

Modeling Technique for Cardiovascular Biomechanics Simulation and Integrated System for Risk Estimation

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For Clinical Application

Computational Biomechanics Simulation

- Requires Interactive Modeling for Realistic Models
 - Low S/N Ratio
 - Artifacts (Motion, Aliasing, Chemical Shift, etc.)
- Relies on Extensive Use of Computer Resources
 - Processor Speed
 - # Of Processors
 - Amount of Memory
 - Memory Bandwidth
 - Communication Speed
 - etc.

For So-Called Tailor Made Medicine

Turn Around Time Must Be Shortened.

Bottlenecks are

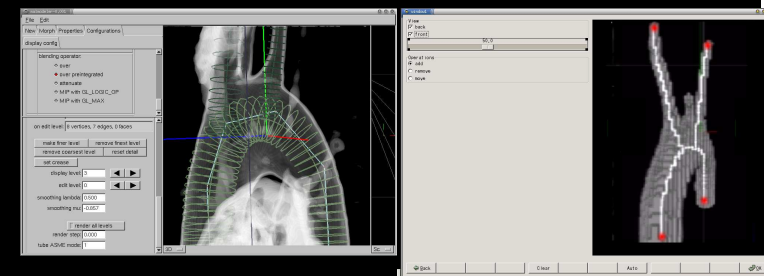
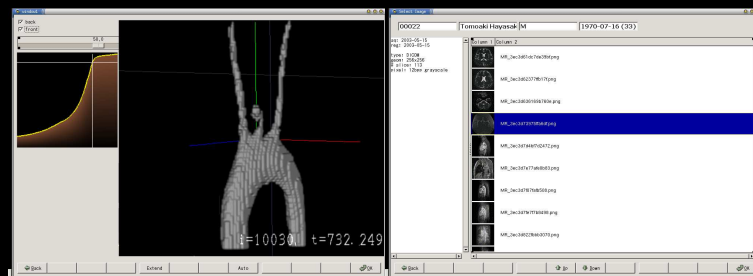
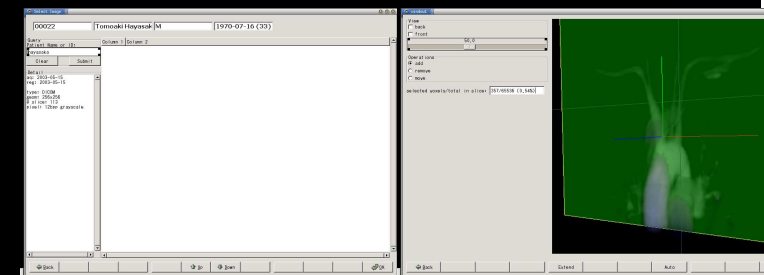
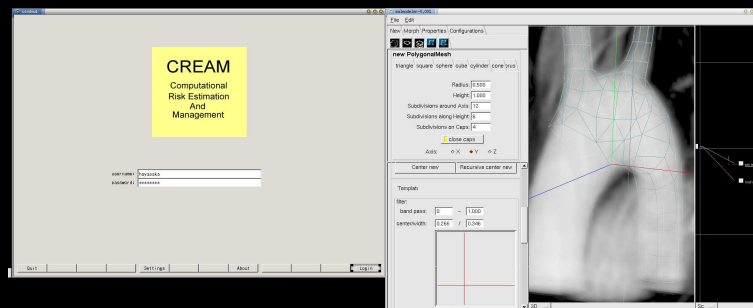
- Modeling
- Computation

CREAM

Computational Risk Estimation And Management
for Cardiovascular Medicine

Goals

- Prediction Based Risk Management
- Risk Estimation in Minutes
- Comprehensive Set of Tools
- Integrated UI



Quick Risk Estimation

Keys for Quick Risk Estimation:

"Do Not Model"

"Do Not Compute"

