Medical Imaging

Image Generator to Support the Application of a Haptic Device for the Simulation of Arthroscopic Surgery

Bradley University

Department of Electrical and Computer Engineering

By: Renata Zabawa

Project Advisor: Dr. Thomas L. Stewart

May 2, 2006

Contents

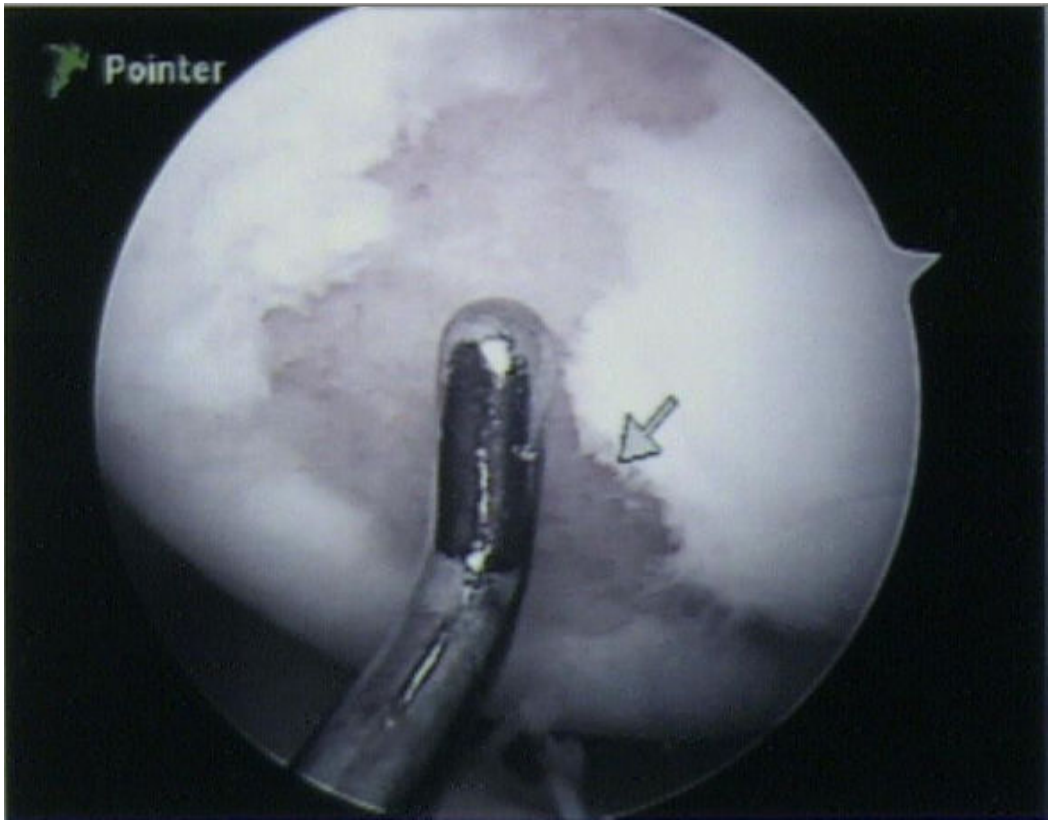
- Introduction
- System Block Diagrams
- Software Block Diagrams
- Models of Arthroscopic Surgery Views
- Future Work
- Questions

Project Introduction

- Magnetic Resonance Imaging (MRI)
- Show cross section knee
- Create 3-D model of cartilage
- Simulate surgeon's view during arthroscopic surgery
- Simulate the arthroscopic surgery with a haptic feedback system

