conditions to produce a diverse set of images that simulate real-world scenarios.
- These synthetic images will serve as training data for the machine vision application.

2.4 Preprocessing and Training

- Implement preprocessing techniques to optimize the synthetic images for machine vision training.
- The machine vision model will be trained using an existing algorithm, focusing on accurately identifying the correct clamping devices based on the CAM process.

2.5 Testing and Verification

- Test the machine vision model, trained using the existing algorithm, with real-world images of clamping devices.
- Evaluate the model's performance in terms of accuracy, reliability, and speed in identifying the correct devices.
- Conduct a comparative analysis to assess the effectiveness of training with synthetic images versus real-world images.

2.6 Validation and Verification

- Conduct thorough validation to ensure the PyTorch machine vision model's accuracy and reliability.

3. Expected Results

- **Automated 3D Model Creation:** Successful creation of 3D models for various clamping devices using Siemens NX, API, and Python scripting.
- **Image Generation:** Development of a software tool that can automatically generate 2D images from 3D models, simulating various conditions.
- **Training Accuracy:** The PyTorch-based machine vision model, trained on synthetic images, should achieve high accuracy in identifying clamping devices, comparable to or better than models trained on real images.
- **Efficiency Gains:** Demonstrated reduction in production downtime due to the use of synthetic images for training, leading to more efficient manufacturing processes.

4. Baseline

- **Siemens NX Software:** Used for creating 3D models and generating synthetic images.
- **API and Python Scripts:** Utilized to automate the 3D model creation and image generation process within Siemens NX.

- **PyTorch Framework: Employed for training and testing the machine vision model.**
- **Real-World Images:** A dataset of images from the actual manufacturing environment will be used for testing and validation.
- **Preprocessing Techniques:** Methods will be applied to optimize synthetic images for effective machine vision training.

6. Resources Needed

- Access to Siemens NX software and necessary API documentation.
- Python programming environment for script development.
- PyTorch framework for machine vision model training and testing.
- A dataset of real-world images of clamping devices for testing and validation.
- Collaboration with IFT for guidance and domain-specific expertise.

7. Conclusion

This project aims to significantly improve the validation process of clamping devices in manufacturing by leveraging synthetic images generated from CAD models and using an algorithm for machine vision training. By reducing the need for real-world data, the project seeks to minimize production disruptions, enhance the accuracy of machine vision systems, and streamline the overall manufacturing process. Through collaboration with IFT at TU Wien, this project will contribute to more efficient, automated, and reliable manufacturing practices.