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Summary

To know where you are and where you are going means knowing where you came from. Therefore this thesis starts with a brief Historical overview explaining the thoughts of our predecessors that led to the eventual development of CASAM. In Dissection the works of the founding fathers of modern anatomy and surgery such as “The first known anatomist”, “the father of modern Surgery”, and “the restorer of anatomy” are described giving an historical overview of human dissection. Averaging describes how scientists such as Leonardo Da Vinci have long tried to capture the shapes of anatomy and reduce them to average and ideal proportions. Warping illustrates “how thinking outside the box” leads to exceptional theories; A Scottish biologist reduced the differences in shapes of related species such as ape and man to simple mathematical functions. In essence this formed the basis for the application of algorithms in the description of variations in anatomy and species.

Current concepts of CASAM are explained in **Part I, Computer Assisted Surgical Anatomy Mapping**. In the first sub-chapters the general principles of Image processing, Geometry and Warping are explained. Secondly their role in the novel anatomy mapping tool CASAM is elucidated when the three phases of the method are explained. First Preparation, photography and landmarks are described. Then in Warping the algorithms and averaging process is outlined and in Renditions the process of computing safe-zones and final renditions summarizing complex anatomy is illustrated.

The application of CASAM in basic surgical research is shown in **Part II, CASAM in Surgical Anatomy**. This part is divided into three subchapters, each describing different sorts of renditions dependent on the clinical research question. In Point distribution model the perforating veins of the lower arm are mapped as they have an impact on survival of Arteriovenous fistulae created for haemodialysis (chapter 2.1).

In Multiple Line model the variations of nerves and arteries are mapped in relation to kidney surgery (chapter 2.2) and ankle surgery (chapter 2.3). In chapter 2.4 regarding knee surgery, not only the superficial nerves are located but their direction is also mapped, encouraging surgeons to rethink the direction of the incision in which the knee is approached. As the wrist is a common site for neuropathic pain after injury of the sensory nerves, two of the radially located superficial nerves were mapped (chapter 2.5). The anatomical relation between these nerves is also quantified as it might explain the high rates of post-injury neuroma formation and neuropathic pain found in the dorso-radial side of the wrist.

In chapter 2.6 the mapping of a Multiple area model is illustrated summarizing the anatomy of the sural nerve and the short saphenous vein. During thermal ablation, heat from the laser might damage the nerve and initially no safe zone could be defined as both structures are located close to each other. However the nerve partially runs below a protective fascia layer and by mapping this area in 20 specimens, even a 3-D Safe-zone for laser surgery is be defined. A “zone of interest” was mapped for three muscles located near the elbow; by defining a zone in which each muscle is present in all 20 specimens without overlap of other muscles a noninvasive preoperative test for tendon transfers for tetraplegic patients can be developed (chapter 2.7). Finally in chapter 2.8 CASAM is used to completely map the skin innervation of the hindpaw in multiple rats. The likelihood of overlap in skin innervation between the three branches of the sciatic nerve and the saphenous nerve was determined using CASAM.

Examples of the application of CASAM in the second pillar of surgery, teaching, are given in **Part III, Surgical Training.** First, the means by which CASAM is implemented in surgical teaching is discussed in chapters 3.1 and 3.2; the web-based version of CASAM allows for quick processing of incision lines drawn by participants on actual specimen. The photographed incisions can then be related to a “gold standard” or the computed location of multiple arteries and/ or nerves. Hereby residents and surgeons are given personalized and direct feedback, supported by multiple variations of anatomy dissected for research. Interestingly the results presented in this study seem to partially contradict the current perceived benefits of “volume surgery”.

Incisions drawn by participants of surgical anatomy courses, or surgeons in general, can be compared and the inter- and intra-surgeon variability can be quantified. In chapter 3.3 incisions drawn for an approach of the tibia are mapped in relation to tibial nailing and chapter 3.4 discusses the inter- and intra surgeon variability in incisions drawn for an approach of the calcaneus in relation to calcaneal surgery. Common variables in the placement of these incision lines such as experience, surgical specialty and exposure to calcaneal surgery are related to how well a surgeon is able to draw an incision conform the “gold standard”, showing that experience is not always related to expert performance.

Finally, in Discussion and future perspectives regularly raised reservations regarding CASAM are discussed. Most importantly the disadvantages and main doubts of warping algorithms and their application in CASAM will be related to data verification by means of conventional anatomy mapping. Currently CASAM is a labor intensive process and researchers not only need to learn how to dissect in a certain way but also be capable of basic coding and have a decent understanding of photo manipulation. Furthermore image manipulation is currently not widely accepted in research. Therefore a simple classification system is proposed that categorises the level of image manipulation to ensure that the reader exactly knows to what extent an image has been altered.

CASAM algorithms are ready for 3D and with 3D hardware available for the general public a current lack of 3D atlases comparing the anatomy of multiple specimens can be filled. Automated landmark placement nevertheless is still difficult but with the right amount of manual input it is definitely feasible. Furthermore a central server running CASAM software has the opportunity to provide a platform for international collaboration between anatomical wet-labs resulting in standardized and comparable anatomy research on a large scale. It will further individualize surgical planning as surgeons have straightforward access to easily interpretable 3D renditions representing a huge amount of anatomical data from people with different ethnical backgrounds. This will minimize the gap between basic anatomical research and the clinical surgeon since web-based data is freely accessible in the operating room. In the future, real time projection of surgically relevant anatomical data on individual patients might even be feasible. In theatre, access to anatomy will not only benefit the patient providing tailor-made surgery and personalised surgical planning, but it will also keep the surgeon up to date on anatomy based surgical approaches and keep him engaged in one of the most important fields of surgery; human anatomy.