MRI Scan of Knee

Actual Views of Arthroscopic Knee Surgery



System Block Diagram

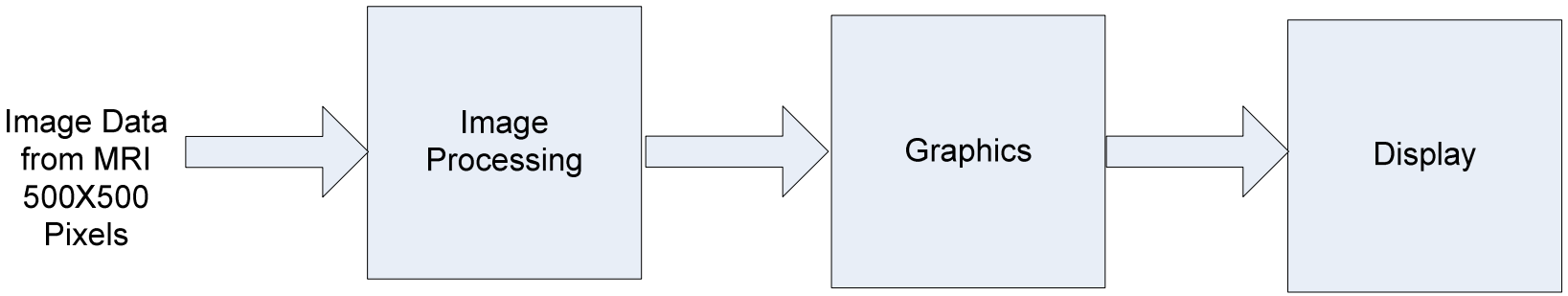
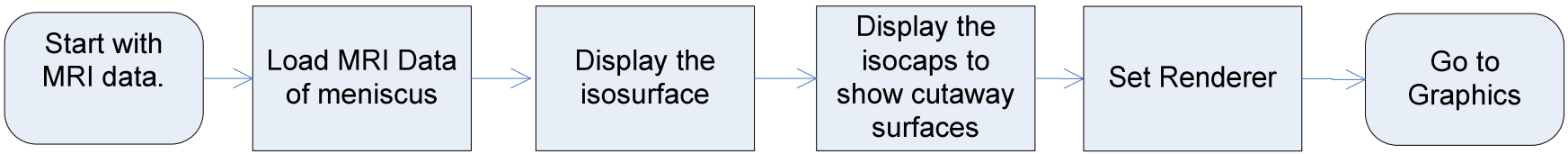
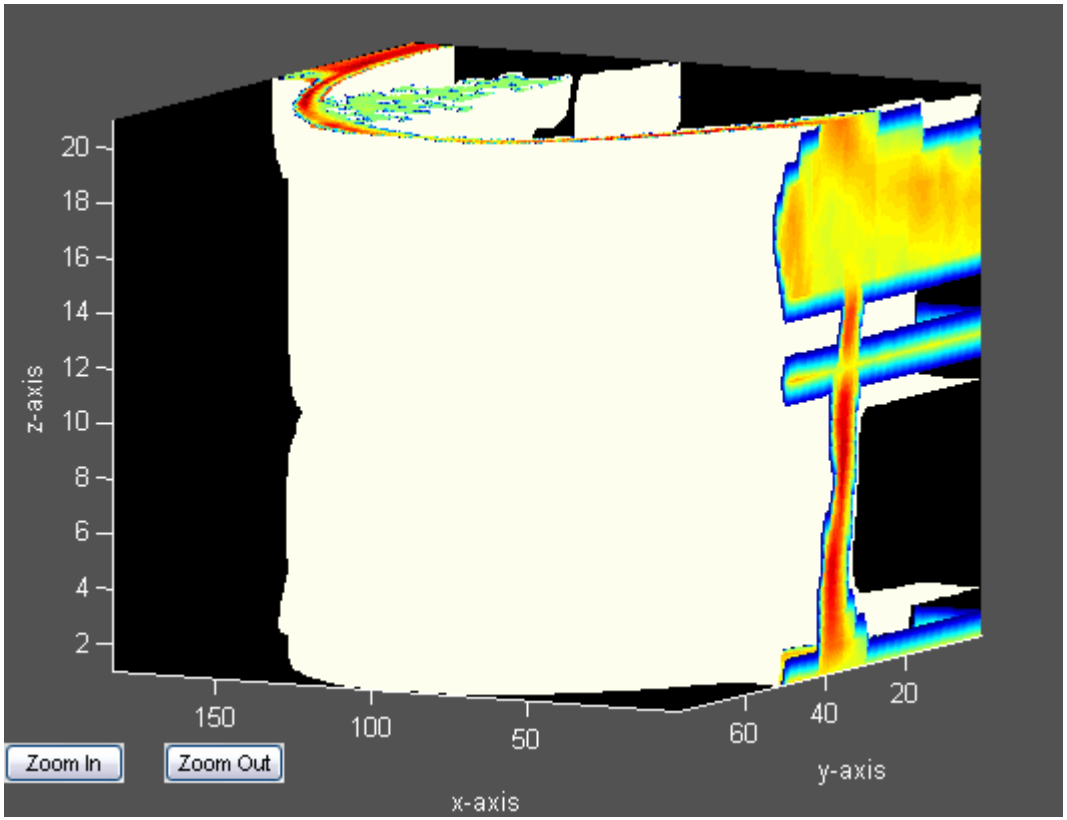


