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

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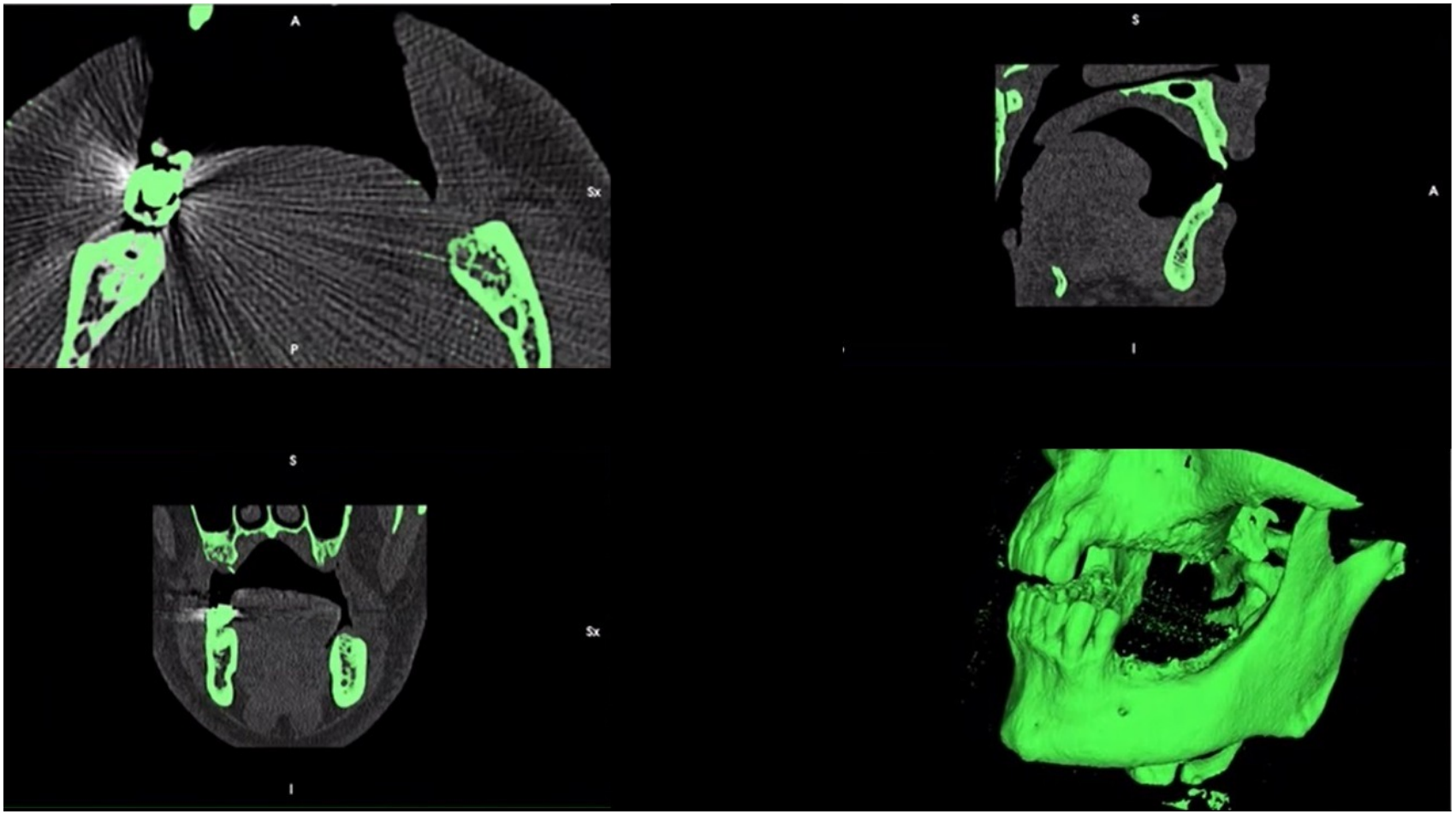
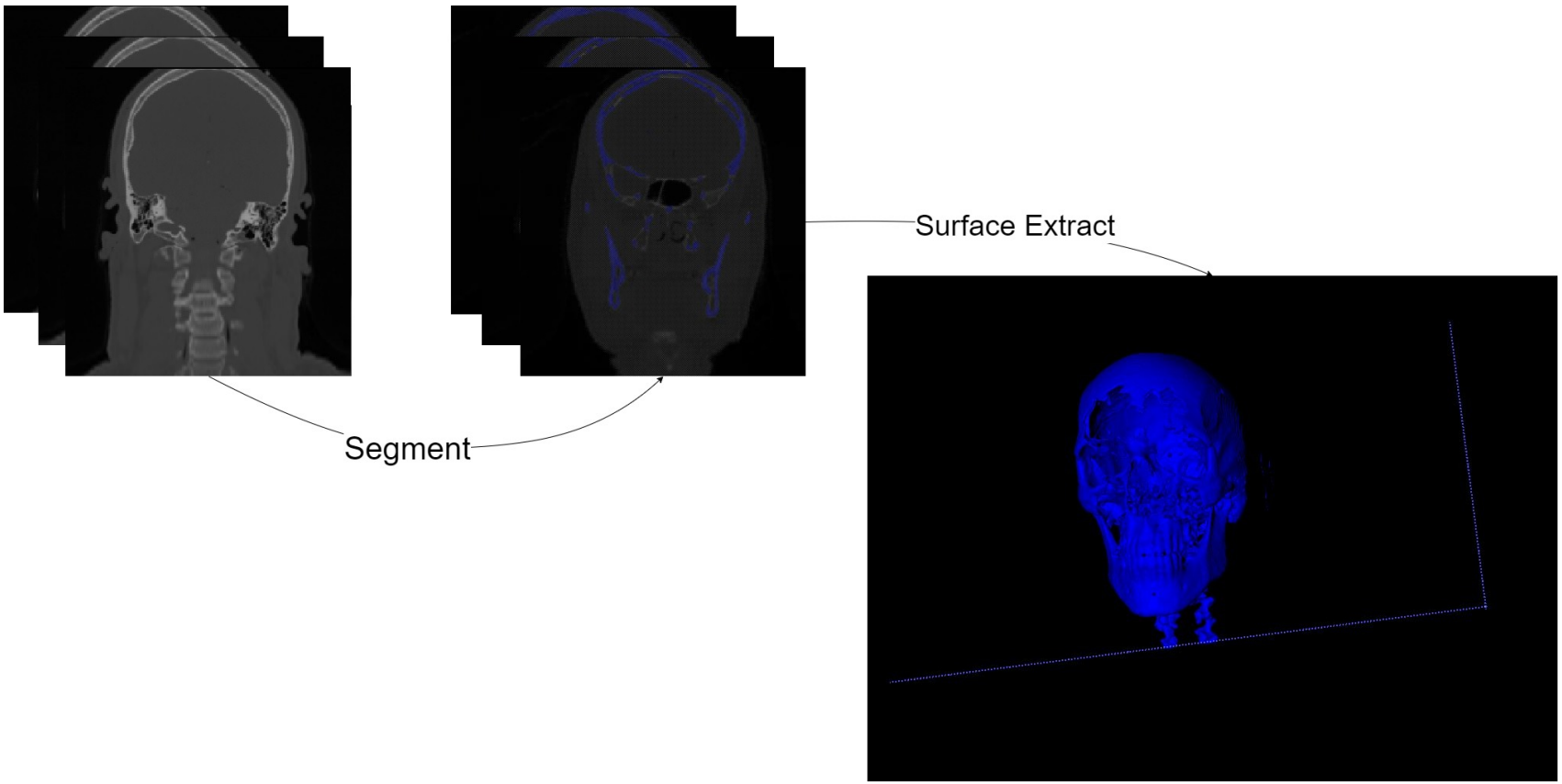
Introduction

