

Chapter 15

Multimodality Medical Image Fusion Using M-Band Wavelet and Daubechies Complex Wavelet Transform for Radiation Therapy

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ABSTRACT

The process of enriching the important details from various modality medical images by combining them into single image is called multimodality medical image fusion. It aids physicians in terms of better visualization, more accurate diagnosis and appropriate treatment plan for the cancer patient. The combined fused image is the result of merging of anatomical and physiological variations. It allows accurate localization of cancer tissues and more helpful for estimation of target volume for radiation. The details from both modalities (CT and MRI) are extracted in frequency domain by applying various transforms and combined them using variety of fusion rules to achieve the best quality of images. The performance and effectiveness of each transform on fusion results is evaluated subjectively as well as objectively. The fused images by algorithms in which feature extraction is achieved by M-Band Wavelet Transform and Daubechies Complex Wavelet Transform are superior over other frequency domain algorithms as per subjective and objective analysis.

INTRODUCTION

Medical imaging and its applications are playing a vital role in modern health care practices. Medical imaging has variety of acquisition techniques viz. X-rays, Ultrasound Guided imaging (USG), Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Magnetic Resonance Angiography (MRA),

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Positron Emission Tomography (PET), Single-Photon Emission Computed Tomography (SPECT) etc. (Depeursinge, Rodriguez, Ville, & Muller, 2014). These imaging technologies are very effectively used by physicians in disease diagnosis, treatment and post treatment analysis. Medical imaging involves acquisition of images from internal organs of the body non-invasively. These medical imaging techniques are applicable to almost every organ of human body. Araki et al. (2014) has used medical imaging for cardio-logical risk analysis using quantification of coronary calcium, whereas liver disease classification is achieved using ultrasound imaging by Suri et al. (2015). Another application of medical imaging is estimation of coronary calcium volumes using Intravascular Ultrasound (IVUS) and generating a relationship with automated carotid intima-media thickness (cIMT) for atherosclerosis disease (Araki et al., 2014; Araki et al. 2015). Intravascular ultrasound (IVUS) image registration using Rigid, Affine, B-Splines and Demons techniques are presented by Araki et al. (2015). The Intravascular Ultrasound (IVUS) bulb images with varying resolutions and imaging conditions for carotid bulb localization and bulb edge detection were experimented and stronger correlation between carotid intima-media thickness (cIMT) and coronary Synergy between percutaneous coronary intervention with TAXUS and cardiac surgery (SYNTAX) score is estimated (Ikeda et al., 2014; Ikeda et al., 2015).

Medical image processing is most advanced technology which is used in almost all stages of cancer treatment starting from diagnosis till adaptive post treatment. It is helpful in locating infected tissues, in deciding treatment plan and taking corrective action based on post treatment images. It is not possible for a device (single modality) to capture all relevant and essential information in a single slice/frame. Therefore, various modalities are used to capture details. Some image acquisition machines are also manufactured to capture more than one modality images using a single machine; but these machines are very expensive and are seldom available or facility may be present at very few medical treatment centers. Obviously, most of the hospitals and medical health centers have single modality machines. Due to use of variety of single medical image modalities, one can achieve different type of information in each modality image. The information in each image can be similar and/or complementary. Each modality has its own pros and cons. For example X-rays / Computed Tomography (CT) captures details of bone structure, hard tissues, implants etc. but unable to provide information about physiological variations whereas Magnetic Resonance Imaging (MRI) images can provide pathological soft tissues and fluid texture information but cannot support bones structures (Kessler, 2006). Thus, single modality may not provide enough clinical information. However multimodality images definitely carry enough complementary information. Therefore, combining this complementary information from various modality images into single image may be added advantage or sometime almost necessary in patient management system for cancer treatment. The process may also help doctors to diagnose and treat accurately and precisely. The process of registering and combining various modality images into a better quality single image with all relevant information from different modalities is called multimodality medical image fusion. The resultant i.e. fused image may be more suitable for visual interpretation in cancer treatment provided the process should be free from noise, addition of unwanted structures and visual artifacts.

Radiation Therapy is a most important and specialized way of treating cancer patients. In radiation therapy, ionized radiation with treatment by photons (X-rays) along with other way of cancer management like chemotherapy, surgery etc. is carried out. Medical imaging and fusion plays a significant role in aiding medical physicist or radiation oncologist for accurate diagnosis and treatment management of the cancer patients. Radiation therapy involves localization of infected cells, planning of radiation doses and treatment analysis. It is very important that diagnosis of spread of tumor or infected cells should be very accurate for treatment using radiotherapy. The images of infected body organ are captured through

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