Image Processing Block Diagram



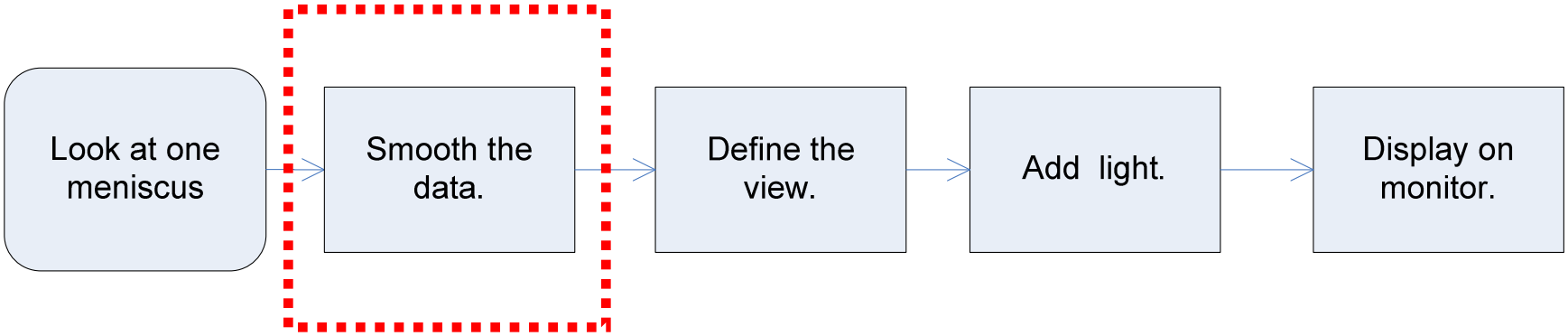
- Creates model of cartilage
  - Isosurfaces-displays overall structure of cartilage
  - Isocaps-reveal details of interior cartilage

Cartilage Model Split



- Rendering with Zbuffer

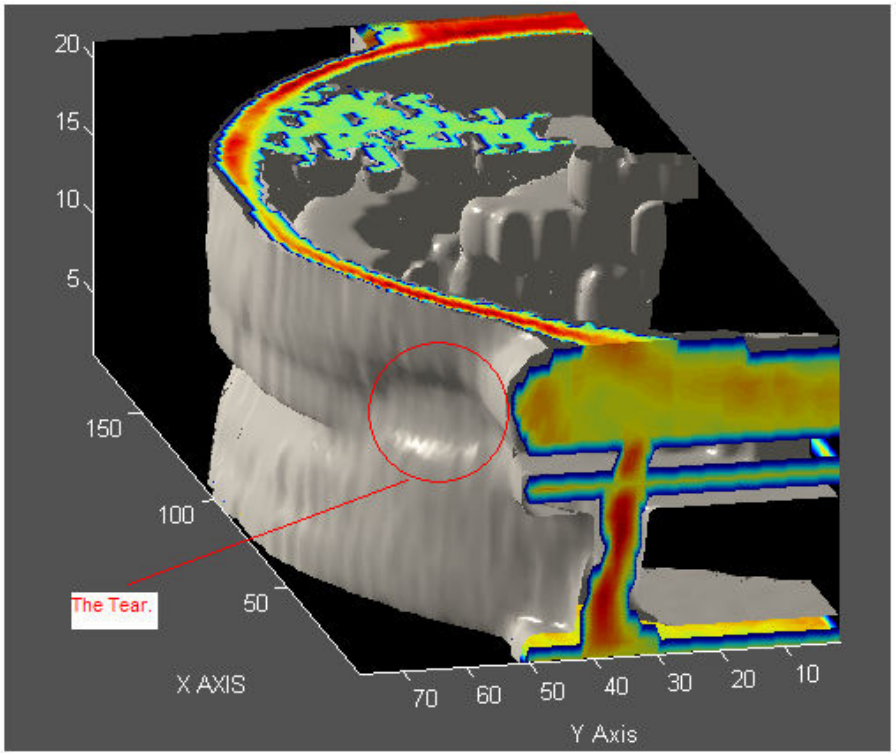
Graphics Block Diagram



- Takes the model of cartilage and creates the simulation of an arthroscopic meniscus surgery

