USTUR Case 0102 CT Image Processing Techniques For Voxel Phantom Development

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Outline

- Introduction
  - History of the USTUR case 0102
  - CT data acquisition

- Current work – Image Processing
  - Segmentation of the USTUR case 0102 CT images
    - Automatic (semi-automatic) Segmentation Technique

- Development of the USTUR case 0102 voxel phantom

- Possible applications of the USTUR case 0102 computational phantom
Introduction

The United States Transuranium and Uranium Registries (USTUR) is a resource of human tissue voluntarily donated by past workers with documented occupational actinide exposures.

USTUR Case 0102:

- a substantial accidental intake of $^{241}$AmO$_2$
- Half of this skeleton is encased in tissue equivalent plastic and serves as a unique “human phantom” for the calibration of whole body counting systems at United States Department of Energy (USDOE) and other laboratories.

http://www.ustur.wsu.edu/
CT Data Acquisition

- USTUR Case 0102 Phantom was scanned at Kadlec Medical Center’s Diagnostic Imaging Unit
  - GE Lightspeed 16 scanner

Stuart E. Gunn (Dedication in Health Phys. 49(4), 1985)
Dicom images of the USTUR case 0102 head phantom were segmented using Eclipse® radiotherapy planning software (Varian Medical, Palo Alto, CA)

- This software has a powerful automatic segmentation feature.

**Basic (Objective) Structures:**
- Air Pockets
- Light Tissue
- Regular Tissue
- Bone (Cortical)

**Complex (Subjective) Structures:**
- Bone Cavity (“Marrow”/Trabecular Spongiosa), which is
- Periostium(in) – bone(cortical) – air

The range of CT numbers corresponding to each region of interest was replaced with a single CT number to characterize each region.
Image Processing (Segmentation)

- Light Tissue
- Regular Tissue
- Air Pockets
- Cortical Bone
- Bone Cavity
Image Processing (Segmentation)

- Resolution of CT images is 0.6 mm
- Resolution after the segmentation process is 0.2 cm
Three Dimensional Images (Head)
Three Dimensional Images (Upper Thorax)
Three Dimensional Images (Upper Arm)
Voxel Phantom Development

- The voxel phantom development steps:
  - The 3D surface models for each phantom (Non-Uniform Rational B-Spline, NURBS) are created with Rhinoceros® software.
  - Images are voxelized using MATLAB® into virtual (computational) phantom.
Applications

- USTUR Case 0102 voxel phantom represents:
  - Bone structure of the head, torso, arm, and leg phantoms
  - Tissue (tissue equivalent material) structure, thickness, density variability
  - Radionuclide content of bones
Applications

- Voxel phantom can be imported into a Monte Carlo code for radiation transport
- Following codes are considered:
  - MCNPX
  - EGSnrc
  - GEANT
- The most “appropriate” code can be chosen based on the following criteria:
  - Ability to process large number of voxel arrays
  - Data manipulation within the code
  - Any other issues these codes may have with a voxelized geometry
Applications

• Experimental response of external planar germanium detectors variously positioned over the extremities can be simulated
Applications

Finally,

Counting efficiency of different detector types and configurations can be calculated for people of different anatomical build and body size.
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