IDAHO STATE UNIVERSITY
U.S. TRANSURANIUM AND URANIUM REGISTRIES

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

CT Data Acquisition

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

Stuart E. Gunn (Dedication in Health Phys. 49(4), 1985)

Image Processing (Segmentation)

- 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)

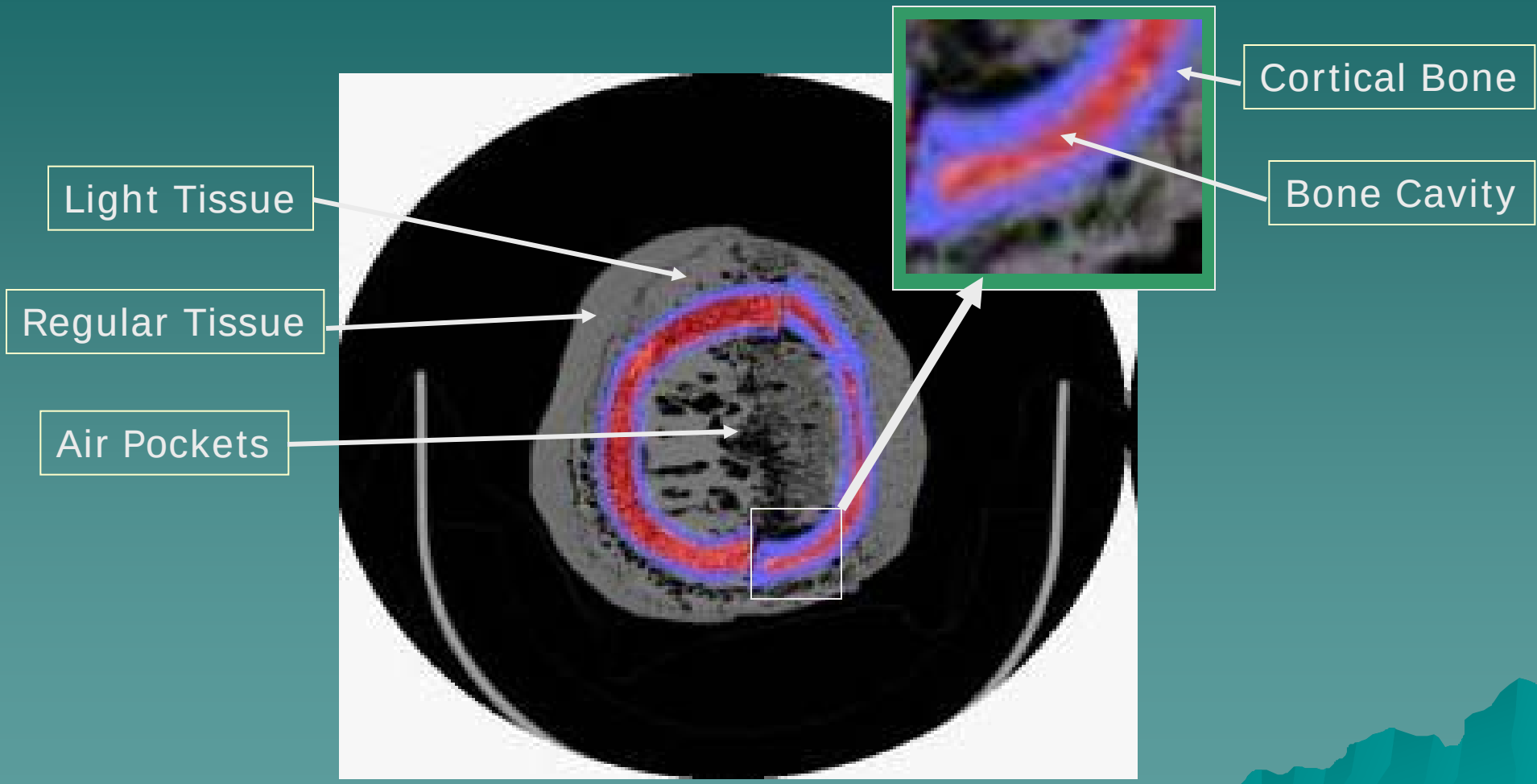
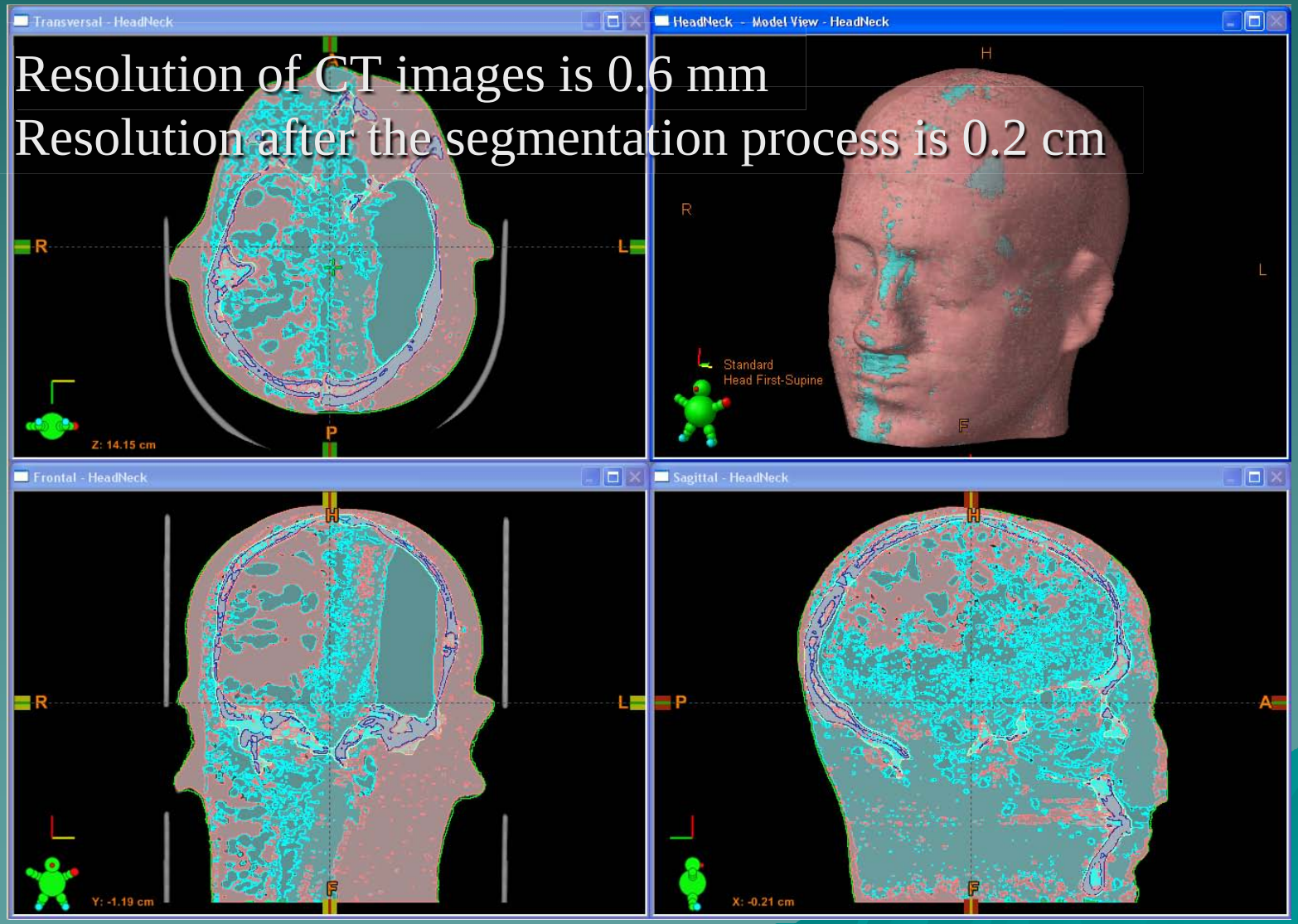
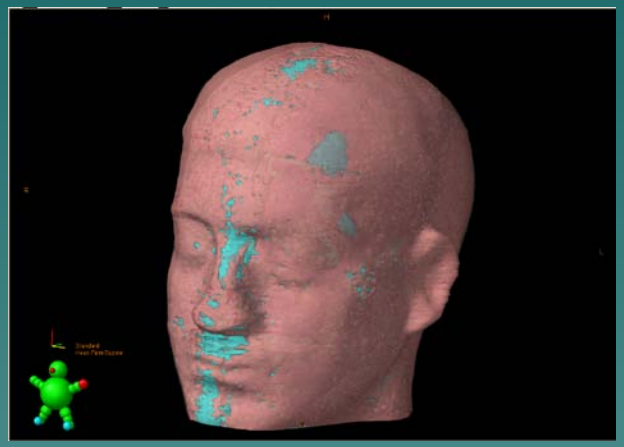