Smooth the Data

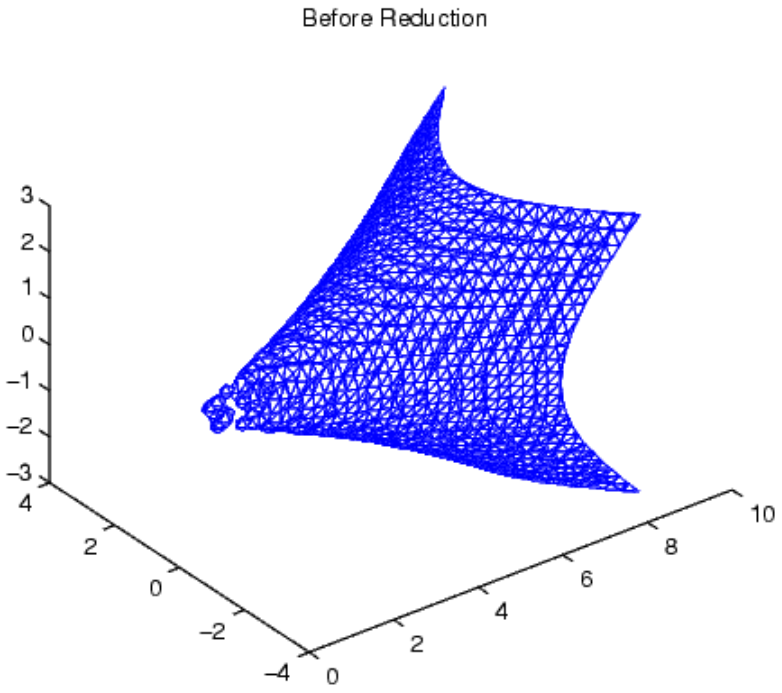
- 1/10 inch thick cartilage stretched on monitor
- Lack of data
- Smoothing filters

