

3D Reconstruction of Individual Anatomy From Medical Image Data: Surface Extraction

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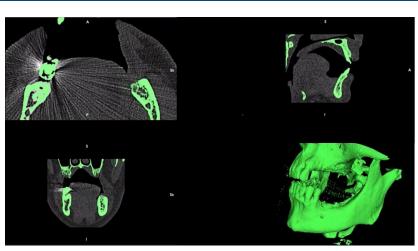


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Introduction

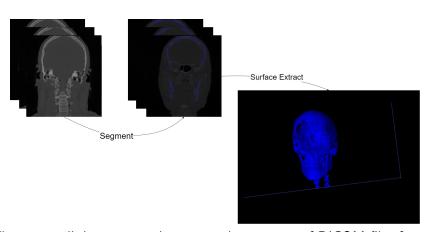


Introduction



After the last meeting, you should've comprehended the flow of reconstructing 3D models from clinical image data.

Introduction



This post will demonstrate how to read in a series of DICOM files from a CT examination and extract a mesh surface of the bone structures.

Dataset





DICOM standard is the de-facto solution to storing and exchanging medical image-data.

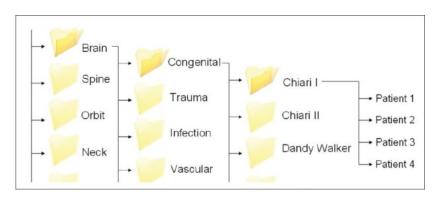
There's a wealth of freely available DICOM datasets online.

- Osirix Datasets
- Visible Human Datasets
- The Zubal Phantom
- Kaggle
- Scientific Data

Most databases forbid their re-distribution by third parties.

Dataset





This is a useful method to organize small image collections, especially when the diagnostic categories are relatively straight-forward.

DICOM File's Structure



Dataset Viettel Solutions Da Nang R&D Team

- The header stores demographic information about the patient, acquisition parameters for the imaging study, image dimensions, matrix size, color space, and a host of additional nonintensity information required by the computer to correctly display the image.
- Programmatically reading and processing DICOM depend on whether the files store the pixel data in a compressed form or not.

Preamble (128 bytes)

Prefix - 'D', 'l', 'C', 'M'

Header:

Data Set

- Group 1 (0002)
 - Element 1 (0002.0000)
 - Element 2 (0002,0001) - Element 3...etc.
- Group 2 (0008)
- Group 3...etc.

Image Pixel Intensity Data: 10011010011001011010100 01011010100100110100110 10100110010110101001001 10011010011001011010100 01011010100100110100111 10100110010110101001.....

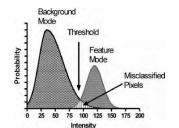
DICOM PS3.5 2020 - Data Structures and Encoding Indian J Radiol Imaging. 2012 Jan-Mar



Knowledge Base

Knowledge Base

- Thresholding is a process of dividing an image into many classes of pixel.
- The purpose of thresholding is to separate one or more regions of interest in an image from regions that do not contain relevant information.



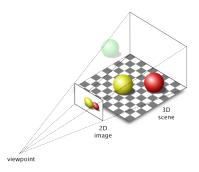






Rendering process could be looked at a two steps process:

- Projecting 3D shapes on the surface of a canvas and determining which part of these surfaces are visible from a given point of view.
- Simulating the way light propagates through space, which combined with a description of the way light interacts with the materials objects are made of, will give these objects their final appearance.



Knowledge Base

Direction of data flow

Visualization model Graphics model Source **Filter** Mapper Actor Renderer

- Direction of 'update'
- Visualization model: generating graphical objects to present the data.
- Graphics model: rendering screen image from the graphical objects.

Marching Cubes Algorithms



Knowledge Base

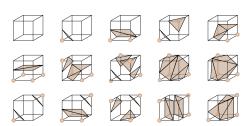
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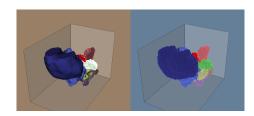
A computer graphics algorithm published in the **1987 SIGGRAPH** proceedings by Lorensen and Cline. Approach:

 Iso-surface cuts volume can approximately represent the ground-truth surface.

Idea:

- Devide the Iso-Surface into a per-volume cell presentation.
- Use triangles.





Marching Cubes Algorithms



Knowledge Base

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Drawback:

- Highly over-sampled.
- Abnormal surface.
- Aliasing artifacts.
- Sharp features within cells are lost.

Solution: Deep learning approach

- Occupancy Networks.
- MeshSDF.
- Deep Marching Cubes.



Development

Development



- Including many advanced algorithms (e.g., surface reconstruction, implicit modelling, decimation) and rendering techniques (e.g., hardware-accelerated volume rendering, LOD control).
- Object-oriented design with different interpreted language wrappers.



VTK Visualization Pipeline



Development

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- The central structure of the Visualization Toolkit is a pipeline of data, from a source of information to an image rendered on the screen.
- The individual modules do not necessarily update their output until they are called upon to do so by some other module.

VTK Visualization Pipeline Sources Provide initial data input from files or generated Filters (Optional) Modify the data in some way, conversion, reduction, interpolation, merging. Mappers Convert data into tangible "objects" Actors Adjusts the visible properties (transparency, color, level of detail, etc.) Renderers & Windows The viewport on the screen Interaction done here also

User Interface & Controls

Not exactly part of the pipeline,
but a very important part of the application



Development

Interpreted Wrapper (Tcl, Java, Python) •Tcl/Tk shell Tcl/Tk source Java interpreter Java JDK Python interpreter Python source C++ core All class source code Libraries and includes (could take hours to (dll and .h files) compile) Or (.a and .h files)

Binary Installation: if you will use

The classes to build your application

Source code Installation:

If you want to extend vtk

Application

Create 3D Printable Files



Application

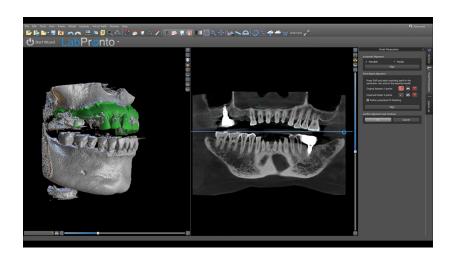
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A 3D medical imaging reconstructions application must provides several tools:

- DICOM support including ACR-NEMA version 1 and 2 and DICOM version 3.0 (Various encodings of JPEG).
- Image manipulation features (zoom, pan, rotation, brightness/contrast, etc).
- Pre-defined threshold ranges according to tissue of interest.
- Segmentation and Semi-automatic segmentation based on watershed.
- Region growing segmentation.
- 3D surface creation, exportation, and connectivity tools.
- High-quality volume rendering process.
- Picture exportation (BMP, TIFF, JPG, PostScript, POV-Ray, etc).

Application







The End

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