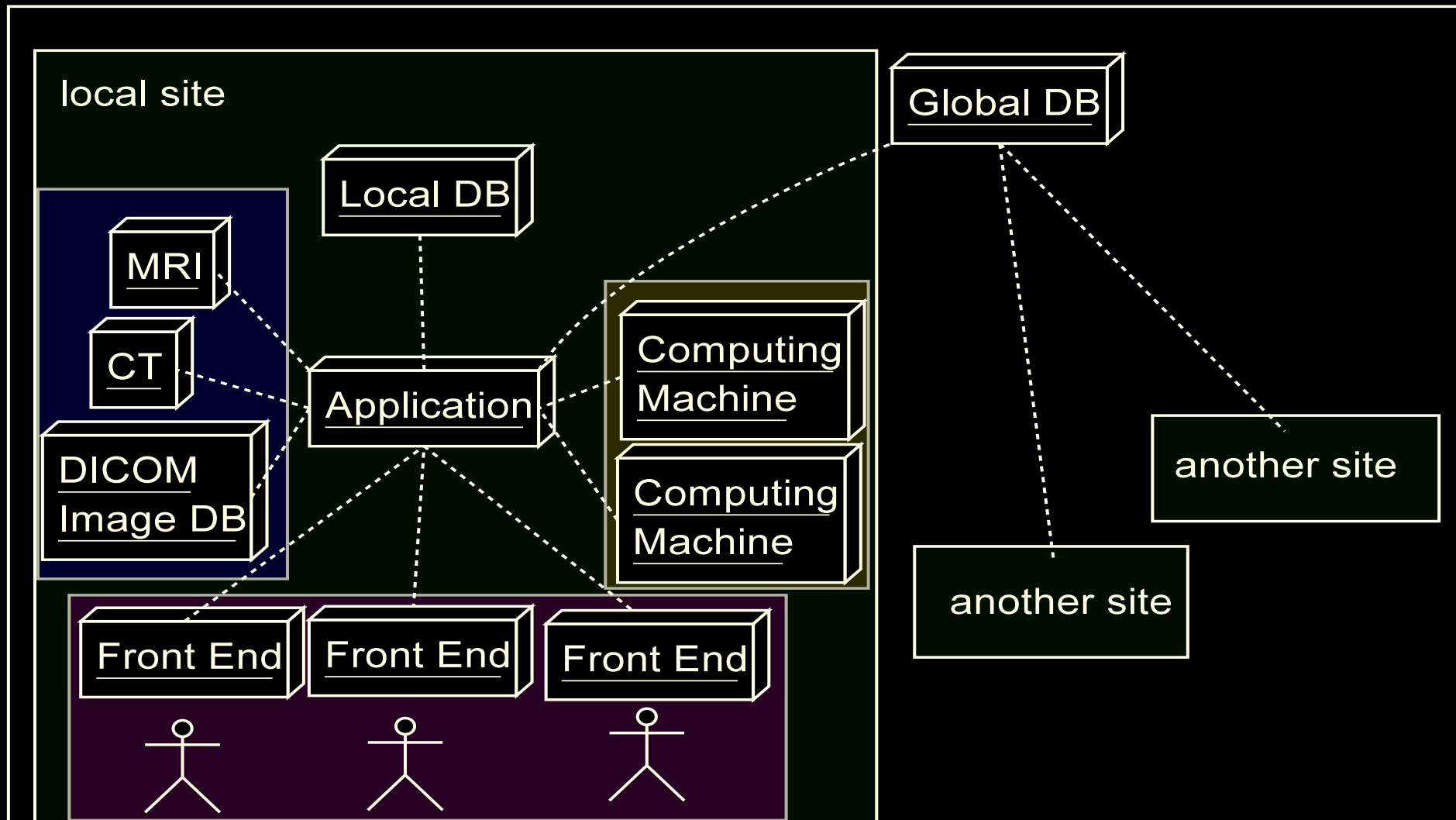
Instead, Utilize Database of Images, Pre-Built Models,
Computational Results & Clinical Outcomes

A Summary Level Use-Case

When New Patient Comes

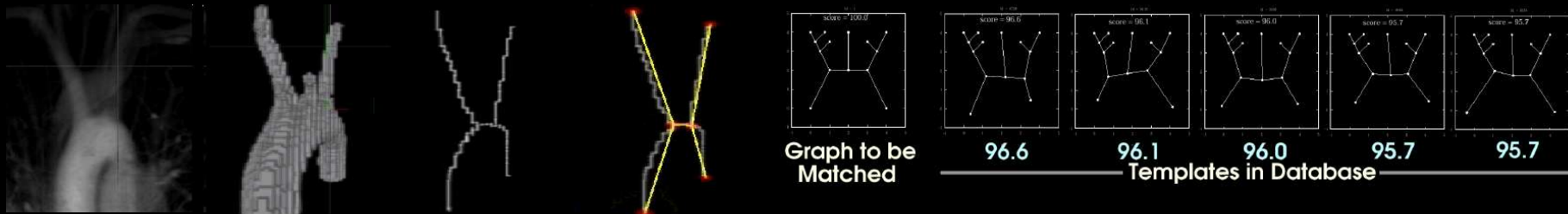
- Acquire the Image of the Patient Using MRI etc.
- Find Similar Image and Associated Data from the DB
- Evaluate Risks Using Pre-Computed Results and Related Clinical Outcomes