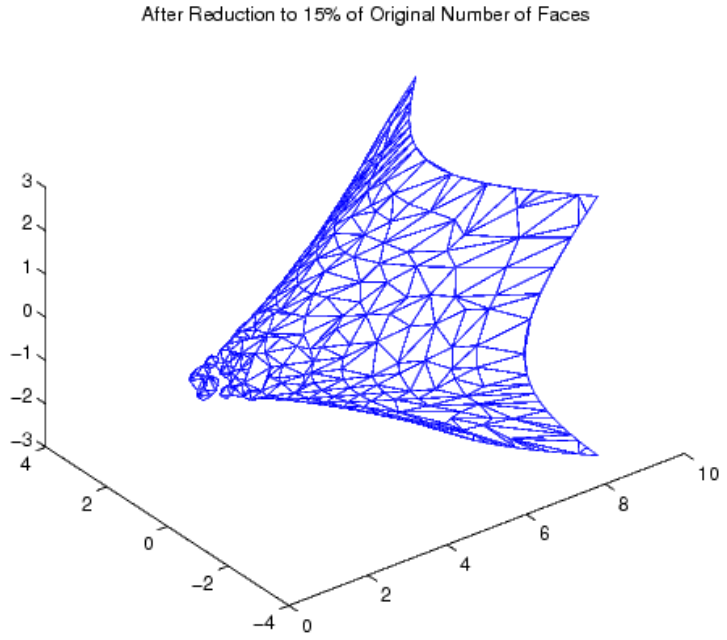


Reduce Patches

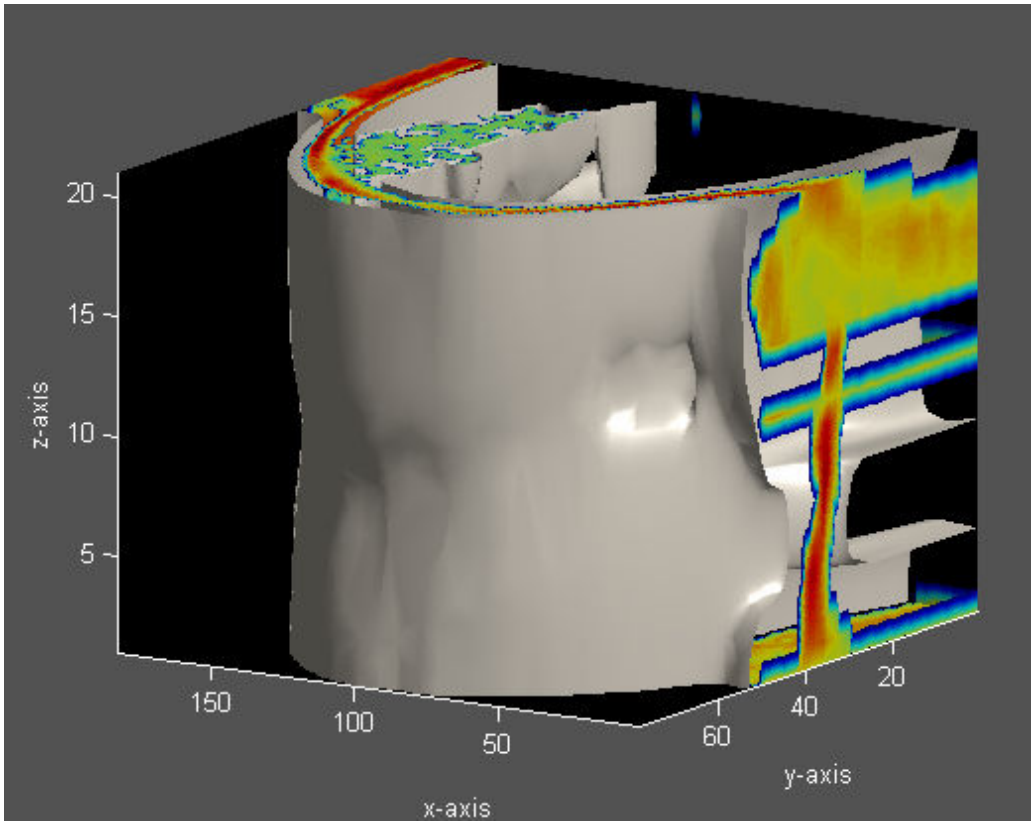
- Reduces the number of faces and vertices of the patch
- Preserve the overall shape of the original object
- Less surfaces, less shadow and bending