Previously



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

The main objective



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

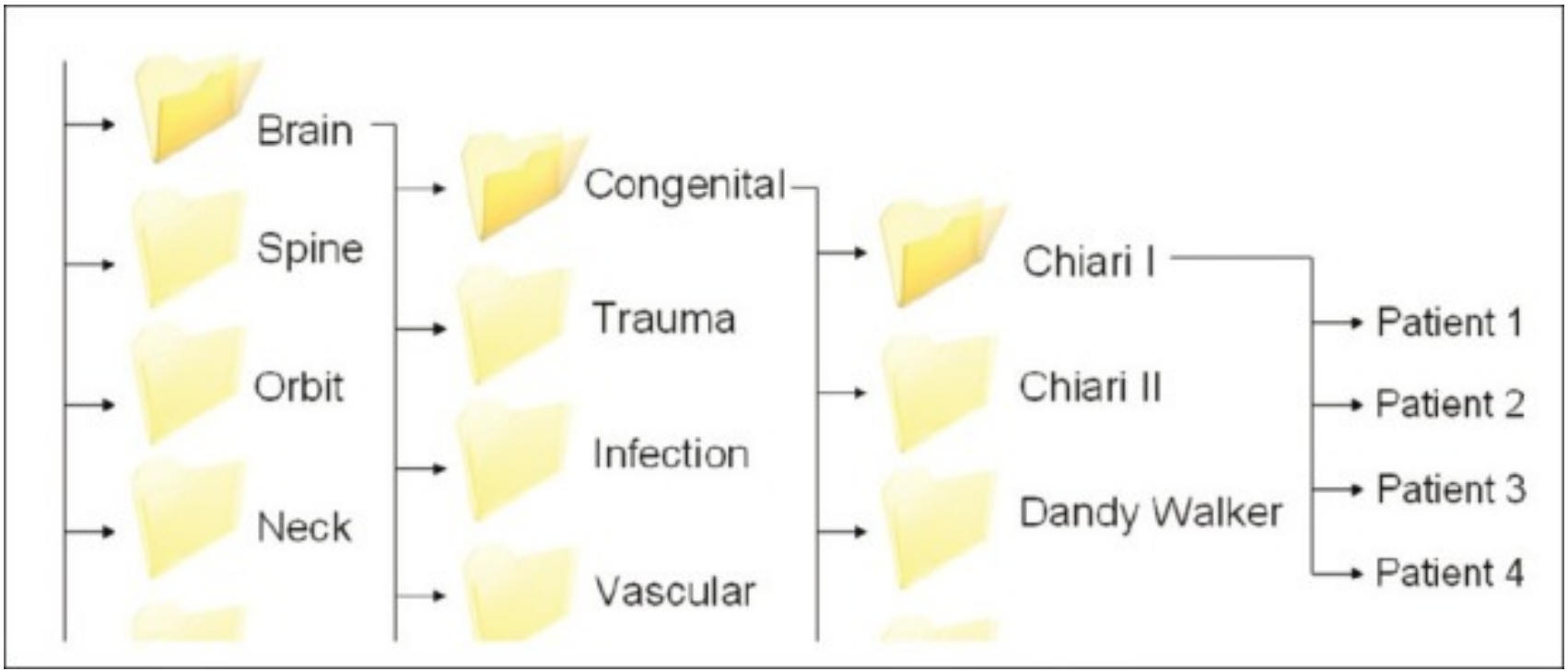
DICOM Standard

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.

Organizing DICOM Data

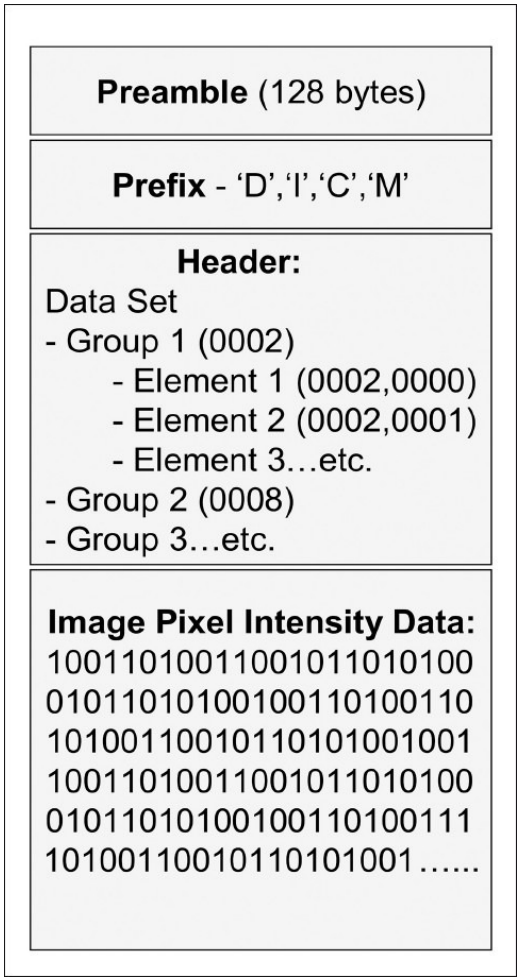


This is a useful method to organize small image collections, especially when the diagnostic categories are relatively straight-forward.

Indian J Radiol Imaging. 2012 Jan-Mar

DICOM File's Structure

- 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.

