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Calvariam: Visual Educational Resources for Maxillofacial Surgery

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Abstract

Maxillofacial surgeries are complex interventions that require detailed planning and highly specialized surgeons. We propose Calvariam, an AR application, to provide future generations of surgeons with a better training experience, via 3D models and detailed videos that showcase detailed structures and spatial relationships. We curated and processed a patient's CT data using MeVisLab. To determine the optimal placement of implants after trauma, we performed bone density calculations and biomechanical analysis of the forces of mastication at the mandibular joint. Anatomically correct 3D models were implemented into an educational animated movie using Maya, Blender, and Adobe After Effects. Finally, we integrated the processed data, models, and animated clip into an AR application using Unity. Initial discussions with domain experts indicate that Calvariam is a first step towards obtaining visual and interactive feedback for maxillofacial surgery education.

1. Introduction

Maxillofacial surgery is an intellectually and physically demanding field, which entails actions to treat illnesses, injuries, and deformities in jaw bones, surrounding tissues and the mouth. Such conditions are primarily caused by trauma, disease, and congenital malformations [PEH*98]. Maxillofacial interventions require fast planning at a high level of detail and the process embodies the following steps: first, a drilling risk assessment is conducted to avoid damage on adjacent structures; then, sheer stress analysis on the mandibular joint determines if the prosthetic implants withstand the forces of mastication; finally, the optimal placement of biocompatible osteosynthesis implants, enduring mechanical stress and promoting ossification, is determined.

Recently, trauma management in maxillofacial surgery has evolved drastically due to advancements in medical imaging, as well as materials used for reconstructions. Although there are educational portals and applications for dentistry, there are currently no anatomical education visualization tools and simulations related to maxillofacial surgical interventions. We propose *Calvariam*, an augmented reality (AR) approach that offers specialized and self-contained visual educational tools for future maxillofacial surgeons with interactive and informative visualization approaches (Figure 1). *Calvariam* comprises three main components:

- Curate and process the data from a real patient's Computed Tomography (CT) scans;
- Create and segment anatomically correct 3D models from the reconstructed data to create an educational animated movie about maxillofacial surgery;
- Combine the generated 3D models and educational animated movie into an interactive mobile AR application.

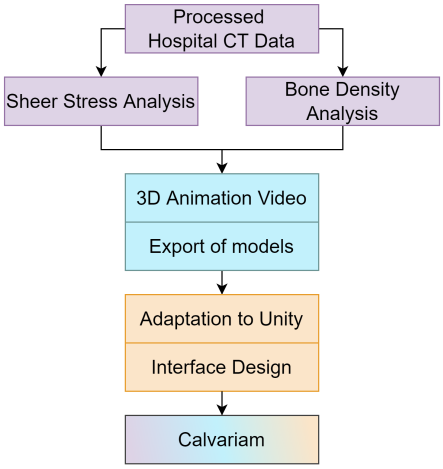

Figure 1: *Preprocessing steps for Calvariam. The color coding (■, ■, ■) indicates three main components to create the final product.*

Calvariam is ongoing work and the first step towards AR-based personalized patient treatment scenarios, where anatomical information can be rendered over anatomical landmarks of a patient in the future. It currently allows us to generate educational videos that can be employed as part of medical education and patient–doctor communication.

2. Methods Used in *Calvariam*

Raw Data Processing. Clinical cranial CT data sets were curated and improved for contrast. Bone density calculations were performed in MeVisLab and the sheer mechanical stress properties at the mandibular joint (Von Misses) were derived with Simscale, a