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Mathematical Methods in Anatomical Landmark Detection for Robust Computational Understanding of Clinical Images

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Recent techniques for medical image segmentation are often based on statistical models, which represent individual variation of organ shapes by limited number of parameters. In addition to such continuous diversity, discrete diversity of structures, that is, ‘anomaly’ in the anatomical term, is often observed in clinical images. Typical example is the number of vertebrae, for which anomaly is found up to 9% in our database. For such variation, fixed topology of anatomical model causes failure in fitting to anomaly structures.

Another issue is that clinical images are obtained in various ranges, such as thoracic, abdominal, or whole body, depending on examination purposes. Such variation often forces us to solve partial match problem between organ shape model and image data.

For those reasons, anatomical landmarks can play key roles in computational understanding of medical images, such as statistical shape model initialization, image acquisition range inference.

We have been working on mathematical models and methods for anatomical landmark detection. The basic scheme consists of two components. The former is based on principle component modeling of local appearance surrounding landmarks, and prepare a group of detected candidate locations for each landmark. The latter is a MAP estimation of the most probable combination of landmark locations in terms of inter-landmark distances via Gibbs sampling with simulated annealing. In the combinatorial optimization, missed landmark (out of imaging range, or detection error) and anomaly are considered for robust detection. Through experiments by using clinical CT datasets, over 90% of landmarks are correctly detected with our method.

In this lecture, the state of the art of our landmark detection scheme is presented with experimental results. In addition, a server system for clinical image analysis, such as computerized detection of abnormalities, developed and used in UT hospital is introduced.

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