Architecture



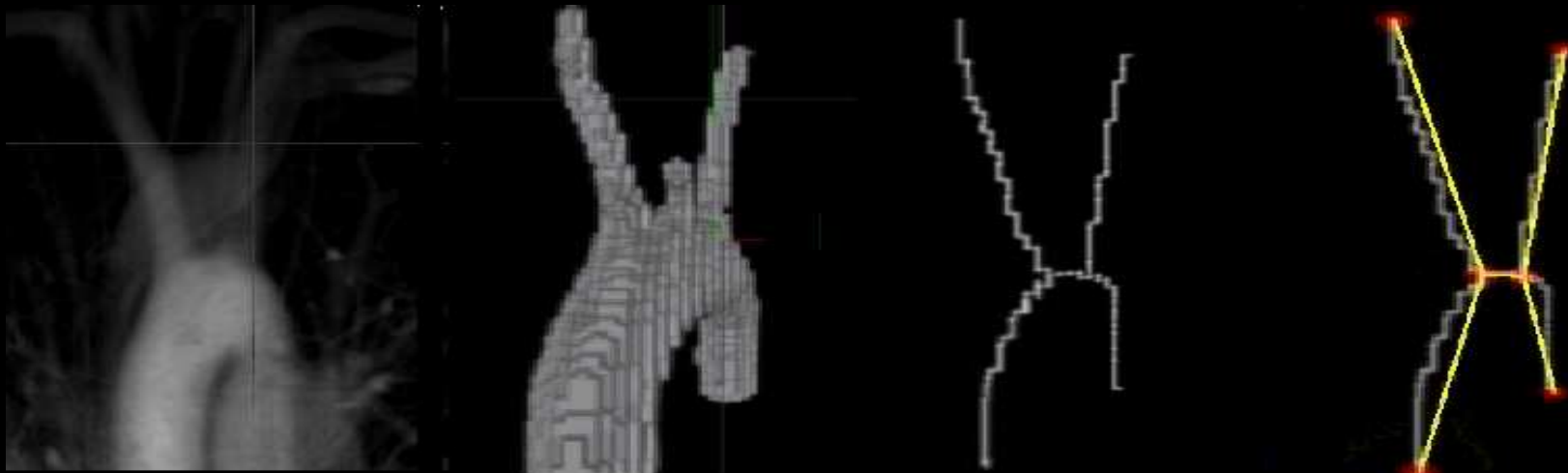
Finding Similar Image

- Direct Image Comparison is Inappropriate
 - Inefficient
 - Error Prone
- Novel Technique Based on Reduced Information
 - Efficient
 - Robust
 - Geometrical Information (Bifurcation Point, Radius)
 - Fitted to Centerline Based Mesh Generation



Topology Estimation

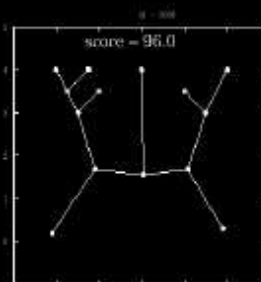
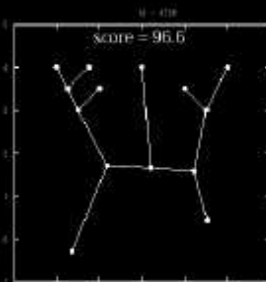
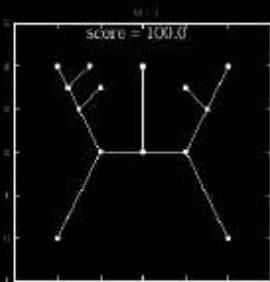
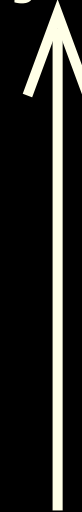
- Segment
- Skeletonize
- Trace Edges



A New Matching Algorithm

$$\begin{aligned} \text{Score} &= \text{Topological Equality} \\ &+ \text{Geometrical Similarity (Root)} \\ &+ \text{:} \\ &+ \text{:} \\ &+ \text{Geometrical Similarity (Leaf)} \end{aligned}$$

