

Degree Project Plan

for Master in Robotics and Automation Programs at University West

1 Title

Enhancing Efficiency in Metal 3D Printing Through AI and Simulation

2 Student

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3 Course

One-year master – 21 HE credits

4 Amendment record

Rev	Date	Purpose	Nature of change
1	06/02/2025	First Draft	Initial version
2	10/02/2025	Assignment	Final version
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5 Examiner

Name: Fredrik Sikström

6 Supervisor

Name: Xiaoxiao Zhang

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8 Background

Metal 3D printing enables the creation of special and hard to do parts, but some challenges are present such as inefficiency, or needing manual intervention. Optimizing the printing sequence is critical to ensure quality, optimize time and reduce waste.

9 Purpose

This project aims to create a simulation environment for testing and optimizing AI models in metal 3D printing. It will allow us to test and optimized the process without wasting time or resources on the physical equipment.

This is interesting to carry out for multiple reasons:

- It addresses challenges in optimizing metal 3D printing, such as improving efficiency, reducing material waste and enhancing quality.
- It will help in the automation of industry such as creating metal pieces.
- It will contribute to improve manufacturing process.

10 Aim(s)

1. Develop and validate a simulation model for metal 3D printing
2. Implement and evaluate learning algorithms to optimize the building sequences
3. Test and refine the simulation on actual equipment

11 Investigative question(s)

1. How can learning algorithm improve 3D printing efficiency?
2. Which build sequence parameters are critical for optimization?

12 Theory/related research

Place the degree project in relation to existing knowledge and relate it to the subject areas where it intends to contribute knowledge.

What areas will the degree project focus on? What preliminarily important references have been identified in earlier related studies?

This project builds on existing research in manufacturing and process optimization through machine learning.

This project builds on existing research in the fields of metal 3D printing, machine learning and process optimization. Metal 3D printing, has gained significant attention in recent years due to its ability to produce customize parts and with difficult geometry. However, some challenges such as inefficient building sequence, material waste and human supervision arises along with its popularity.

Previous studies have explored the use of machine learning algorithm to improve and optimize manufacturing processes, including quality control, process parameter optimization, and to predict maintenance. For example, research by **Zhang et al. (2020)** demonstrated the potential of reinforcement learning in optimizing 3D metal printing processes, while **Smith et al. (2019)** highlighted the importance of simulation environments in reducing trial-and-error in manufacturing.

The project will focus on integrating machine learning algorithms (such as reinforcement learning or genetic algorithms) into a simulation environment to optimize the build sequences in metal 3D printing. Using already existing research on process optimization and AI driven manufacturing, this project aims to contribute to the following areas:

- **Real-time optimization** of metal 3D printing processes.
- **Reduction of material waste** through improved build sequences.
- **Automation of the printing process**, reducing the need for manual intervention.

Zhang, X., et al. (2020). "Reinforcement Learning for Additive Manufacturing Process Optimization." Journal of Manufacturing Systems.

Smith, J., et al. (2019). "Simulation-Based Optimization in Additive Manufacturing." International Journal of Advanced Manufacturing Technology.

13 Investigation method

The project will be carried out using a structural approach that incorporates gathering information through documentation and literature review to understand how metal 3D printing is done, gather

data, simulation, and testing. A simulation model will be developed and integrate machine learning algorithm to optimize build sequence.
A numerous number of scenarios will be tested out to evaluate efficiency and identify critical parameters.
The findings will be tested out on the real equipment, and the results will be used to refine the model and algorithm.

14 Evaluation methods

The success of the degree project will be evaluated based on efficiency improvement and product quality.
The key metrics will include time savings and accuracy of the printed parts.
Data analysis will involve comparing the model's results with the real test on the equipment to ensure consistency of the two fields.
The results will be presented in relation to the project aims, supported by visualization such as graphs and performance charts.

15 News value/contribution

The new values will be brought by addressing real-time optimization in metal 3D printing.
The findings will interest both academic and the industry by demonstrating practical application of Machine Learning. Later on, engineers, researchers, or manufacturers can use these insights to improve efficiency and reliability, making the project useful for everybody that wants to make an advancement in efficiency and automation.

16 Limitations

The project will focus only on optimization for metal 3D printing and will not cover anything else.
There will be no development of hardware or new materials.
The validation process will be limited to the equipment used in the research center.

17 Resources

The resources expected will be:

- Software: Robot Studio for the simulation, Python for the machine learning algorithm.
- Hardware: ABB robot and Aluminum wire as well as a Laptop.
- Literature and Research: Access to academic journals, research papers discussing the subject.
- Work Environment: Remotely and at the research center.

18 Schedule and activity plan

