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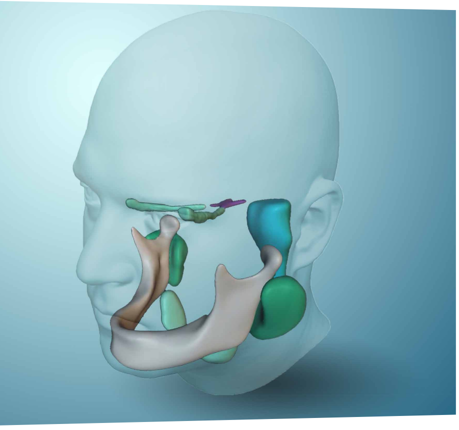

Case Study: Winning the "Head & Neck Auto Segmentation 2015" Grand Challenge

Imorphics delivered the best overall performance in a public demonstration segmentation task of CT radiotherapy planning images of the head and neck

At left: segmentation of a selection of organs at risk in CT radiotherapy planning images of the head and neck.

About Imorphics

Based in Manchester, UK, Imorphics provides technology for the automatic identification of organs and tissues from 3D medical images, to sub-millimeter accuracy. Global medical device and pharmaceutical companies rapidly innovate using our technology to understand and analyze CT, MRI and ultrasound images.

To find out more, please visit our website at www.imorphics.com.

"This challenge demonstrated that our technology is robust enough to deal with the wide range of differing anatomical shapes and tissues that are presented in real clinical applications such as radiotherapy planning"

Mike Bowes Phd, CEO

The Challenge and How We Performed

In order to provide an independent determination of algorithm performance in medical image detection, registration and segmentation, the prestigious Medical Image Computing and Computer Assisted Intervention Society (MICCAI) conference series runs an annual competition.

Each year, the "Grand Challenge" allows entrants from both academia and industry to test their methods in a fair and direct comparison with the state-of-the-art on previously unseen medical images. The testing is done live and concurrently during the conference or else online using pre-delivered software applications in order to give a fair representation of clinical performance.

For this challenge, we tackled an anatomical structure that we had no previous experience with. CT radiotherapy planning images of the head and neck can present some particular problems with structures that have very low contrast to surrounding tissue and may be thin in comparison to the image slice thickness. However, we were successful in that:

- We produced fully-automated segmentation of the mandible, salivary glands, optic nerves, chiasm and brain stem with no additional manual correction.
- We were one of only three teams that competed to complete the segmentation of 5 test images within the two-hour time limit.
- We did particularly well on the difficult optic nerves for which we had a mean a DICE overlap score of 0.78 compared to the nearest competitor with 0.62.

Addressing the Problem

To address the problems of speed, accuracy and precision in automated 3D medical image segmentation, many image analysis algorithms have been developed over the years to automate the task.

However, these algorithms are usually not robust to anatomical shape variability and they struggle when organ boundaries are noisy or indistinct due to low contrast between regions in the image. They therefore require considerable manual correction. To make these algorithms work better, they are usually highly customized to the individual anatomical structure of interest and a specific imaging modality, representing man-years of research and development for each task.

In contrast to custom segmentation solutions, the use of statistical shape models has proved to be one of the most successful approaches to medical image segmentation. The underlying idea is to use a set of examples that represent the variability of an object's shape and appearance to train a deformable 3D model of the anatomy.

Since its inception, Imorphics has developed several revolutionary patent-protected methods to radically improve the performance of 3D statistical models.

Imorphics Technology

Our technology now represents a trainable platform for the segmentation and analysis of virtually any anatomical structure or tissue in a 3D medical image.

Using this machine learning technology, we have now demonstrated fully-automated identification and segmentation of bones, cartilage and other musculoskeletal tissues, sub-cortical brain tissues, prostate, liver, and other abdominal organs, skulls and sinuses with sub-voxel or sub-millimeter accuracy.

A relatively large number of organs at risk (OARs) were chosen for this Challenge, some were paired and some single. In radiotherapy planning, CT images are usually used to provide electron density data for dosimetry calculations. Some of these OARs exhibit poor contrast at their boundaries with surrounding tissues in CT images. Some OARs, such as the optic nerves, are very thin compared to the imaging resolution; and some are often compromised by intense CT image artifacts caused by dental implants, such as at the parotid glands. Our statistical model-based approach is designed to cope with exactly these kinds of image processing problems.

> "Our success in these Grand Challenges continues to provide an independent validation of the efficiency of our technology in solving real-world medical imaging problems"
>
> Alan Brett Phd, Head Of Business Development

Conclusion

Imorphics have won all four of the MICCAI Grand Challenge competitions that they have entered. These were for the segmentation of knee bone and cartilage in 2010 (SKI10), of the prostate in 2012 (PROMISE12), abdominal organs in 2014 (VISCERAL) and this Head & Neck radiotherapy challenge in 2015.

Importantly, our latest technical developments mean that we can now segment surfaces of organs such as the prostate with average distance errors of around 0.1mm.

We continue to provide world-class 3D image understanding services to contract research organizations and pharmaceutical sponsors of clinical trials; and revolutionary fully-automatic software applications for segmenting and analyzing 3D images with sub-millimeter accuracy to manufacturers of medical devices. As a contract research organization (CRO), we have provided services to all the major imaging core lab CROs and also direct to several of the largest pharmaceutical companies. In the medical devices market, we have delivered solutions for orthopaedic image-guided surgery, image guided neurosurgery and population shape analysis for implant design.