# Revolutionizing Custom Medical Device Production: Developing an Intelligent Automated Postprocessing Pipeline for Dental 3D Scans using Synera

## Type:

Bachelor Thesis / Semester Thesis / Master Thesis

## Content:

konstruktiv

## Description:

### About Enki Interdentalis:

Enki Interdentalis is a dynamic startup poised to revolutionize interdental hygiene. We are developing the Enki Mouthguard, a customized, 3D-printed mouthpiece that accelerates and automates the cleaning of interdental spaces using a precisely targeted water-air mixture. Our mission is to enhance oral health and improve quality of life by offering an effective, safe, and easy-to-use solution. Central to our innovation is the ability to rapidly and accurately create patient-specific devices based on intraoral 3D scans. The concept has already been shaped into a business model through participation in the Xplore Venture Creator Accelerator by UnternehmerTUM, and its potential has been recognized through finalist nominations at the TUM IdeAward, the Zeidler Research Foundation, and the Formnext Rookie Award.

### Motivation for this Thesis:

The advent of personalized medical products, perfectly tailored to individual anatomies, holds immense promise for improving healthcare outcomes. Intraoral 3D scanning technology is a cornerstone for achieving this level of customization in dentistry. However, raw 3D scans often require significant manual postprocessing – a time-consuming, operator-dependent bottleneck that hinders scalability and introduces variability. For a startup like Enki Interdentalis, streamlining this workflow is paramount to efficiently produce our innovative Enki Mouthguard.

This thesis aims to address this critical challenge by designing, implementing, and validating an automated 3D scan postprocessing pipeline. Leveraging Synera, a cutting-edge parametric and visual programming environment for engineering design automation. We aim to create a robust, efficient, and scalable solution that transforms raw scan data into high-quality, design-ready models, paving the way for next-generation personalized dental care.

### Proposed Work Packages:

1. **Comprehensive Literature Review & State-of-the-Art Analysis:**
    a. In-depth study of common artifacts and quality issues in dental 3D intraoral scans.
    b. Review of existing 3D scan postprocessing techniques (manual, semi-automated, automated) and software tools, with a focus on dental applications.
    c. Exploration of Synera's capabilities and limitations for geometric processing and workflow automation.
    d. Identify research gaps in automated dental scan postprocessing.
2. **Detailed Requirement Engineering & Process Definition for Enki Interdentalis**:

a. Collaborate with Enki Interdentalis team to precisely define the input scan characteristics and the required output model specifications for Enki Mouthguard design.
b. Identify and prioritize all necessary postprocessing steps (e.g., data import & validation, cleaning/noise reduction, hole filling, smoothing, alignment, mesh decimation, …).
c. Model the target automated workflow, including decision points and error handling.

3. **Development of a Robust Validation Framework:**
   a. Define quantitative and qualitative metrics for evaluating the performance of the automated pipeline.
   b. Geometric Accuracy: Deviation from manually processed "gold standard" models or original anatomy (e.g., using Hausdorff distance, surface deviation maps).
   c. Processing Time: Time taken per scan.
   d. Robustness: Success rate across a diverse dataset of scans with varying quality.
   e. Output Quality: Smoothness, feature preservation, absence of artifacts.
   f. Reduction in Manual Effort: Quantify the decrease in operator time.
   g. Prepare a representative dataset of diverse dental 3D scans for development and testing.
4. **Implementation of the Automated Pipeline in Synera:**
   a. Systematically implement each identified postprocessing step as an automated module within or connected to Synera.
   b. Focus on parametric design to allow for easy adaptation and optimization.
   c. Develop strategies for robust error handling and user feedback within the pipeline.
   d. Investigate and implement advanced algorithms for challenging steps (e.g., AI-assisted jaw alignment).
5. **Testing, Validation, and Optimization:**
   a. Systematically test the pipeline using the defined validation framework and dataset.
   b. Analyze results, identify bottlenecks or areas for improvement, and iteratively refine the pipeline.
   c. Conduct a comparative analysis of the automated pipeline against manual postprocessing methods or other existing (semi-)automated tools. Assess the impact of different Synera parameter settings on the output quality and efficiency.
   d. Investigate the scalability of the solution for high-throughput processing.
6. **Documentation and Thesis Compilation:**
   a. Thorough documentation of the developed pipeline, including its architecture, algorithms, and user guidelines
   b. Comprehensive write-up of the thesis, detailing the methodology, results, discussion, and conclusions

## Prerequisites:

- High degree of self-responsibility and initiative, proactive engagement within a startup environment.
- Prior experience with parametric design software is highly advantageous (Synera-specific knowledge will be acquired).
- Basic programming/scripting skills can be beneficial for advanced customization within or around Synera.

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