Weighted



Graph to be Matched

96.6

96.1

96.0

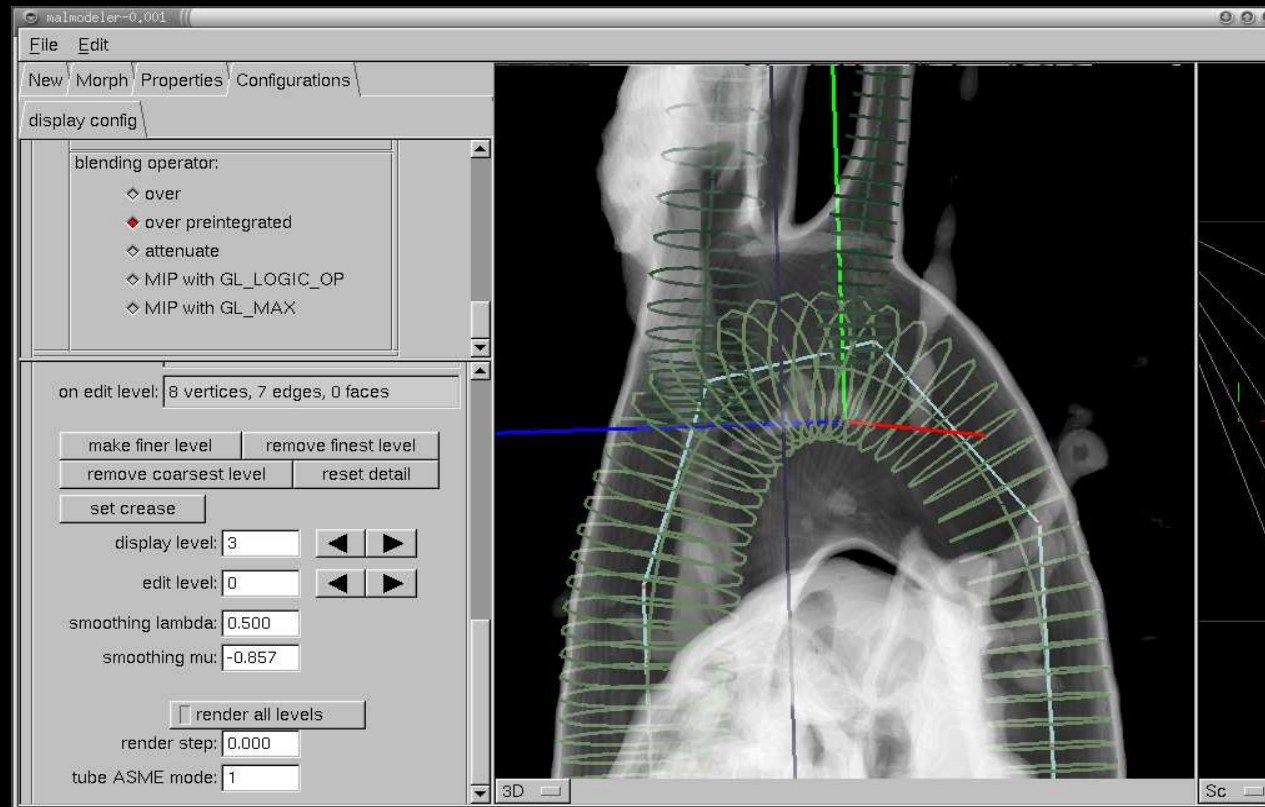
95.7

95.7

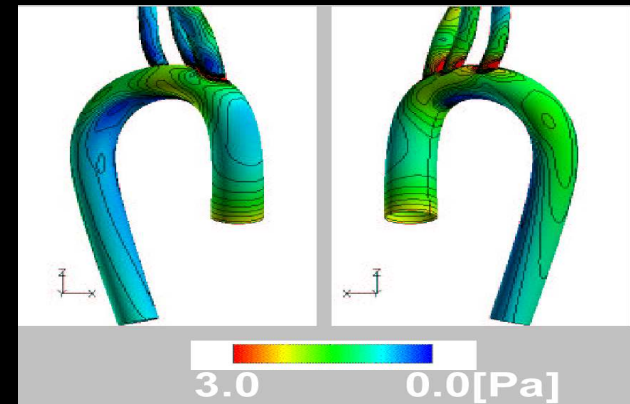
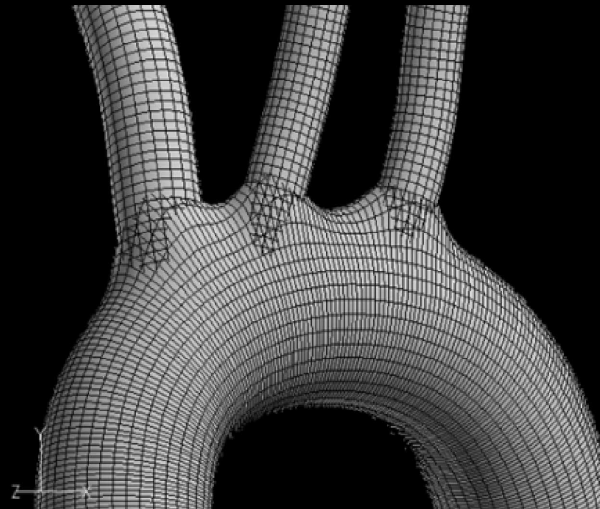
