Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Xiaochen Ding
Student number	5926882

Studio		
Name / Theme	BK-Graduation	
Main mentor	Serdar Asut	Design informatics
Second mentor	Charalampos Andriotis	Structural Design & Mechanics
Argumentation of choice of the studio	I have a strong passion in additive manufacturing, combined with AI technologies, with a focus on sustainable material mechanical properties.	

Graduation project	
Title of the graduation project	Responsive Fabrication System for Real-Time Detection and Correction in Construction-Scale 3D Printing of Curved Tower Structures with Clay Using Machine Learning
Goal	
Location:	Delft
The posed problem,	Large-scale 3D printing with clay presents significant challenges in achieving structural integrity, precision, and consistency, especially when dealing with complex geometries and dynamic environmental conditions. Traditional open-loop systems are limited in their ability to detect and compensate for real-time anomalies, leading to defects such as layer shifting, material flow inconsistencies, and adhesion failures. These defects not only compromise the quality of the printed structure but also increase material waste and production time. For the relevant previous research, the machine learning (ML) models used for anomaly detection in additive manufacturing often suffer from overfitting and lack scalability, making them fluctuate in prediction accuracy during

	calibration process. To address these challenges, it is crucial to evaluate and select the most suitable ML architecture for this specific context, considering options such as ResNet, EfficientNet, CNN, VGG-16, YOLOv5, DNNs, and Vision Attention Networks (VAN). Each model offers distinct advantages and trade-offs in terms of accuracy, computational efficiency, and adaptability. Addressing these limitations requires a robust, real-time closed-loop calibration system that incorporates advanced ML algorithms, transfer learning for scalability, and robotic extrusion synchronization. Such a system would ensure adaptive control of key printing parameters, maintain structural and aesthetic integrity, and facilitate efficient, large-scale production. This research aims to address these challenges by developing an integrated solution for real-time defect detection, process optimization, and scalable clay 3D printing technologies suitable for construction-scale applications.
research questions and	How can a responsive, real-time calibration system utilizing machine learning be developed to detect and compensate for defects, optimize layer adhesion and weight distribution, and maintain structural integrity in large-scale clay 3D printing for construction?
design assignment in which these result.	**Develop a Real-Time Calibration System**: Design and implement a responsive system capable of detecting and adjusting G-code parameters dynamically during large-scale clay 3D printing. **Integrate Machine Learning for Anomaly Detection**: Utilize advanced machine learning models to identify and classify defects such as layer shifting, under-extrusion, and adhesion failures in real time. **Optimize Layer Adhesion and Structural Integrity**: Investigate and model the relationship between printing parameters, material properties, and environmental factors to ensure