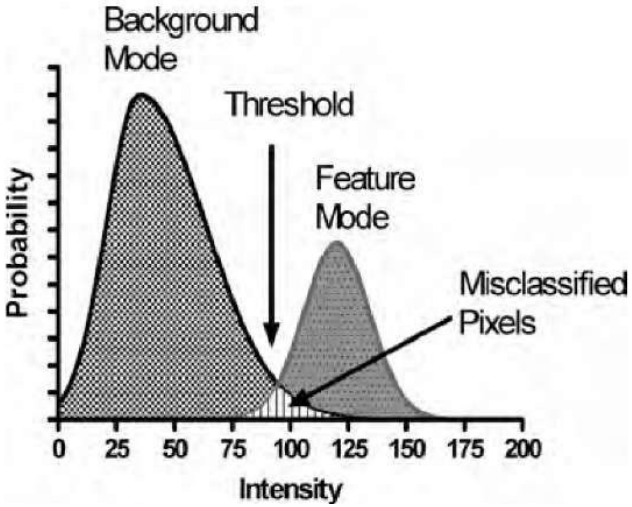


DICOM PS3.5 2020 - Data Structures and Encoding
Indian J Radiol Imaging. 2012 Jan-Mar

Knowledge Base

Thresholding

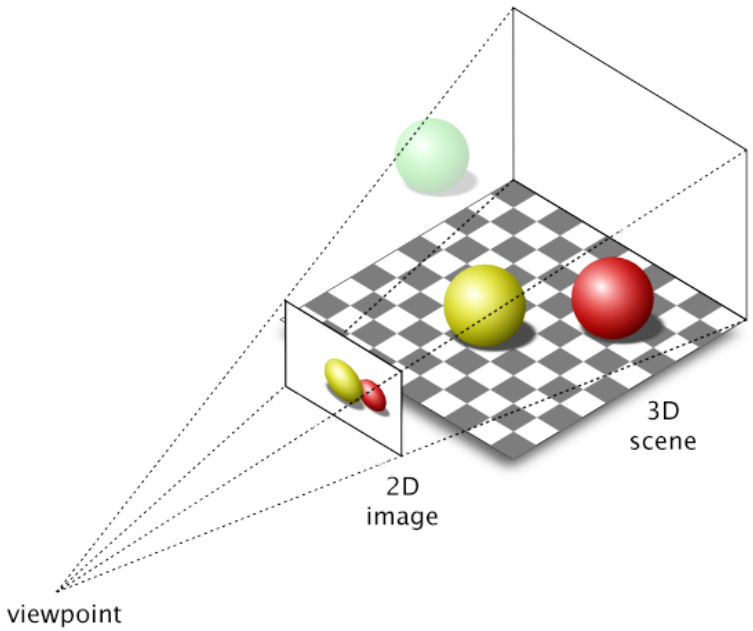
- Thresholding is a process of dividing an image into many classes of pixel.
- The purpose of thresholding is to separate one or more regions of interest in an image from regions that do not contain relevant information.



