Volumetric Visualization of Medical Imagery: A New Paradigm for Radiology

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The past several years have seen an explosion in the detail and amount of medical imaging data that can be routinely produced during the course a cross-sectional imaging examination. Ten years ago a typical CT examination generated 30-50 images; today's helical CT scanners generate hundreds of overlapping slices for interpretation. Spatial resolution and sampling, particularly in the through-plane direction, have also improved. Similar trends are evident in MR and ultrasound. While all of these and other modalities have become more sophisticated, the dominant method for radiological interpretation, that is, visual assessment of each of the cross-sectional images generated by the modality, has not changed. And as the number of images increases, so does the time required for interpretation.

While radiologists may be keeping up in 1999, it is doubtful that the current paradigm will even be possible in the near future. As evidence of this, consider the introduction of multiple-detector ring helical CT which, for example, can image a contrast bolus as it travels from above the renal arteries to the toes in one minute, and can generate over 1000 2.5 mm-thick slices spaced every 1.25 mm. Not only must we worry that the time and, therefore, the cost of interpretation will be significantly increased, but we must consider fatigue and other factors that might compromise diagnostic accuracy.

The new paradigm of radiological interpretation will be based upon treating the acquired image data as a volume to be explored, and from which to extract images and quantitative data that document the condition of the patient. Note that while several volume visualization techniques, such as maximum intensity projection, surface rendering, volume rendering, flat and curved reformatted planes, thin slab renderings, *etc.*, have been available for several years, these have largely been used to supplement the diagnosis made by assessment of the primary source images, and for conveying findings to referring physicians. In the new paradigm of radiological interpretation, these and other techniques, including segmentation and computer-assisted diagnosis, exist as choices that can be made as part of the exploration process. However, the concept of diagnosis based on these methods without, perhaps, ever viewing the primary source images, is new and must be validated for each and every possible diagnosis. Nevertheless, in the new world of 1000+ images per examination, diagnosis based on review of source images is similarly not yet validated and may, indeed, not even be possible.

This presentation focuses on the motivation and requirements for volumetric visualization of medical imagery as a primary mode of diagnostic interpretation. Examples of our current clinical practice and research in the 3D Medical Imaging Lab at Stanford will be given to illustrate the challenges and potential solutions.

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Educational objectives:

(1) To motivate the necessity for changing the diagnostic interpretation paradigm from one of cross-sectional image assessment to volumetric visualization and analysis.

(2) To define the requirements for diagnosis by volumetric visualization and analysis.

(3) To provide examples of present-day and potential future approaches to this concept.