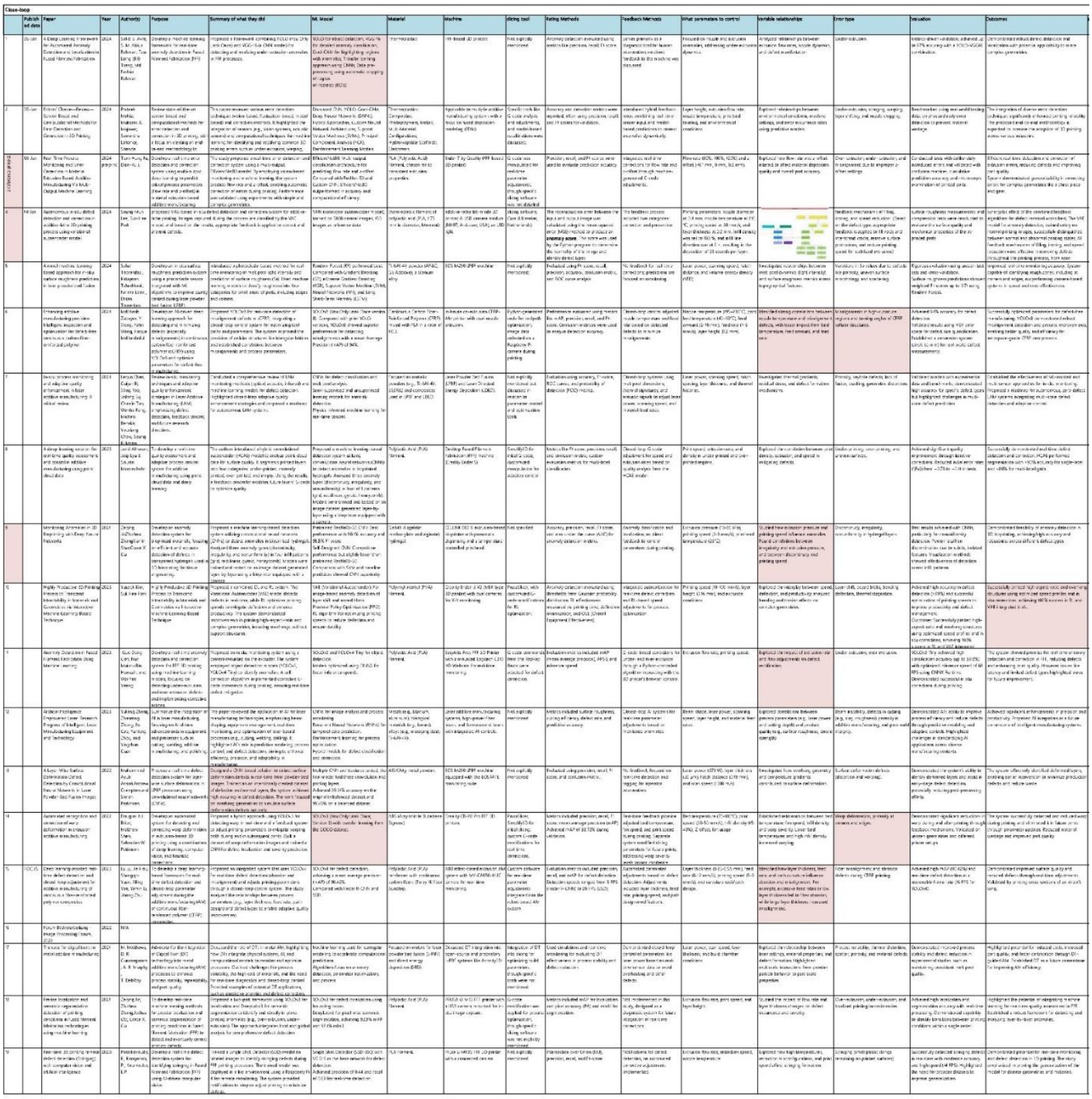
	proper layer adhesion and structural stability, even in complex geometries and varying conditions. **Evaluate Scalability of Machine Learning Models:** Assess whether the machine learning model developed for small-scale printing can be effectively scaled to construction-scale 3D printing. Explore the use of transfer learning to adapt the model for larger-scale applications while maintaining accuracy and efficiency. **Balance Local and Global Design Coherence**: Develop algorithms that link local defect corrections (e.g., smoothing ridges or filling gaps) with global structural and aesthetic requirements to maintain high print quality. **Investigate Layer Weight Distribution**: Explore methods to dynamically control material distribution, ensuring heavier layers for stability at the base and lighter layers toward the top for improved overall structural performance. **Evaluate System Performance**: Conduct experimental tests on scaled prototypes and complex geometries to validate the effectiveness of the system in achieving defect-free and high-quality prints. **Explore Robotic Arm Integration**: Investigate the integration of a robotic arm synchronized with extrusion processes to set up the experiments.

Process

Method description

The proposed workflow and methodology for this research are designed to develop and validate a responsive, real-time calibration system for large-scale clay 3D printing. This framework integrates systematic experimentation, machine learning (ML) model development, and iterative testing to address key challenges in structural stability, defect detection, and environmental adaptability. 1. Initial Dataset and Experimental Setup 2. Machine Learning Model Development 3. Validation of Model Predictions 4. Scaling to Construction Applications 5. Iterative Feedback and Optimization

Literature and general practical references



Close-loop

	Published date	Paper	Year	Author(s)	Purpose	Summary of what they did	ML Model	Material	Machine	slicing tool	Rating Methods	Feedback Methods	What parameters to control	Variable relationships	Error type	Evaluation	Outcomes

Precedent: paper *"Autonomous in-situ defect detection and correction in additive-lathe 3D printing process using variational autoencoder model"*

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

My graduation project, titled "Responsive Fabrication System for Real-Time Detection and Correction in Construction-Scale 3D Printing of Curved Tower Structures with Clay Using Machine Learning," aligns closely with the core themes of my Building Technology (BT) master track and the broader MSc AUBS programme. It integrates principles of computational design, material science, and sustainable construction, which are fundamental to the BT curriculum. The project's focus on optimizing 3D printing technologies resonates with the programme's emphasis on innovation, digital fabrication, and sustainable architectural practices.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

The relevance of my graduation work extends across social, professional, and scientific domains. Socially, the project contributes to the development of sustainable construction techniques, addressing the need for environmentally friendly materials and processes in the face of global climate challenges. By enabling the efficient use of clay, a natural and widely available material, the project promotes affordability and accessibility in architectural fabrication, especially in underserved regions.

Professionally, the project advances the application of machine learning and robotics in architecture and construction, offering tools that enhance precision, efficiency, and adaptability in large-scale 3D printing. This has implications for the construction industry's ability to meet increasing demands for customized, high-quality, and sustainable structures while minimizing material waste and labor-intensive practices.

Scientifically, the integration of real-time monitoring and adaptive control systems in 3D printing pushes the boundaries of additive manufacturing research. The project addresses critical gaps in scalability, material variability, and defect mitigation, contributing novel insights to the fields of machine learning, computational fabrication, and material science. These advancements support the broader goal of developing resilient, efficient, and responsive architectural systems in the digital age.