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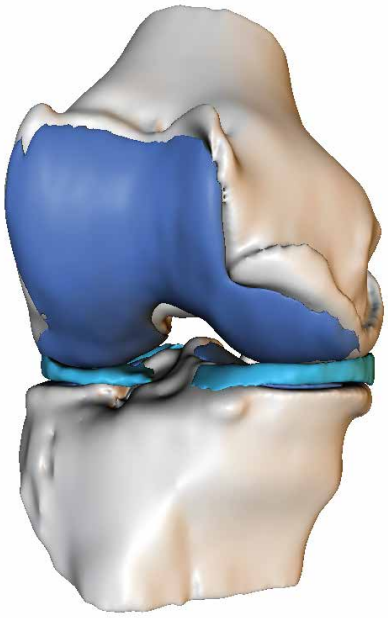

Case Study:

Winning the "Segmentation of Knee Images 2010" (SKI10) Grand Challenge

Imorphics delivered the best overall performance in an open demonstration task of knee bone and cartilage segmentation from MR images

At left: segmentation of an osteoarthritic knee showing advanced osteophytes. As well as the major bones, articular cartilage and the meniscus are included.

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 although we have a 3D segmentation technology that is generally applicable, it can also beat the best in the field when used in a specific application such as the knee"

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 actually built the segmentation system using training examples from NIH Osteoarthritis Initiative data which only contains mild images from patients with mild OA, whereas the Grand Challenge data contained a number of advanced OA cases with many osteophytes. In spite of this, we had considerable success:

- Our delivered software performed fully automated segmentation "out of the box" of the femur, tibia, femoral cartilage and tibial cartilage with no additional manual correction.
- Our average distance error ranked first out of 19 groups with an excellent 0.42mm for the femur and 0.38mm for the tibia.
- In cartilage volume difference scores, we again ranked first with an average volume error of 4.2%.

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 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.

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.

The collection of images used in the SKI10 challenge represented the large heterogeneity of clinical data that is typically used for surgical planning. The test images employed MRI with a wide variety of sequences including both T1 and T2-weighting. Many images used gradient echo or spoiled gradient echo sequences, and fat suppression techniques were common as well.

However, as in this case, using Imorphics' technology, a single statistical model can be developed to deal with the anatomical appearance present in multiple imaging modalities or multiple MR imaging sequences.

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 the Head & Neck radiotherapy challenge in 2015.

Importantly, our latest technical developments mean that we can now segment the knee 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.

> "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".
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> Alan Brett Phd, Head of Business Development