Toward the Development of an Accurate 3D Human Body Model Implemented in a Real-Time, Interactive Application to Enhance Anatomy Teaching.

Matthieu Poyade[1], Lauren Clunie[2], Brian McGeough[1], Anna Lysakowski[3], Paul Rea[2], Paul Anderson[1]
[1]Digital Design Studio, Glasgow School of Art, [2]Laboratory of Human Anatomy, School of Life Sciences, College of Medical, Veterinary and Life Sciences, University of Glasgow,
[3]Dept. of Anatomy and Cell Biology, University of Illinois at Chicago

Abstract: There are many multi-media applications to support human anatomy education. These applications complement traditional teaching by providing opportunities for learners to interact with 3D anatomical models, encouraging self-paced learning. Anatomical accuracy may be compromised, however, in some models that rely more on artistic interpretation than on objective data acquisition. This paper presents the research project **3D Head and Neck Anatomy**, commissioned by National Health Service Education for Scotland (NES) and conducted by a multi-disciplinary team of digital specialists and anatomy experts. The model also has a haptic (sensory feedback) component intended for training dental students in simple procedures. We have revisited the methodological framework to support the workflow of the new Scottish Funding Council/NES funded project, the **3D Definitive Human**. This new framework uses the acquisition of data from cadaveric dissections via photogrammetry, volumetric data via MRI and CT, and 3D modelling of these anatomical data. Our goal is to achieve a highly accurate 3D human body model in a real-time, interactive application.

Introduction

During the last few years, the number of applications for supporting the learning of human anatomy has flourished online. The integration of annotated and interactive 3D models to support the acquisition of knowledge of human anatomy represents a significant improvement of traditional teaching strategies. Despite dedicated modelling efforts, models often lack of accuracy as they do not proceed from an objective acquisition of data derived from data scanning. In contrast, 3D image processing systems as AMIRA, provide accurate anatomical models, but interaction is relatively limited for instructional purposes.

We believe an accurate digital model of the human anatomy offering enhanced exploration techniques will lead to great improvements in current teaching.

We present the **3D Head and Neck Anatomy** project, commissioned by NES and conducted by visualization specialists from the Digital Design Studio, part of the Glasgow School of Art, and anatomy experts from the University of Illinois at Chicago and the University of Glasgow. We describe an established workflow which uses laser scanning, medical imaging processing technologies, modelling software, and programmable interfaces for the development of a real-time interactive application. We also revisit this methodological framework In anticipation of the **3D Definitive Human**, an ambitious project funded by Scottish Funding Council/NES, which aims to develop an interactive platform to support the teaching of the whole human anatomy.

3D Head & Neck Anatomy

Methodology for the Development of an Accurate Anatomical Model

The development of an accurate anatomy model required a methodological framework that supports an agile workflow, which considers:

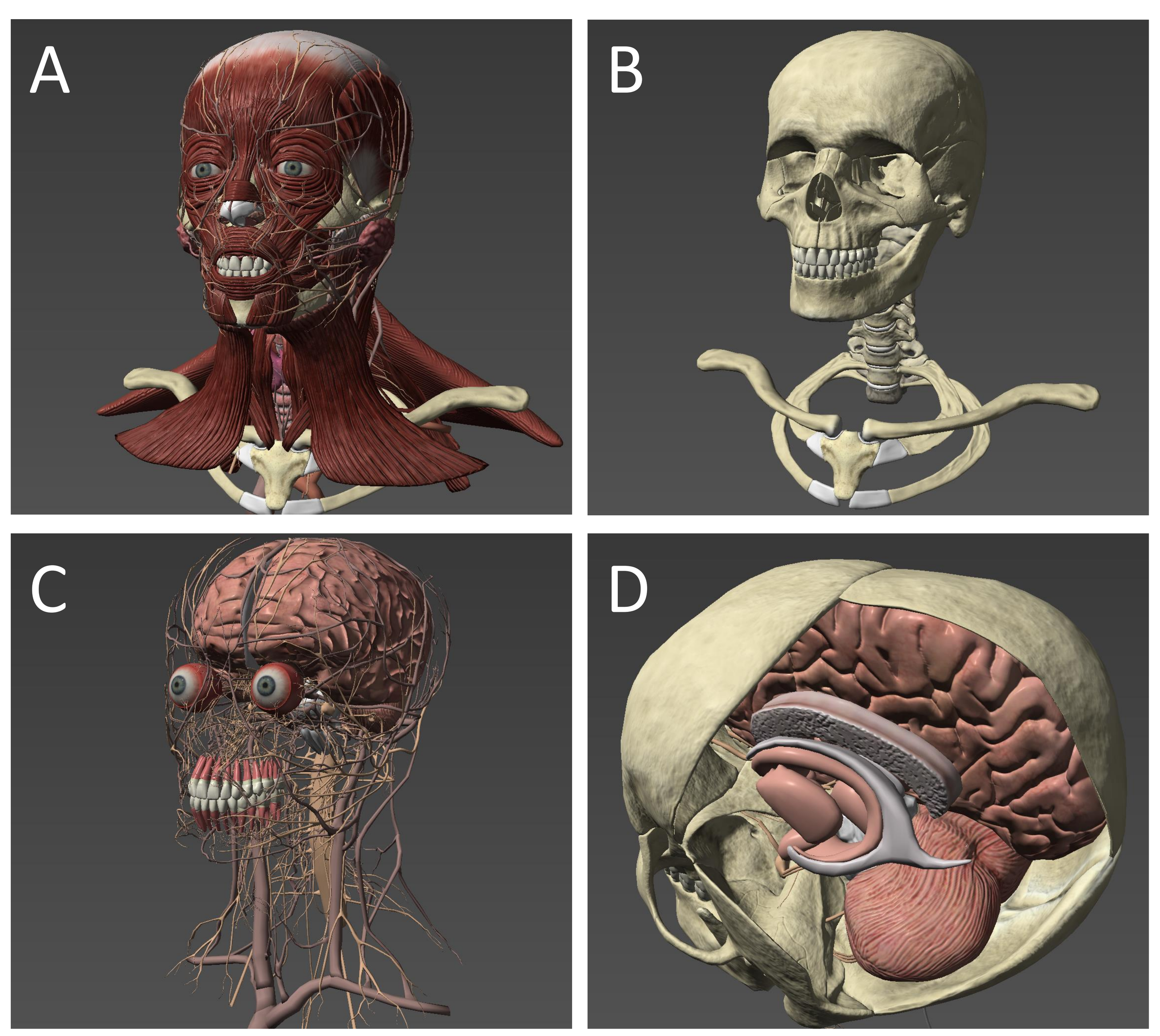

Figure 1. Some "Virtual Dissections" from the Head & Neck Anatomy Model

1. The identification and dissection of a suitable male cadaver between the ages of 50-65.
2. Objective acquisition of data: (a) Laser scanning captured skeletal data accurately. However, as soft tissue scan data did not accurately match the shape of living tissues, they were used as a reference for modelling; (b) In parallel, a volumetric dataset of the brain of a live subject was obtained from MRI and CT scans (Fig. 1D). AMIRA software was used for segmenting brain data.
3. Low polygonal models were created.
4. As textures of cadaveric and living tissues differ in colour, photographic data of living soft tissues were used as reference to build the textures of the model.
5. Several texture layers were overlain for a photorealistic render of tissues.
6. An interactive visualization platform with customized exploration functionalities was developed.
7. The application has been tested and is well received by clinicians. Verification was performed at every stage of development.

The resulting dataset represents a comprehensive structure that captures and presents a normalized, unbiased model (Fig. 1).

Head & Neck Application

The Head and Neck Application is a visualization platform that provides real-time interaction with our accurate anatomical dataset. The user can manipulate the model but also perform virtual dissections by dragging and dropping (Fig. 2A), hiding or revealing relevant structures, and labeling data for instructional purposes (Fig. 2B). Cross sections can also be done to isolate specific information in planes similar to MRI and CT scans (Figs. 2C,D).

An accompanying suite for large scale displays allows enhancing the interaction tracking the user's point of view. Along with stereoscopic projection, it provides an immersive experience for an audience to explore the anatomy at wider scale.