Rendering Process

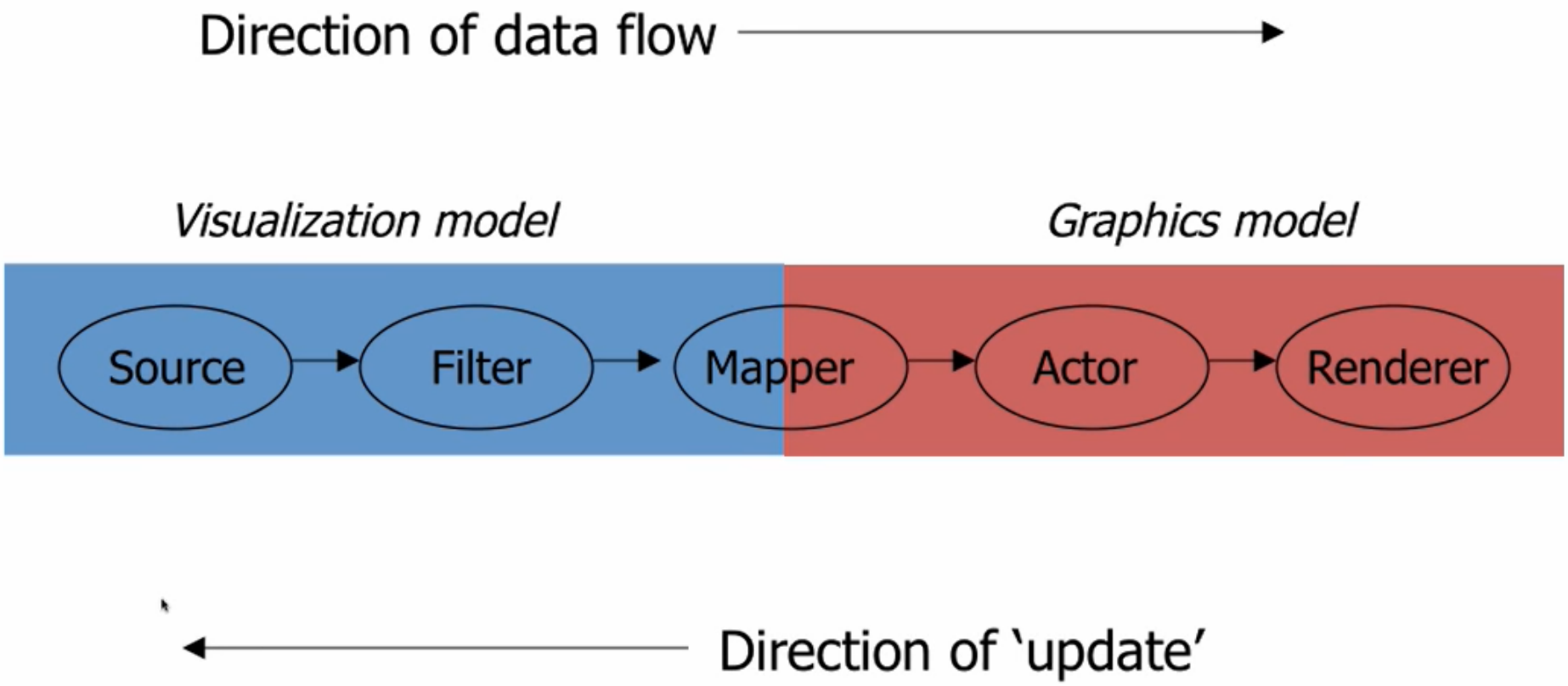
Rendering process could be looked at a two steps process:

- 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.



Rendering an Image of a 3D Scene: An Overview

Rendering Pipeline



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

Rendering an Image of a 3D Scene: an Overview

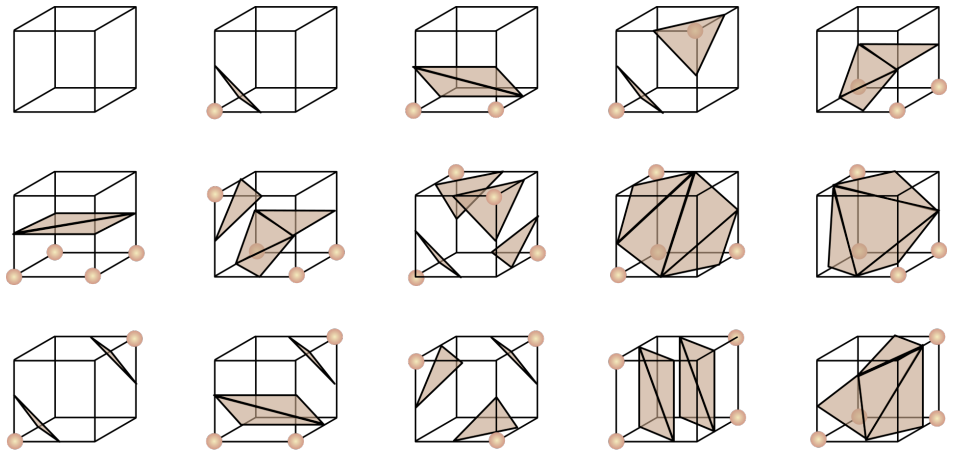
Marching Cubes Algorithms

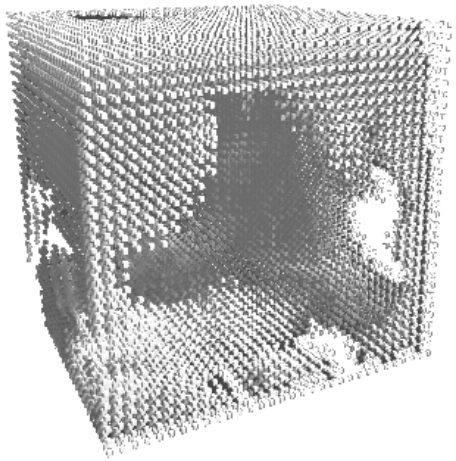
A computer graphics algorithm published in the **1987 SIGGRAPH** proceedings by Lorensen and Cline.
Approach:

