Keynote Speaker-1

3-D Imaging Models: Technology and Application

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In the last decade, 3D imaging technology has become increasingly important and useful not only for consumer and industrial applications, but also for medical purposes. This is due to the capability of 3D images to give real geometry structure for further analysis. Reconstruction and visualization of 3D images, however, need large resources in terms of computing capacity and processing time. This has an impact on research directions to provide efficient computing resources to enable real-time 3D imaging and analysis. In this talk, I will provide a review of 3D imaging technologies and future directions in 3D imaging technology, and explore their application in industry and medicine. This will cover both modalities based on electromagnetic energy model and mechanical energy model. The electromagnetic energy model will cover 3D visualization of material interaction with radio frequency (magnetic resonance imaging), microwave, infrared, visible light, X-Ray and Gamma Ray. Whereas, the mechanical energy model will cover 3D visualization of material interaction with ultrasound wave.

3D imaging technology is divided into two main parts. First is data acquisition, which involves transmitter and receiver. Second is 3D reconstruction including conversion of raw data into images and techniques to display the resulting 3D images. Both acquisition and reconstruction require high-performance hardware and software. Hardware includes sensor, data processor, and display. Software is required to capture raw data, convert raw data into an image model, improve image quality, and visualize 3D images. This involves large modeling work such as model for image representation from raw data and model for 3D image visualization. Physics and statistics equations are very commonly used in modeling for image representation. There are at least two types of 3D visualizations. They are multi-planar images and rendered images. Multi-planar images are required usually for quantitative analysis, whereas rendered images are mostly for qualitative analysis or just to show the 3D appearance of images.

X-Ray images are reconstructed based on X-Ray energy absorption in the radiated material. This enables the differentiation of bone and soft tissue for medical application; metal and liquid for airport inspection, and material structure for material quality inspection in industry. 3D acquisition using X-Ray can be done using rotated X-Ray tubes and sensors or array tubes and sensors. The data captured from the sensors are then reconstructed into 3D images with suitable intensity and coordinates. The reconstruction in many cases requires noise reduction techniques, colour coding, and projection. Since X-Ray penetrates objects, the resulting 3D images are suitable to be used to visualize structures present inside the object and to measure the volume of objects.

Visible light 3D visualization is currently the most common used in consumer products. This can be shown in the current low-cost 3D television and cinema. Visible light is normally used to visualize the surface of an object based on light reflection. The 3D image acquisition can be done with few methods including multi-position camera sensors and array laser sensors. Whereas the 3D visualization needs high-resolution displays and high-speed parallel processors. In order to achieve the effect of 3D visualization, 3D glasses for human eyes are currently used. Beside light reflection effects, light attenuation effect can be also used to visualize structures inside transparent objects.
The speed of development in broadband technology as well as miniaturization of antenna has enabled microwave 3D imaging. This is still an emerging technique. But it will be a promising method to visualize an object as a result for microwave interaction with different dielectrics. For the visualization of dielectrics properties, some models have been applied. They are Finite Difference Time Domain (FDTD) and Finite Element Method (FEM). Accuracy and resolution of microwave 3D imaging needs still to be improved, this is due to the nonlinear wave phenomena. Some researchers tried to apply high order FDTD, this however consumes high computing capacity. Multi frequencies reconstruction also been applied to solve this problem. Microwave 3D imaging will take some years to reach maturity. Some applications of this technique are radar and breast imaging.

3D Magnetic Resonance Imaging (MRI) uses few hundred megahertz radio frequency to disturb polarized hydrogen spin so that it returns back to unpolarized state in certain relaxation time. The relaxation time is influenced by hydrogen structure and bounding which can differentiate between types of material. In the recent years, 3D MRI has become the best non ionizing medical imaging modality, due to its excellent resolution and contrast for both soft and hard tissue. Current research in this modality is trying to improve coil sensitivity, use higher tesla and find algorithms for faster 3D visualization. The application of MRI is not only in medicine but also for industrial and material testing. For the past few decades, MRI has also been used to characterize material. Apart from its excellent image quality, MRI has limitations when interacting with metal. This problem remains to be unsolved for the foreseeable future.

Ultrasound is one form of mechanical energy. It has similar characteristics with sound, but has higher frequency. This wave has different nature with electromagnetic wave. Ultrasound needs a medium to propagate. The propagation property of ultrasound wave in an object can be used for object characterization. Ultrasound already had its uses since the first world war to detect object underwater. Nowadays, Ultrasound is used to visualize fish distribution in ocean. Ultrasound is also widely used in industry for example in the material structure inspection, flow measurement and object characterization. Since ultrasound is one of the safest techniques for imaging, it has been used for medical imaging for the past few decades. Currently, ultrasound is the most common medical imaging modality.

3D ultrasound imaging system has been undergoing development for the past 40 years, and came to clinical application around 20 years ago. There are at least 4 types of 3D ultrasound reconstruction technologies. They are: 1-D ultrasound probe with mechanical swept, 2D-array ultrasound probe, 1-D freehand probe with additional tracking sensor and 3D fixed ring probe. The trend is currently trying to miniaturize 2D-array probe to have larger number of piezoelectric elements in a small size probe. Using this technique, it is possible to obtain 3D real time images in short time. This will reduce operator dependence and improve patient safety. Besides reconstruction technologies, 3D visualization and image analysis technologies play an important role in current ultrasound research. We are already able to see the movement of foetus in 4D images as well.

Combinations of different imaging modalities are the subject of current research and are expected to continue in the near future. Some reviews and future trends of 3D image fusion between above modalities will be further discussed in this talk.
Biography of the Speaker

Eko Supriyanto is currently Professor and the Head of Clinical Science and Engineering Department at the Universiti Teknologi Malaysia. He was born in Demak, Indonesia and obtained his degree in Electrical Engineering, as well as his master in Biomedical Engineering from Bandung Institute of Technology. He obtained his doctor in electronics from University of Federal Armed Forces Hamburg, Germany. After working a few years at university and industry in Germany, he worked as senior lecturer in Universiti Teknologi Malaysia, and consultant for MOH and WHO.

He is visiting professor at Faculty of Computer Science and Automation, Ilmenau University of Technology, Germany and visiting professor at Radiology Department, Faculty of Medicine, Padjajaran University, Indonesia. He has been keynote speaker at international conferences on E-Health and Image Processing. He is author of 7 books published by German and Austrian publisher.

Eko Supriyanto has published over 120 scientific publications in international journals and conferences especially on:

- Ultrasound and electromagnetic technologies
- Medical imaging and image processing
- Electronics sensor and instrumentation
- Medical informatics and computing

Eko Supriyanto has more than 22 scientific awards with the recent awards from National Research Council of Thailand as Inventor of the Most Creative Product Year 2011, and Semi Grand Prize from Korean Invention Promotion Association 2009. He has more than 15 patents and copyrights and 2 spin off companies.

His main scientific interests:

- Ultrasound and electromagnetic sensor
- Signal and image processing
- Biomedical instrumentation
- Modelling and simulation
- Medical informatics
- E-Health
- Health care management system