3D Human Internal Organs Representation Model (Updates)

SIGGRAPH Web3D Standardization Meeting (Korea Chapter)

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Myeong Won Lee (The University of Suwon)
Requirements (1)

• 3D printing and scanning
  • Interface to 3D printers for internal organs
  • Interface to 3D scanners for internal organs
Requirements (2)

• Human health care service applications
  • Internal organs representation
  • Human health device and information service
3D Digital Human Modeling (1)

• Concepts
  • Provision with digital processing functionalities for an entire human body in 3D using all visual and functional information about internal organs as well as external human surface model and skeleton motion
  • 3D modeling and animation technology for digital information processing that can represent shapes, properties, function, and motion for human bodies, including internal organs
  • Standardized 3D digital information necessary for developing 3D medical and health care applications
3D Digital Human Modeling (2)

- **Required technologies**
  - **Shape modeling** of internal and external whole bodies in partial or whole forms using graphics technology
  - **Motion modeling** of internal and external whole bodies in partial or whole forms using graphics technology
  - For all visual human models, **functional properties** should be able to be defined and combined for shape and motion modeling of a human model

Partially controlled internal skin information modeling
Humanoid Body Related Standards

- ISO/IEC 19774 Humanoid Animation: 2006 V1.0 (IS)
- ISO/IEC 19774 Humanoid Animation – Part 1: Architecture V2.0 (FDIS)
- ISO/IEC 19774 Humanoid Animation – Part 2: Motion Capture V2.0 (FDIS)
- ISO 7250-1: 2008 Basic human body measurements for technological design – Part 1: Body measurement definitions and landmarks
- ISO/TR 7250-2: 2010 Basic human body measurements for technological design – Part 2: Statistical summaries of body measurements from national populations
Standardization Topics

• Representation data model for visualizing human internal organs and their functionalities
  • Modeling data exchange format of human internal organs
  • Animation data exchange format of human internal organs

• Interface data model for representing functions of medical and health devices with human internal organ models in 3D scenes
Representation Data Model for Human Internal Organs

- Modeling data model
  - Soft object representation
  - Soft object modeling
  - Landmarks
  - Information model for shape representation

- Animation data model
  - Animation methods
  - Animation parameters
  - Animation definition
  - Information model for animation representation

- Interface data model with medical and health devices
Skeletal System

Muscular System

Cardiovascular System

Digestive System

Endocrine System

Nervous System

Human Anatomy System
Internal Organs

commons.wikimedia.org
Internal Organs Set

- Lungs
- Spleen
- Large Intestine
- Male Reproductive System
- Kidneys
- Brain
- Artery
- Female Reproductive System
- Bladder
- Liver
- Pancreas
- Gallbladder
- Skin
- Heart
- Blood
- Stomach
Digestive System
Digestive organs

- Esophagus
- Gallbladder
- Stomach
- Large intestine
- Small intestine
- Pancreas
- Liver
Digestive System Modeling