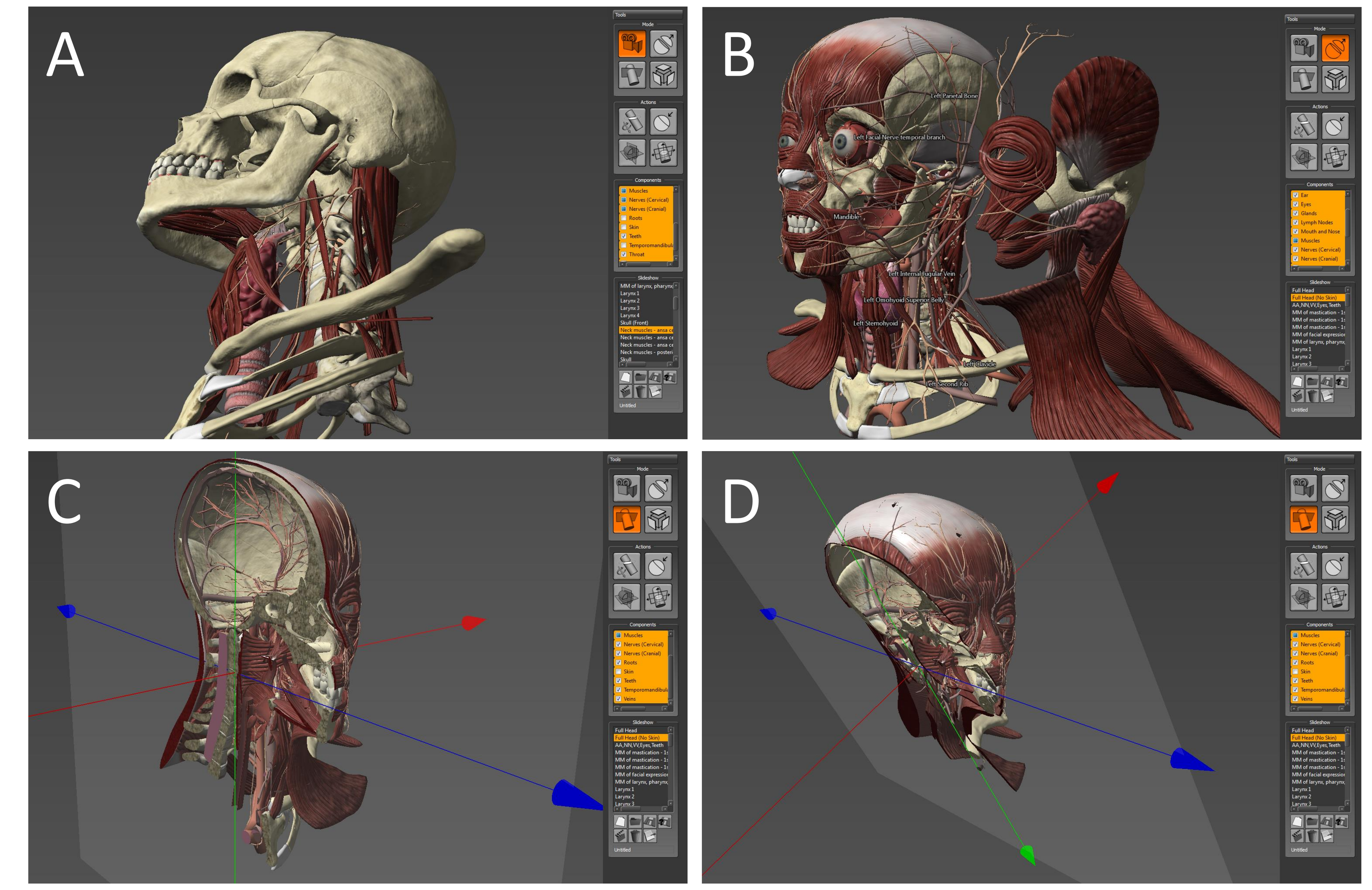

Figure 2. Operating Features of the Head & Neck Anatomy Model

Dental Injection Training Simulator

The initial administration of local anaesthetic injection on live patients is a critical part of the dental curriculum. The lack of knowledge of the anatomy of mandible structures has been reported as a major issue.

The Head & Neck Anatomy project also aimed to develop a training system to complement dental training, familiarize students with local anaesthetic injection in the region of the inferior alveolar and lingual nerve, and encourage self-paced learning (Fig. 3). The integration of an accurate digital model of the mandible anatomy enhanced with the interaction paradigm offered by haptic force feedback devices, provides a safe and repeatable environment for training and improving the understanding of spatial relationship between anatomical structures.

The haptic device enables controlling a virtual syringe and inserting the needle into the different types of soft tissue, simulating corresponding tactile sensations. All haptic sensations have been heuristically parameterized and verified by dental experts.