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

Idea:

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





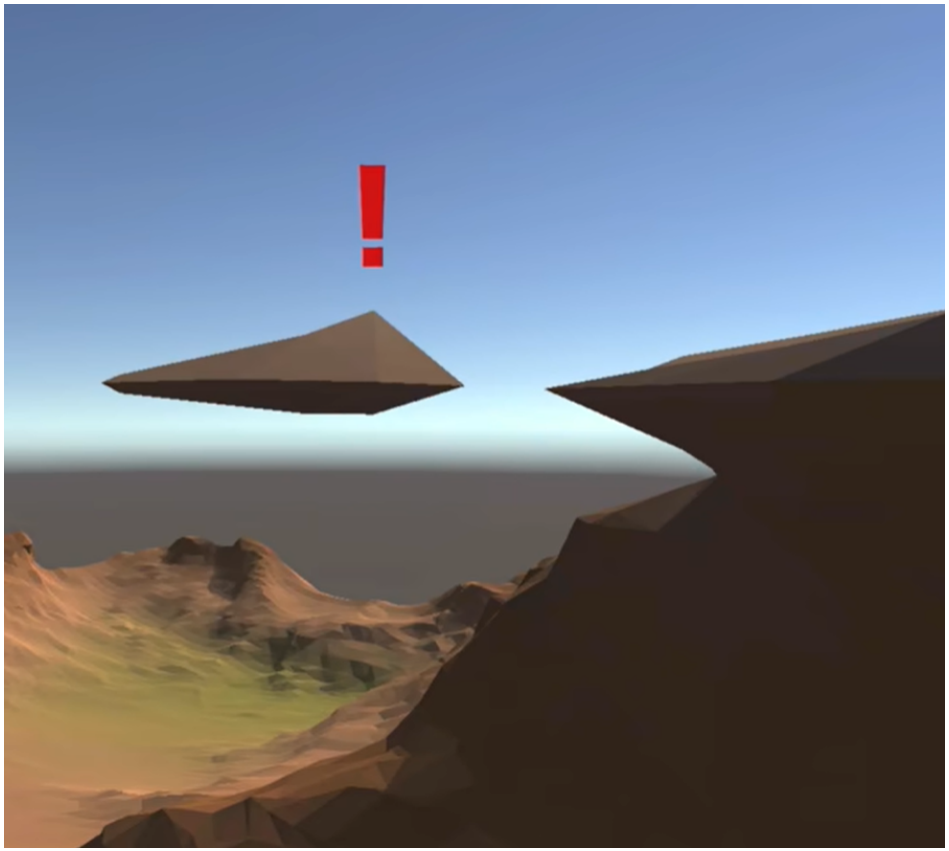
Demo

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

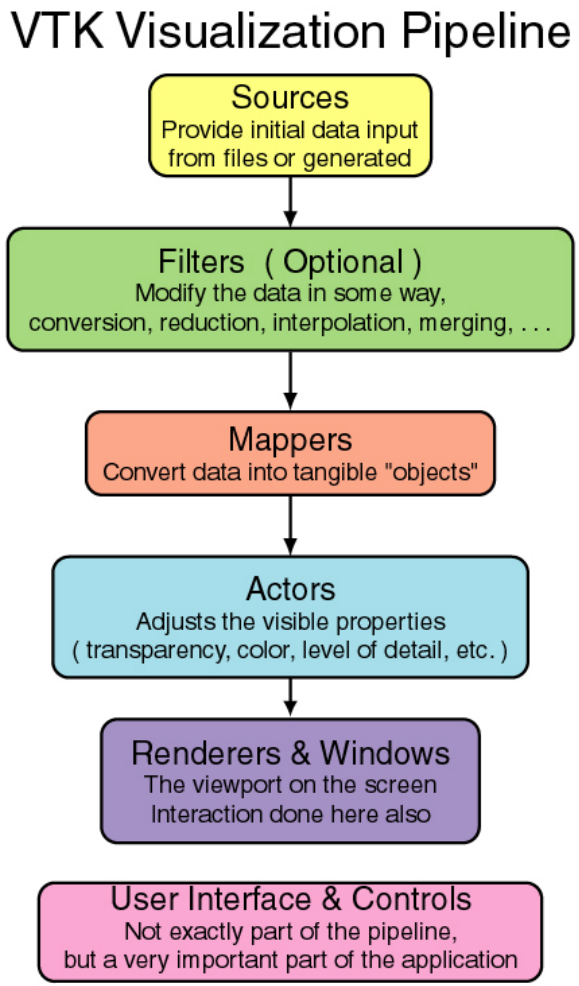
Kitware - VTK