3ds Max Viewport Shot

x3d Viewer
Digestive System - Esophagus

http://www.wikipedia.com/

https://www.innerbody.com/image_dige01/dige03-new2.html
Esophagus Modeling

3ds Max Viewport Shot

Esophagus

x3d Viewer
Esophagus X3D Structure

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</Scene>
</svg>
```
Digestive System - Stomach
Digestive System - Stomach

Layers of Stomach Wall:

- Mucosal lining
- Submucosa
- Muscularis
- Adventitia

Fig. 268: The Interior of the Stomach and Upper Duodenum

NOTE: 1) The mucosal lining of the stomach shows a series of longitudinally oriented gastric folds or empy vague which tend to disappear when the...
Stomach Modeling

3ds Max Viewport Shot

- esophagus
- fundus
- cardia
- Pyloric canal
- body
- Pyloric sphincter
- Pyloric antrum

x3d Viewer Image
Stomach Modeling

- esophagus
- fundus
- cardia
- body
- duodenum
- pyloric canal
- pyloric sphincter
- pyloric antrum

Stomach layer
- mucosa
- submucosa
- muscularis
- subserosa
- serosa

Stomach

2019-7-29
Problem in layers modeling:
Some polygons turned outside and intermingled
Stomach X3D Structure

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Digestive organs - Duodenum

25 cm long & Subdivided into 4 parts

First / upper part – 5 cm
Second / vertical part – 7.5 cm
Third / horizontal part – 10 cm
Fourth / ascending part – 2.5 cm
Duodenum Modeling

3ds Max Viewport Shot

Rendering Image

x3d Viewer Image
Digestive System – Small Intestine (Ileum)

http://www.innerbody.com/
Small Intestine Modeling

3ds Max Viewport Shot

jejunum

ileum

x3d Viewer Image
Digestive System – Problem of Small Intestine Modeling

Overlapping polygon

problem
Small Intestine Animation using Interpolators
Small Intestine X3D Structure

Small Intestine X3D Structure
Digestive System – Large Intestine

Front of abdomen, showing the large intestine, with the stomach and small intestine in gray outline
https://en.wikipedia.org/wiki/Large_intestine


https://medium.com/@vincentmarger/nutrition-and-digestion-large-intestine-71dab5c05aaf
Large Intestine Modeling

3ds Max Viewport Shot

Transverse Colon
Splenic Flexure
Descending Colon
Cecum
Sigmoid Colon
Appendix
Rectum
Anus

x3d Viewer Image
Large Intestine X3D Structure

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Abdominal Regions
Digestive System - Pancreas

Anatomy of the pancreas
https://en.wikipedia.org/wiki/Pancreas

https://www.innerbody.com/image/endo03.html
Pancreas Modeling

3ds Max Viewport Shot

head

body
tail

x3d Viewer Image
The gallbladder sits beneath the liver
https://en.wikipedia.org/wiki/Gallbladder

http://www.innerbody.com/image/digeov/dige04-new.html

eHealthStar.com
Gallbladder Modeling

3ds Max Viewport Shot

fundus

neck

duct

body

x3d Viewer Image
Gallbladder X3D Structure

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Digestive System - Liver

Location of human liver (in red)
https://en.wikipedia.org/wiki/Liver

Sections of the human Liver
https://www.webmd.com/digestive-disorders/picture-of-the-liver#1 / © 2014 WebMD, LLC. All rights reserved.
Liver Modeling

3ds Max Viewport Shot

Right liver

Left liver

x3d Viewer Image
Liver X3D Structure
Circulatory System

http://www.fit-ed.org/

The heart, showing valves, arteries and veins. The white arrows show the normal direction of blood flow.

https://en.wikipedia.org/wiki/Heart

https://www.innerbody.com/image/card01.html
Heart Modeling

3ds Max Viewport Shot

Heart Aorta

Heart Superior Vena Cava

Heart Right Atrium

Heart Right Auricle

Heart Inferior Vena Cava

Heart Right Ventricle

Heart Artery

Heart Pulmonary Artery

Heart Pulmonary Vein

Heart Left Ventricle

Heart Left Auricle

Rendering Image

x3d Viewer Image
Heart X3D Structure

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Urinary System

https://www.cincinnatichildrens.org/health/u/urinary-system
Urinary System Modeling

3ds Max Viewport Shot

x3d Viewer Image
Urinary System - Kidney


https://www.innerbody.com/image_repo01/dige24-new.html
Kidney Modeling

3ds Max Viewport Shot

Kidney Right

Kidney Left

x3d Viewer Image
Kidney X3D Structure
Urinary System - Ureter

https://www.mayoclinic.org/

Ureter Modeling

3ds Max Viewport Shot

Ureter right

Ureter left

x3d Viewer Image
Urinary System - Bladder

https://www.mayoclinic.org/

Bladder Modeling

3ds Max Viewport Shot

Bladder

x3d Viewer Image
Bladder X3D Structure

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X3D Structure

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Internal organs data model

• Modeling
  • Organ
    • Regions
      • Region name
      • Region meta interface
      • Geometry
      • Appearance
    • Layers
      • Layer name
      • Layer meta interface
      • Geometry
      • Appearance
  • Animation
    • Region based keyframe animation
    • Region based motion data animation
Level of details for representation

- Based on eye investigation (microscopy?)
- LOD 1
  - Organ level representation (stomach, lever, ..)
- LOD 2
  - Region level representation for each organ
- LOD 3
  - Layer representation
Conclusions (1)

• Representation data model for human internal organs
  • Modeling data model
  • Animation data model
  • Interface data model with medical and health devices

• Modeling: region and layer based modeling
  • Level of details (LOD1, LOD2, and LOD3)
  • Region partitioning and landmarks
  • Layer definition

• Animation: region and layer based deformation
  • Definition of deformation parameters

• Interface with medical and health devices
  • Definition of information from devices
  • Meta information related to specific parts of an organ
Conclusions (2)

• Standards development (ISO/IEC JTC 1/SC 24/WG 6)
  • Human internal organ representation and data model (Part 1)
  • Human respiratory system representation (Part 2)
  • Human digestive system representation (Part 3)
  • Human circulatory system representation (Part 4)
  • Human urinary system representation (Part 5)