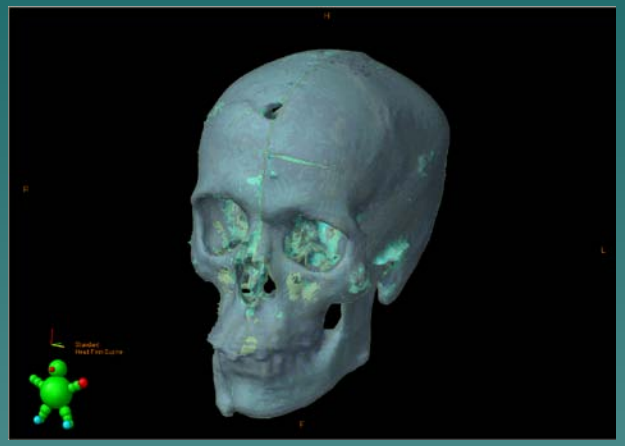
Image Processing (Segmentation)

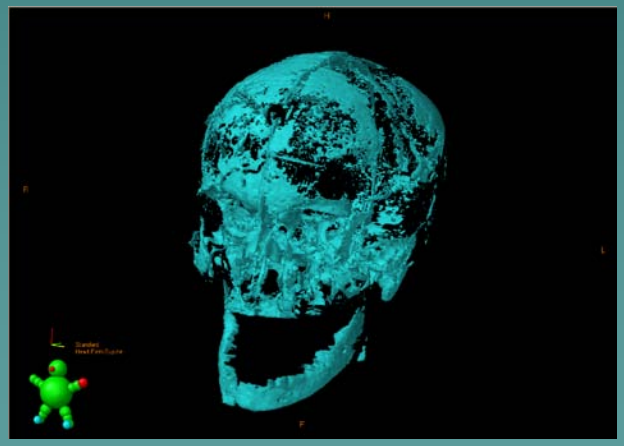
- Resolution of CT images is 0.6 mm
- Resolution after the segmentation process is 0.2 cm



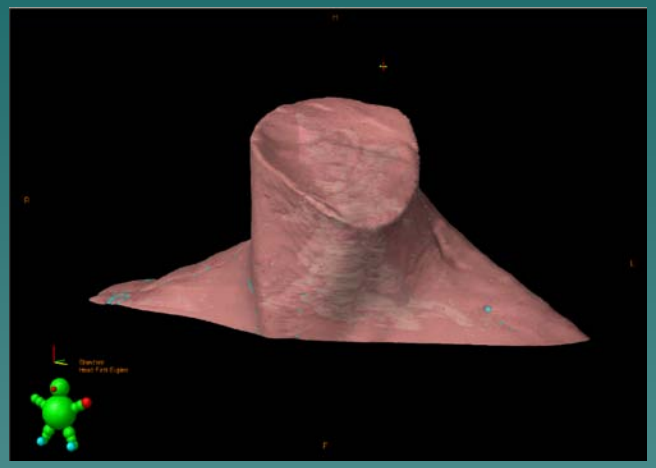
Three Dimensional Images (Head)

