

Development of a Radiation Dose Reporting Software for X-ray Computed Tomography (CT)

by

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ABSTRACT

X-ray computed tomography (CT) has experienced tremendous technological advances in recent years and has established itself as one of the most popular diagnostic imaging tools. While CT imaging clearly plays an invaluable role in modern medicine, its rapid adoption has resulted in a dramatic increase in the average medical radiation exposure to the worldwide and United States populations. Existing software tools for CT dose estimation and reporting are mostly based on patient phantoms that contain overly simplified anatomies insufficient in meeting the current and future needs. This dissertation describes the development of an easy-to-use software platform, “VirtualDose”, as a service to estimate and report the organ dose and effective dose values for patients undergoing the CT examinations. “VirtualDose” incorporates advanced models for the adult male and female, pregnant women, and children. To cover a large portion of the ignored obese patients that frequents the radiology clinics, a new set of obese male and female phantoms are also developed and applied to study the effects of the fat tissues on the CT radiation dose. Multi-detector CT scanners (MDCT) and clinical protocols, as well as the most recent effective dose algorithms from the International Commission on Radiological Protection (ICRP) Publication 103 are adopted in “VirtualDose” to keep pace with the MDCT development and regulatory requirements. A new MDCT scanner model with both body and head bowtie filter is developed to cover both the head and body scanning modes. This model was validated through the clinical measurements. A comprehensive slice-by-slice database is established by deriving the data from a larger number of single axial scans simulated on the patient phantoms using different CT bowtie filters, beam thicknesses, and different tube voltages in the Monte Carlo N-Particle Extended (MCNPX) code. When compared to the existing CT dose software packages, organ dose data in this software provides a better CT dose assessment by using anatomically realistic patient phantoms. All the related organ doses are incorporated into a standardized database compiled using Microsoft Structured Query Language (SQL) server 2008. Organ doses from contiguous axial or helical scans defined by a specific protocol can be rapidly obtained from the database. A next-generation software architecture and Active Server Pages (ASP) .NET

framework are adopted to create a browser-hosted application to improve the user interactivity and reporting functionality including scanning parameter selection and organ dose reporting. “VirtualDose” has been developed as a web-based CT dose reporting platform to facilitate several important features including: (1) easy access via Internet; (2) no need for installation on the local computer; (3) a user-friendly, dynamic, browser-hosted graphical user interface; (4) use of advanced patient models for the adult male and female, pregnant women, children, and obese patient models; (5) adoption of modern CT scanners and protocols, as well as the most recent ICRP 103 effective dose algorithms; and (6) flexibility to manage and easily upgrade without impacting user’s usage.