Chapter 3.20
Immersive Image Mining in Cardiology

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INTRODUCTION

Buried within the human body, the heart prohibits direct inspection, so most knowledge about heart failure is obtained by autopsy (in hindsight). Live immersive inspection within the human heart requires advanced data acquisition, image mining and virtual reality techniques. Computational sciences are being exploited as means to investigate biomedical processes in cardiology.

IntraVascular UltraSound (IVUS) has become a clinical tool in recent several years. In this immersive data acquisition procedure, voluminous separated slice images are taken by a camera, which is pulled back in the coronary artery. Image mining deals with the extraction of implicit knowledge, image data relationships, or other patterns not explicitly stored in the image databases (Hsu, Lee, & Zhang, 2002). Human medical data are among the most rewarding and difficult of all biological data to mine and analyze, which has the uniqueness of heterogeneity and are privacy-sensitive (Cios & Moore, 2002). The goals of immersive IVUS image mining are providing medical quantitative measurements, qualitative assessment, and cardiac knowledge discovery to serve clinical needs on diagnostics, therapies, and safety level, cost and risk effectiveness etc.

BACKGROUND

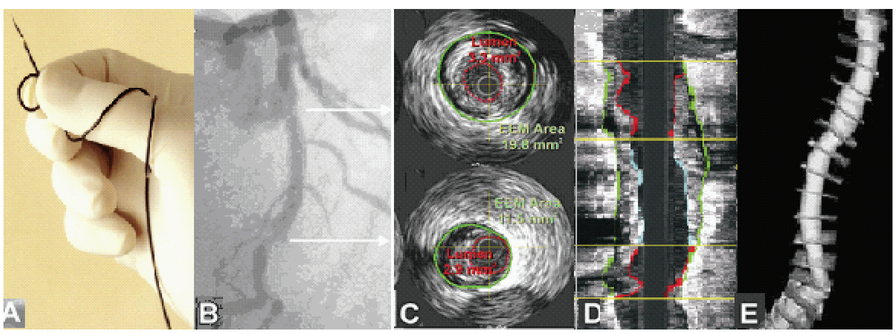
Heart disease is the leading cause of death in industrialized nations and is characterized by diverse cellular abnormalities associated with decreased ventricular function. At the onset of many forms of heart disease, cardiac hypertrophy and ventricular changes in wall thickness or chamber volume occur as a compensatory response to maintain cardiac output. These changes eventually lead to greater vascular resistance, chamber dilation, wall fibrosis, which ultimately impair the ability of the ventricles to pump blood and lead to overt failure. To diagnose the many possible anomalies and heart diseases is difficult because physicians can't literally see in the human heart. Various data acquisition techniques have been invented to partly remedy the lack of sight: non-invasive inspection including CT (Computered Tomography), Angiography, MRI (Magnetic Resonance Imaging), ECG signals etc. These techniques do not take into account crucial features of lesion physiology and vascular remodeling to really mine blood-plaque. IVUS, a minimal-invasive technique, in which a camera is pulled back inside the artery, and the resulting immersive tomographic images are used to remodel the vessel. This remodeling vessel and its virtual reality (VR) aspect offer interesting future alternatives for mining these data to unearth anomalies and diseases in the moving heart and coronary vessels at earlier stage. It also serves in clinical trials to evaluate results of novel interventional techniques, e.g. local kill by heating cancerous cells via an electrical current through a piezoelectric transducer as well as local nanotechnology pharmaceutical treatments. Figure 1 explains some aspects of IVUS technology.

However, IVUS images are more complicated than medical data in general since they suffer from some artifacts during immersed data acquisition (Mintz et al., 2001):

- Non-uniform rotational distortion and motion artifacts.
- Ring-down, blood speckle, and near field artifacts.
- Obliquity, eccentricity, and problems of vessel curvature.
- Problems of spatial orientation.

The second type of artifacts is treated by image processing and therefore falls outside the scope of this paper. The pumping heart, respiring lungs and

Figure 1. IVUS immersive data acquisition, measurements and remodeling



A: IVUS catheter/endosonics and the wire. B: angiograophy of a contrast-filled section of coronary artery. C: two IVUS cross-sectional images and some quantitative measurements on them. D: Virtual L-View of the vessel reconstruction. E: Virtual 3D-Impression of the vessel reconstruction.