Imaging Informatics

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Current Status of the Field

Biomedical imaging informatics is a subfield of both imaging science and biomedical informatics, which deals with the representation, analysis, management, integration and visualization of biomedical data and knowledge. Informatics has become an important area of activity in biomedicine because of the explosion of data in all fields, and the subsequent need to manage and integrate these data in order to gain an understanding of biological function in health and disease. As is evident from the topics of this conference, nowhere is the proliferation of data more evident than in biomedical imaging. Thus, since most imaging modalities are increasingly available either in digital form directly or can be converted to digital form, images are an important form of data that can benefit from techniques developed in the larger field of informatics. However, the non-textual and multi-dimensional nature of imaging data, as well as the large quantities of such data, gives rise to challenges that are not necessarily present in other forms of biomedical data. Imaging informatics can in general be divided into image generation, image manipulation, image management, and image integration. Some of the most spectacular early successes in what is now called biomedical informatics were in the area of image generation through the reconstruction techniques that are at the core of CT, MR and PET scanners. In fact, most imaging instruments are now essentially highly specialized computers, so in that sense informatics already permeates medical imaging, yet it is invisible to all but the device manufacturers.

Image manipulation, on the other hand, is more visible because it has not yet solved the fundamental problem of automatic image understanding. However, significant progress has been made in sub-problems of image manipulation, such as enhancement, segmentation, feature detection, classification, 3-D reconstruction, and visualization. Many of these techniques are now widely available on manufacturers' or third-party consoles, but many are still in the research stages.

Image management is a particularly important activity in radiology departments, and has led to the increasingly widespread adoption of Picture Archiving and Communications Systems (PACS), but images are still generally retrieved by associated metadata (patient ID, date of exam) and not by content ("find images that look like this one").

Image integration is also increasingly widespread through multi-modality image fusion, both in hospital settings through the linking of PACS with Radiology Information Systems and the Electronic Medical Record, and to some extent in research settings.

Future Directions for the Field

As research in the various sub-fields of imaging informatics proceeds, the solutions will most likely be embedded in the devices themselves, in the viewing workstations, or in server-based systems that are transparently integrated into network-accessible hospital and research information systems. Since the ultimate goal of imaging is to gain an understanding of the functioning of the individual subject, it is likely that all forms of images will eventually be integrated with other biomedical data into a customized multi-scale computational model that represents the structural and functional state of the subject at any given time. In such a systems biology approach, the model could not only be used to predict and monitor patient response to specific customized therapy, but it could also provide a visual interface to the medical record and to associated biomedical knowledge sources. Such an integrated and holistic view will not be achieved overnight, but the advances in imaging presented at this meeting, combined with advances in high throughput molecular techniques, multi-scale computational modeling, and informatics methods for managing and integrating these data and models, give hope that this goal is achievable within the not-so-distant future.