- An open-, freely avaiable software system for image processing, 3D graphics, volume rendering and visualization.
- 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.

Source: Visualization Toolkit

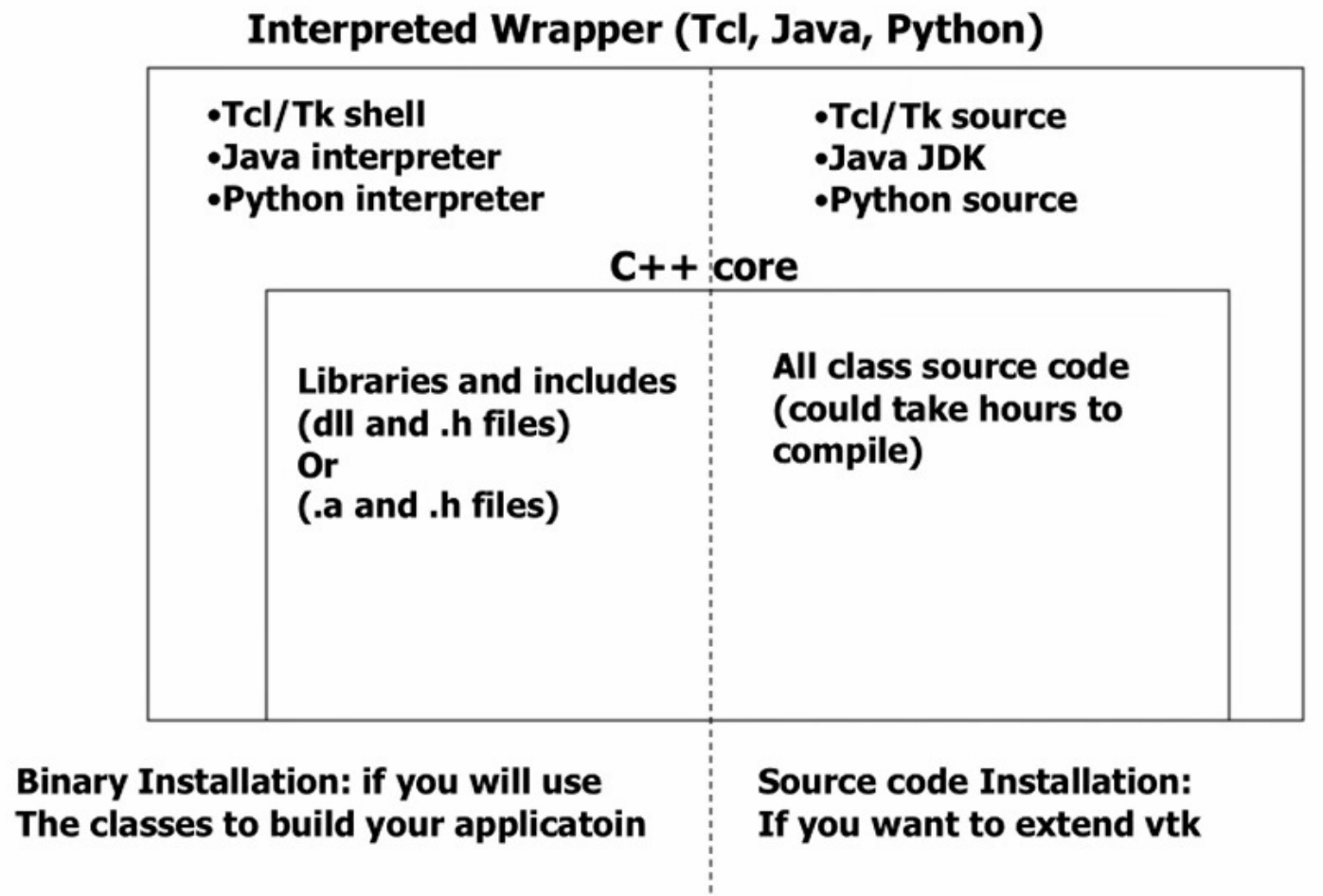
VTK Visualization Pipeline

- 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.