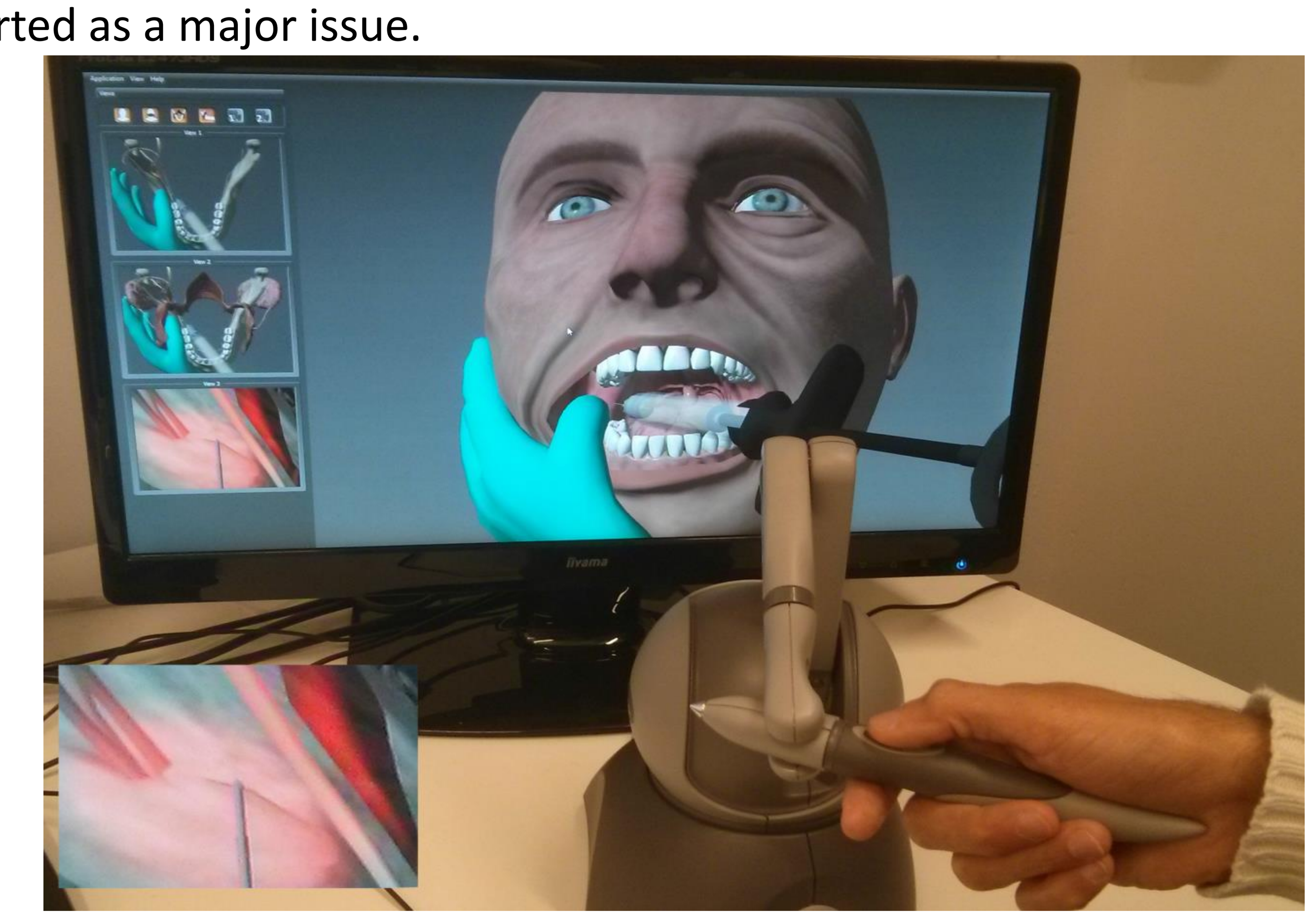
Figure 3. The local anaesthesia injection training system

3D Definitive Human

We are revisiting the workflow established during the Head and Neck Anatomy project, for development of an accurate digital model of the full human body anatomy. Our aim is to improve the interface in the head and neck application, thus providing a new set of functionalities (e.g., corner-cut cross section, MRI/CT data viewer & multimedia viewer) to reinforce the interaction paradigm and the exploration of the whole human body anatomy.

The acquisition of the anatomical dataset is fully based on MRI/CT data scans of a male cadaveric specimen. Anatomical structures are being classified and isolated from data scans using medical software, such as AMIRA.

Additionally, several prosections were carried out to isolate relevant anatomical structures and capture their surface through photogrammetry, a method employed to construct reality look-alike 3D models from photographs. This will allow us to construct an interactive multimedia library of prosected structures to be proposed through the enhanced application interface.

Acknowledgements

We gratefully acknowledge funding support from the Scottish Funding Council/NES (PA), the US-UK Fulbright Commission (AL) and computer graphic expertise from Ibrahim Buksh, Victor Portela, James Simpson, Stefania Calderera & Yeshwanth Pulijala.

Contact Information: m.poyade@gsa.ac.uk; lauren.clunie@glasgow.ac.uk; b.mcgeough@gsa.ac.uk; alysakow@uic.edu; paul.rea@glasgow.ac.uk; p.anderson@gsa.ac.uk