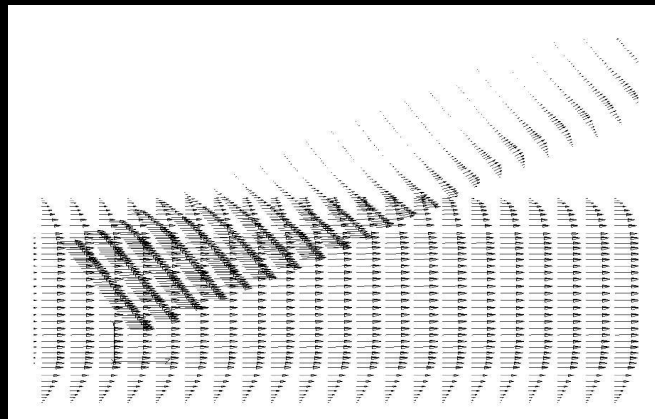
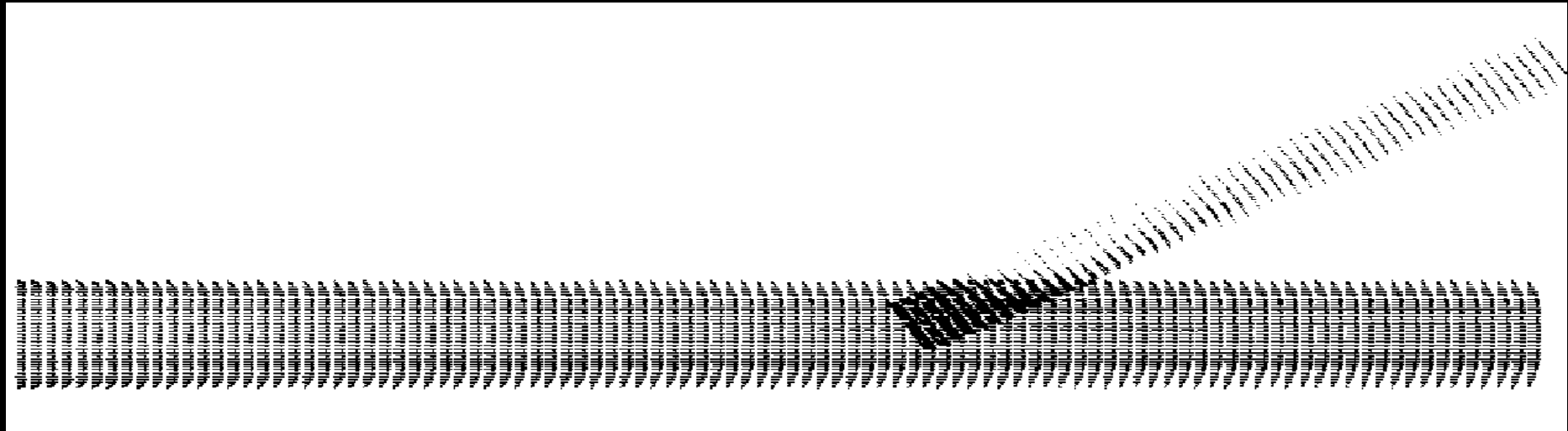
Templates in Database

Initial Model Construction

Previously Developed "malmodeler" with Enhancements of Centerline Based Grid Generation



