SECURE for Student Success

Undergraduate Research Program

Department of Manufacturing Systems Engineering and Management

Research Duration:	Summer 2025 (June – August 2025)
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Title of Project:	Prediction of Part Manufacturing Costs using Machine Learning in Machining Processes

Goals and Objectives of the Project, Expectations and Outcomes

1) Project Significance

In modern manufacturing, accurately predicting the cost of producing a part based on its geometry is essential for efficient resource allocation, pricing strategies, and improving overall manufacturing processes. Traditional methods for cost estimation are often time-consuming, labor-intensive, and subject to human error. By leveraging machine learning, such as 3D convolutional neural networks (CNNs), the project aims to automate and improve the precision of cost classification. This automation will significantly streamline the cost estimation process, leading to more consistent and reliable predictions, reducing both lead times and production costs.

This project is particularly important as industries increasingly seek ways to integrate advanced data-driven methods into their manufacturing workflows. The outcome of this work could lead to more accurate financial planning and resource allocation, while also laying the foundation for future research in intelligent manufacturing systems.

2) Goals and Objectives

The goal of the project is to develop and implement a machine learning framework to classify the direct manufacturing costs of parts based on their geometric features. This will involve creating a predictive model that can categorize parts into different cost ranges (low, medium, high) based on input data.
The objectives include:

- **Obj1:** Data collection and preparation
- **Obj2:** Model development, validation and testing
- **Obj3:** Project deliverables

3) Expected Outcomes

The expected outcomes of the project are:

- Cost Classification Model: A Machine Learning model capable of classifying parts into low, medium, or high cost ranges based on part geometry.
- Labeled Parts Database: A fully labeled dataset of parts categorized by cost for future use in machine learning and manufacturing research.
- Skill Development: Hands-on experience for students in applying machine learning to manufacturing, enhancing their industry-relevant skills.

4) Methodology

The project methodology is structured around two key tasks, each contributing to the overall goal of developing a machine learning framework for classifying manufacturing costs of parts. The manufacturing process will be turning process. The tasks are designed to progressively build the data, model, and validation needed for accurate cost classification.
The research team comprises 3 – 5 undergraduate students, led by PI with expertise in manufacturing processes and data analytics. The PI has the necessary qualifications to carry out this study. She holds a Ph.D. in Manufacturing and Materials Engineering with extensive experience in traditional manufacturing processes. She also teaches courses in manufacturing processes and part modeling, e.g. MSE 412/L Manufacturing Process and Lab and MSE 508/L CAD/CAM Systems and Lab in which the results from this project can help in preparing showcases of the courses.

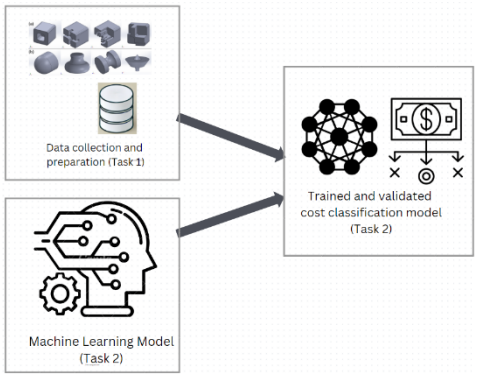

Figure 1: Project overview

The project consists of two primary tasks which are schematically depicted in Figure 1.

Task 1: Data Collection, Preparation, and Labeling (Obj1)

- **Objective**: Build a comprehensive dataset of part geometries, and label them based on manufacturing cost categories.
- **Approach**:
    - Gather data on part geometries from copper (Cu) machining processes.
    - Index these geometries data into a structured database.

    - Collaborate with machine shop technicians to assess the machining complexity of each part and assign cost labels (low, medium, high) based on machining ease.
    - This labeled dataset will serve as the foundation for training the machine learning model.
- **Deliverables**: A fully indexed and labeled database of parts categorized by cost.

Task 2: Model Development, Training, and Validation (Obj2)

- **Objective**: Develop, train, and validate a machine learning model to classify manufacturing costs based on part geometries.
- **Approach**:
    - Design and train a machine learning model using the labeled dataset from Task 1. The model will automatically learn geometric patterns, classifying parts into cost categories.
    - Validate the model's predictions by cross-referencing with technician feedback and real-world cost data.
- **Deliverables**: A calibrated and validated machine learning model for cost classification.

5) Potential Significance and student involvement

This project offers significant potential for improving manufacturing efficiency by automating the cost estimation process using machine learning. Accurate and timely cost classification will help manufacturers optimize resource allocation and reduce production costs. The model can be scaled for various materials and machining processes, providing a versatile tool for industry-wide application. Additionally, the collaboration with machine shop technicians ensures real-world relevance and applicability, while contributing to the academic field by exploring the use of machine learning in manufacturing cost estimation.

Students will gain hands-on experience in data collection, preparation, and machine learning model development. They will work with real-world datasets of part geometries, learning to structure large datasets and train ML models. Additionally, students will engage in model validation and optimization, gaining practical insights into how machine learning can solve real-world manufacturing challenges.

The project provides a cross-disciplinary learning experience, as students collaborate with machine shop technicians to understand cost drivers in machining. This blend of technical, practical, and analytical skills will prepare students for careers in engineering, data science, or manufacturing, while giving them valuable experience in writing capstone reports and presenting findings.

6) Plans for Dissemination

The outcomes of this project will be shared through multiple channels to maximize impact. Students will present their work at the final symposium, participating in both the poster session and presentation session. This will provide an opportunity to showcase the project's significance, methodology, and results to peers, faculty, and industry professionals.

Additionally, we plan to submit the findings to relevant academic conferences in the fields of machine learning and manufacturing. By sharing the research in these venues, we aim to contribute to the broader academic conversation and highlight the real-world applications of ML models in cost classification.