Source: General Architecture of the VTK Pipeline

System Architecture



Application

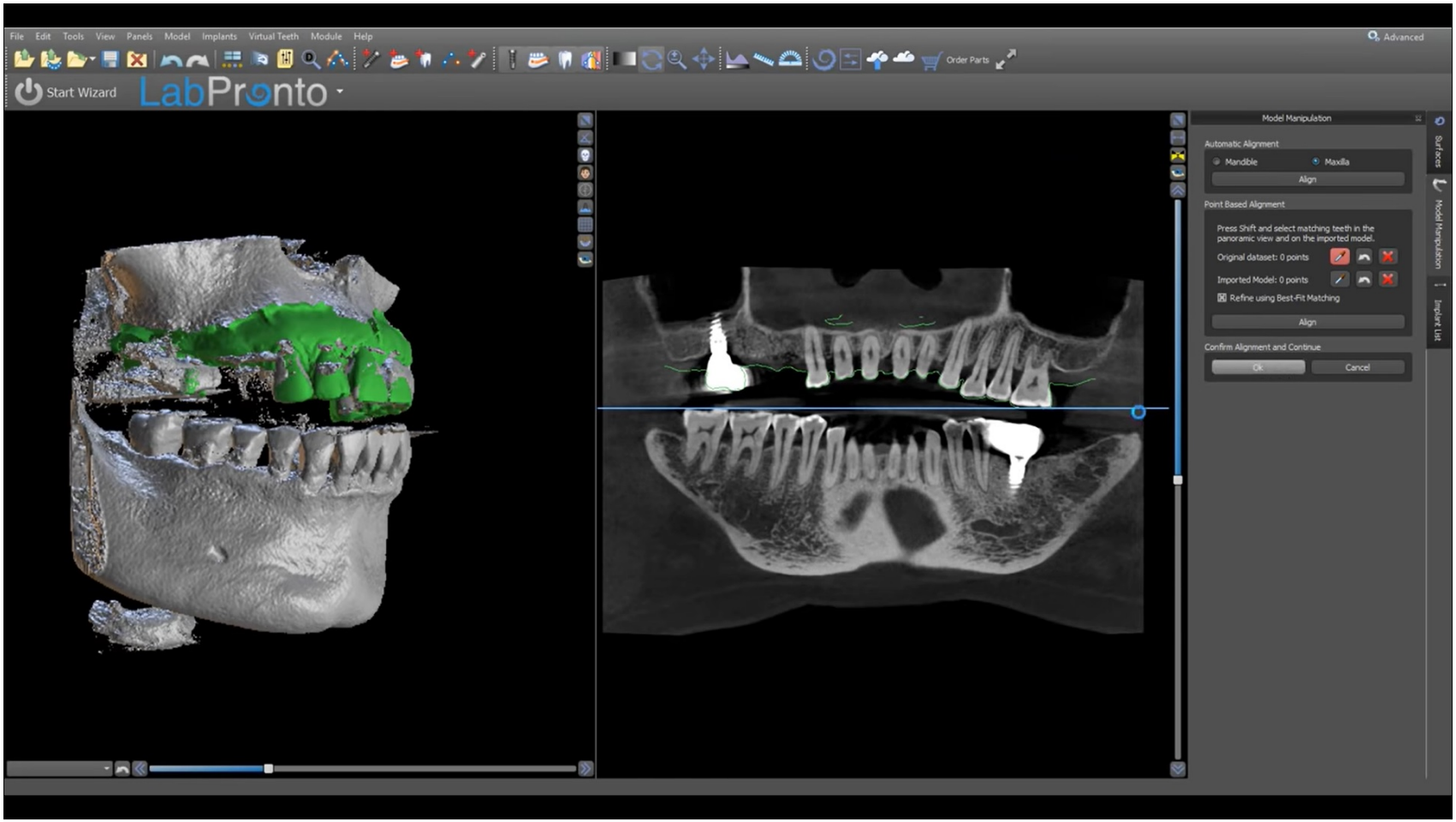
Create 3D Printable Files

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).

Moisaka: Healthcare Digital e-Learning Solutions

Blue Sky Plan



Main Page: BlueSkyPlan

The End

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