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Effect of CT acquisition parameters of spiral CT on image quality and radiation dose

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Abstract: Additive Manufacturing (AM) is the most advanced manufacturing process in medical and dental industry. Computed Tomography (CT) images are the primary source to fabricate the medical models. Spiral CT scanner captures larger volume tissue in a short scan time. The major defects that appear in CT image acquisition process are Beam Hardening (BH), image noise and radiation dose. Tube voltage, tube current and pitch are the major parameters for CT image acquisition. In the present work, an attempt has been made to investigate the effect of various CT image acquisition parameters in the CT image acquisition of dry mandible phantom. A Taguchi L_9 orthogonal array was used for experimental plan. The scanning defects of BH artifact and image noise were calculated by using Beam Hardening Correction Factor (BHCF) and the standard deviation of X- ray photons in the voxel respectively. Similarly radiation dose was measured with CT Dose Index volume ($CTDI_{volume}$). Grey Relational Analysis (GRA) method is used to optimize the CT image acquisition parameters, resulting increase in quality of CT images with less radiation dose. It was found that the image defects were less at optimal parameters found from GRA method compared to default image acquisition parameters.

Key words: Additive Manufacturing, Spiral CT, Beam hardening, Radiation dose, Image noise, Grey relational analysis.

1. Introduction

Computed Tomography (CT) is one of the important techniques to capture the images of tissues [1]. Presently most of the doctors and surgeons use the CT images to diagnose the patient [2] and for their surgical procedures [3]. Additive Manufacturing (AM) is an advanced technique, using it physical medical models can be produced by providing CT images. The AM models are used in various clinical applications such as custom implants, prosthetics, templates, instruments for surgical procedures etc [4-6]. The data from the CT imaging systems are considerably less accurate than the AM machine. The dimensional accuracy of the CT image plays a crucial role in manufacturing of accurate medical model. These errors appear during CT image acquisition stage and can propagate in the subsequent processes like CT image construction, 3-Dimensional (3D) modeling and manufacturing of the AM medical model [7].

In the present work, the authors emphasize to reduce the errors during the CT image acquisition. The CT images dimensional accuracy is affected by Beam Hardening (BH) artifact [8]. There are two types of artifacts, one is cupping and the other one is streak artifact. Out of these two, only cupping BH artifact causes inaccurate model of the tissues. In this study an attempt has been made to reduce cupping artifact, thereby increase the dimensional accuracy of the CT images. The presence of dense material in the middle portion of a uniform cylindrical phantom influences the X-rays in becoming hard, as compared to the rays passing through the edges. The hardened beam has less attenuation and high intense as it reaches the detector, due to this the resultant attenuation profile differs from the original profile [9]. The profile resembles a cup and this is also called cupping artifact, is shown in Fig. 1.

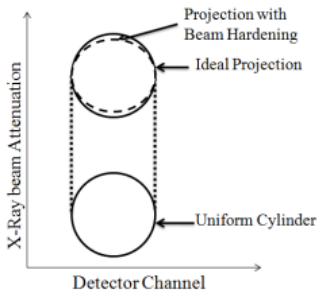

Fig.1. BH artifact on cylinder