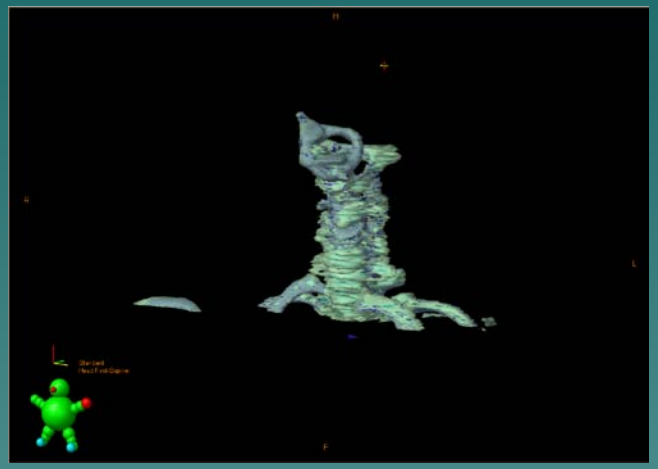


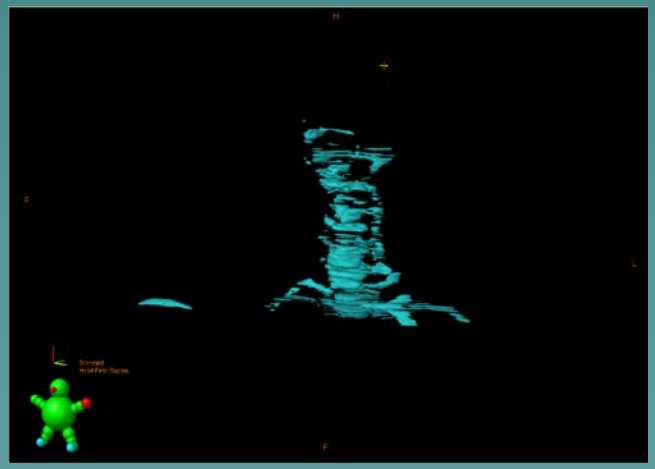




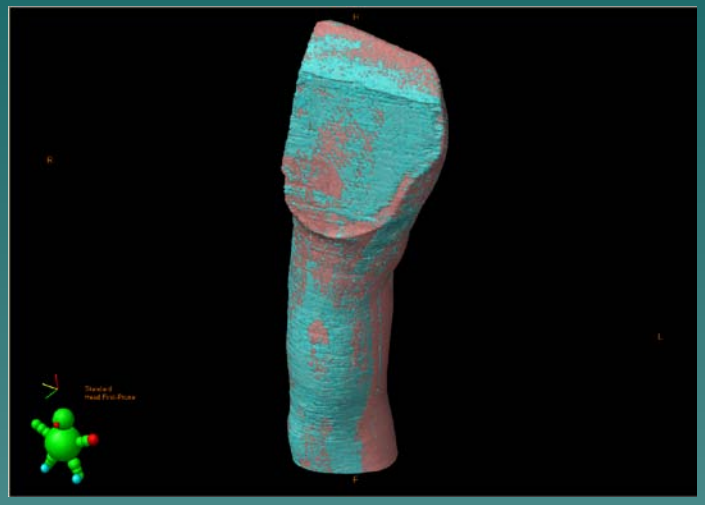
Three Dimensional Images (Upper Thorax)







Three Dimensional Images (Upper Arm)



Voxel Phantom Development

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

Applications

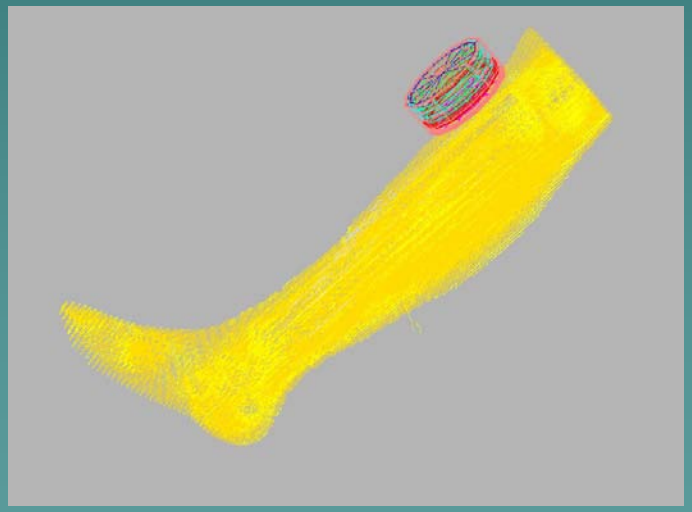
- USTUR Case 0102 voxel phantom represents:
  - Bone structure of the head, torso, arm, and leg phantoms
  - Tissue (tissue equivalent material) structure, thickness, density variability
  - Radionuclide content of bones

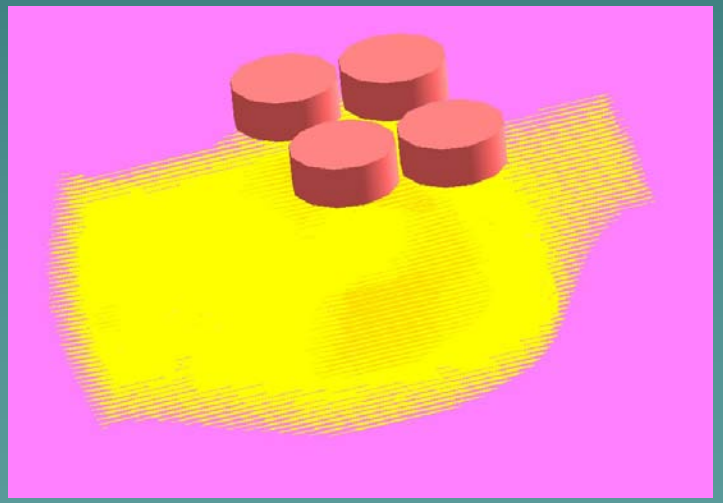
Applications

- 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

Acknowledgments

- This material is based upon work supported by the U.S. Department of Energy, Office of Illness and Injury Prevention Programs [HS-13], under Award Number DE-FG06-92EH89181

Disclaimer

Thank you!