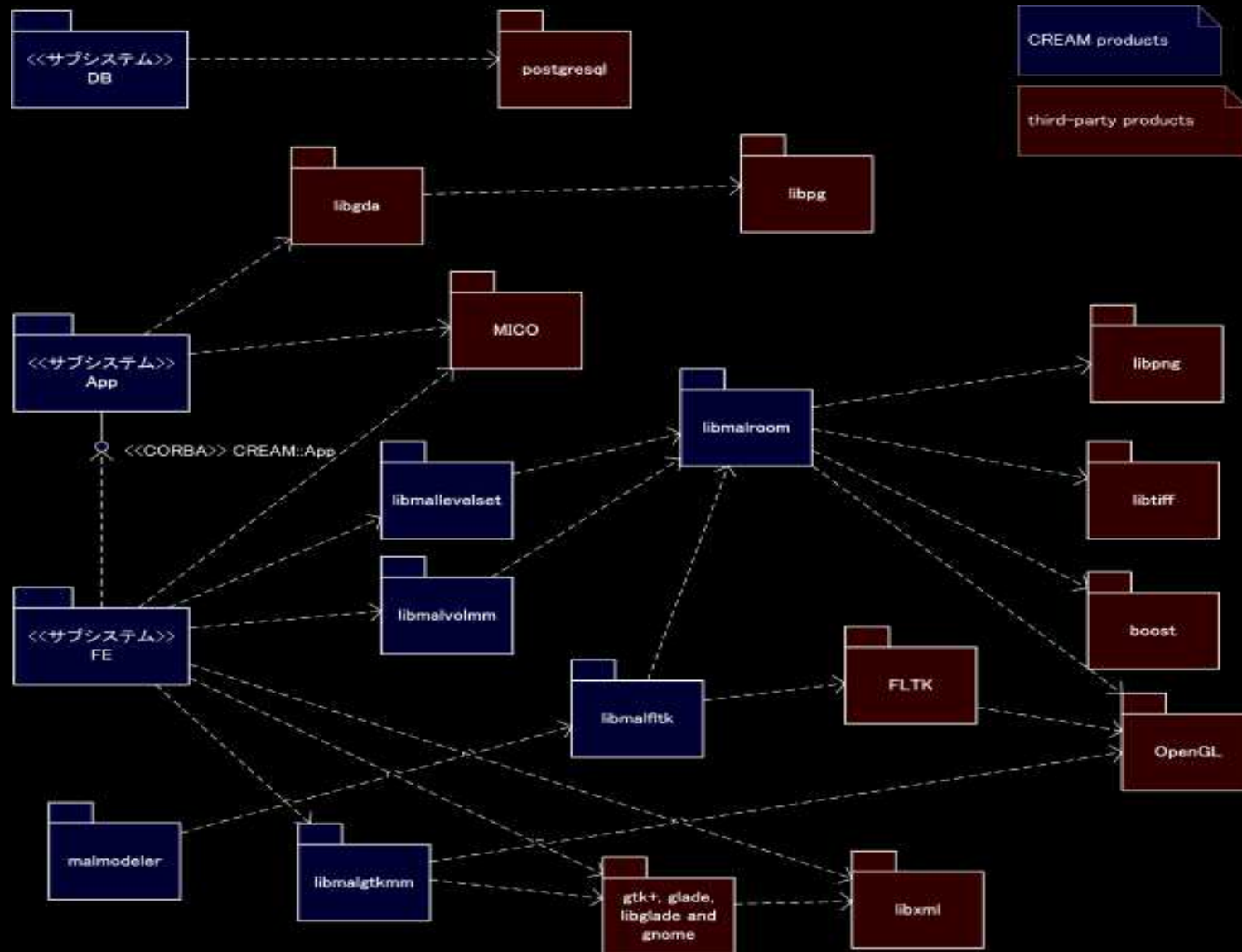
CFD Analysis Using Over Set Mesh



Implementation

- Linux
- g++ (C++)
- MICO (CORBA)
- libxml (XML)
- DCMTK (DICOM Toolkit)
- Postgresql (RDBMS)
- FLTK and gtk-- (GUI)
- OpenGL
- Sun Grid Engine

Components and Objects 1/2



Components and Objects 2/2

App

- Business objects (patient, image, etc.)
- DB access
- Session management
- Transaction management

FE

- Individual UI programs
- Screen transition
- Image handling
- Topology handling

Summary

Features

- DB of Image, Model, Results, Clinical Outcomes
- Quick Risk Estimation by Pre-Computation

Status

- Design Finished
- Fundamental Components Implemented
 - Topology Estimation
 - Matching
 - Centerline Based Modeling
 - CFD Using Over Set Mesh

Furture Works

- Finish UI

Acknowledgment

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