Chapter 13
Metal Artifact Reduction:
A Problem of Tremendous Importance in Medical Imaging

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ABSTRACT

Metallic implants are known to generate bright and dark streaking artifacts in x-ray computed tomography (CT) images. These artifacts cause loss of information, reduces the resolution, forms noise which hinders diagnostic capability. The reduction of metal artifact is of immense importance in the present scenario. We propose seeded watershed segmentation-interpolation based sinogram correction method to reduce the metal artifacts caused by metallic implants. We tend to find projection bins affected by the metallic objects in the raw projection data and to replace the corrupted values by appropriate estimates. The novelty of proposed method lies in segmentation of metal part from the CT image by seeded watershed segmentation method, using IlastiK tool. Proposed method is experimented using dataset pertaining to different clinical cases. Solution is studied for correctness by quantitatively as well as qualitatively. The result presents significant improvement in artifact reduction aiding to better diagnostic ability.

1. INTRODUCTION

The science of medical imaging owes much of its existence to the discovery of X-rays by W C Roentgen over 120 years ago in 1895. It was the development of practical computed tomography (CT) scanners in the early 1970s by G Hounsfield in 1973 and others that brought computers into medical imaging and clinical practice. G Hounsfield shared the Nobel Prize in 1972, along with Allan Cormack who independently discovered some of the reconstruction algorithms. His invention showed that it is possible to compute high-quality cross-sectional images with greater accuracy when the projection data is acquired and complete in all aspect. However the solution to the problem of how to reconstruct a function from its

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projection data is based on the proposal by Radon in 1917. The problem of image reconstruction from projection data is an inverse problem with many solutions.

The problem of image reconstruction from projections has repeatedly arisen over last 5 decades in various applications of scientific, technical and medical fields. Scientific applications are Cryo Electron Crystallography (Reconstruction of molecular structure by using data from electron microscopes), Radio astronomy (Maps of radio emission of celestial objects), Astronomy (X-ray structure of supernova remnants and reconstructing electron-density distribution in the solar corona), Seismic Tomography (Slice of the earth using seismic data) and Volcanology (Three-dimensional (3D) volumes from tomographic images of active, explosive volcanoes) etc. Technical applications includes Non-Destructive Testing such as industrial radiography or industrial CT scanning, to indicate presence of cracks in the radiograph, passage of sound through the weld and back, or indicate a clear surface without penetrant captured in cracks. Diamond packaging and construction, Micro CT for non-invasive imaging of wood anatomy, scanning of baggage for potential threat items in aviation security settings

Medical applications of image reconstruction is tremendous, CT is one application which has revolutionized medical imaging. Image reconstruction from projections is also used in nuclear medicine to map the distribution of concentration of gamma ray emitting radionuclide in a given cross section of human body. Another prominent application of image reconstruction from projections is Magnetic resonance imaging (MRI); a technique used to investigate the anatomy and physiology of the body without exposure to ionizing radiation. Positron emission tomography (PET) and single-photon emission computed tomography (SPECT, a nuclear medicine imaging technique to produces a three-dimensional image of functional processes in the body. Data set collected in PET is much poorer than CT, so reconstruction techniques are more difficult. Image reconstruction is applicable even for Small animal imaging. Of all the applications, probably the greatest effect in the world at large has been in the area of diagnostic medicine; CT has revolutionized radiology.

Basically the CT works on the principle of X-Ray imaging. The output intensity that is measured after an X-ray beam passed through an object depends on the material distribution of the object along the ray. Consequently, the complete illumination of an object by an X-ray beam yields a 2D intensity image in which the contrast is induced by the varying structures and attenuation properties in the object. Such an intensity image, which basically represents a projection of a 3D object onto a 2D plane, is an X-ray photo as presented in Figure 1.

One limitation of X-ray photos is that they do not provide depth information, since the measured intensity of the beam that traversed the object is independent of the material order along the ray. However, when X-ray projections of the object are acquired at many different orientations, a complete 3D attenuation map of the object can be reconstructed. This technique, called Tomographic imaging, is widely used as a medical diagnostic tool, but has also various industrial applications.

X-ray transmission CT is a non-destructive imaging technique providing 3D structural information of an object under examination. The desired 3D image is computed from a set of X-ray projections of the object, which are recorded by the X-ray CT scanner at different orientations as shown in Figure 2.

CT has many important applications such as medical diagnostics and small animal imaging, which supports pre-clinical drug testing. Other applications are found in the industry (diamond, packaging, construction), where CT scanners are employed for nondestructive testing. Figure 3 presents a typical setup of a clinical CT scanner: a source-detector pair rotates around a patient that is lying on a bed.

Several scanning geometries can be considered such as parallel beam, fan beam and cone beam geometry as presented in Figure. 4 (a) and (b). Parallel and fan-beam geometry were typically used in early