Reduce Patches

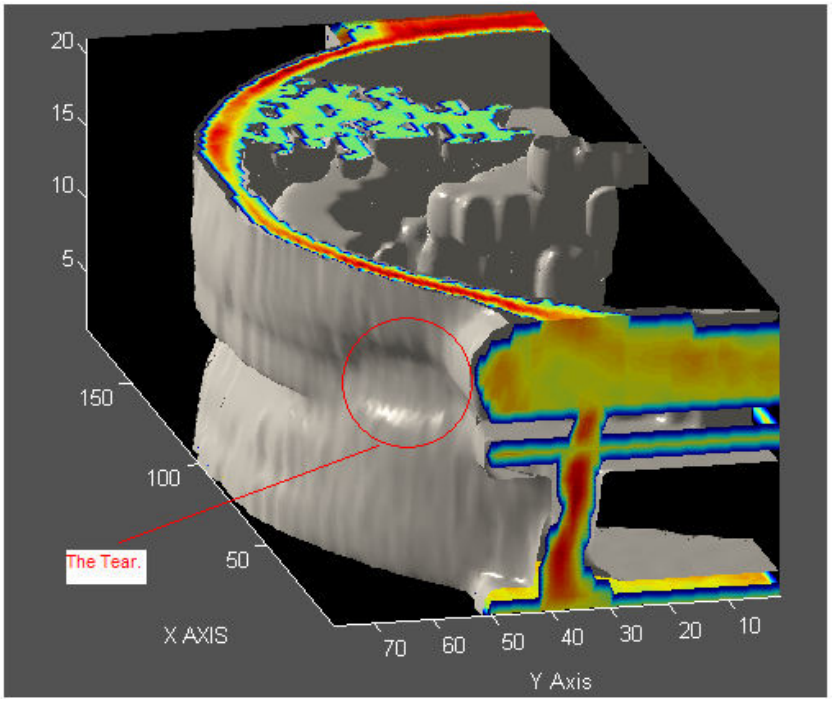


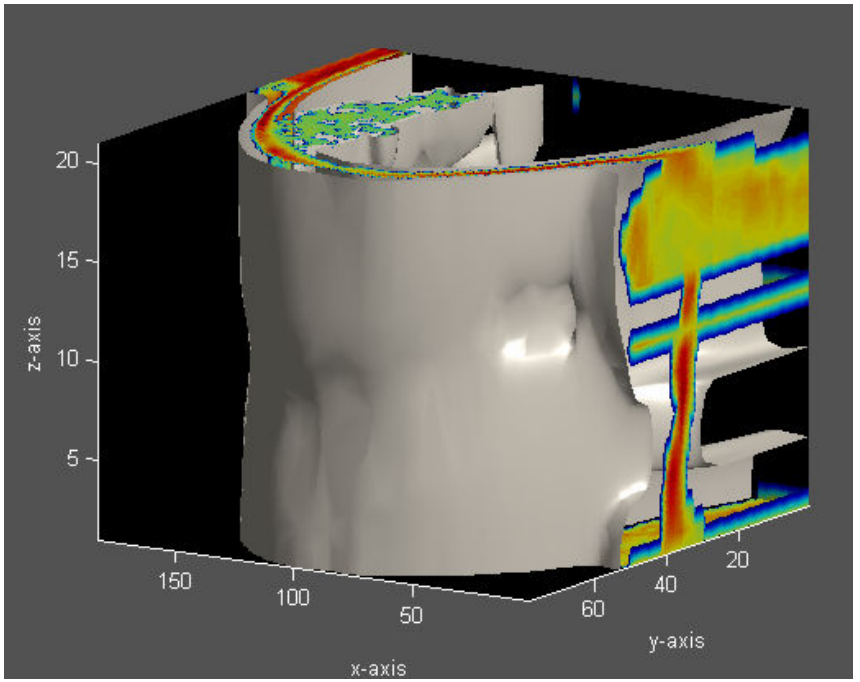


Smoothed Cartilage Model

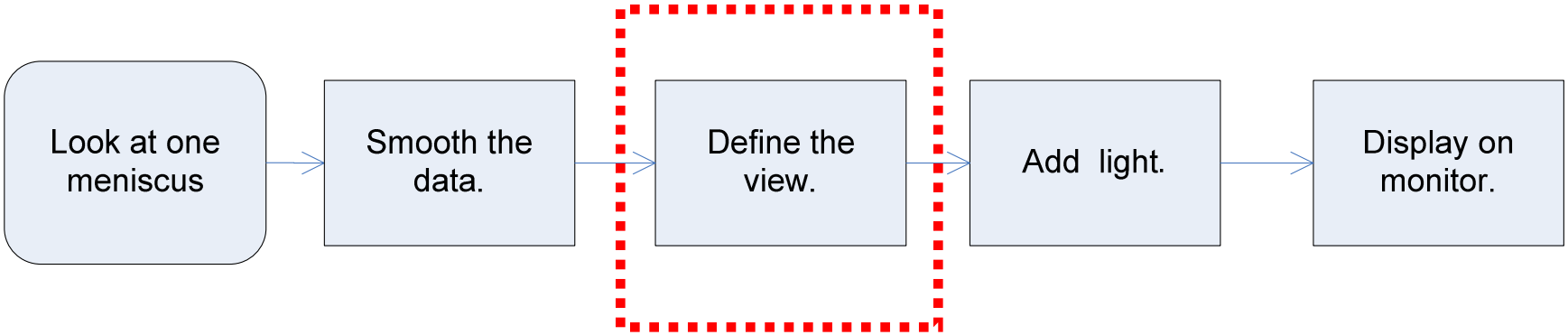


Comparison Cartilage Models





Graphics Block Diagram

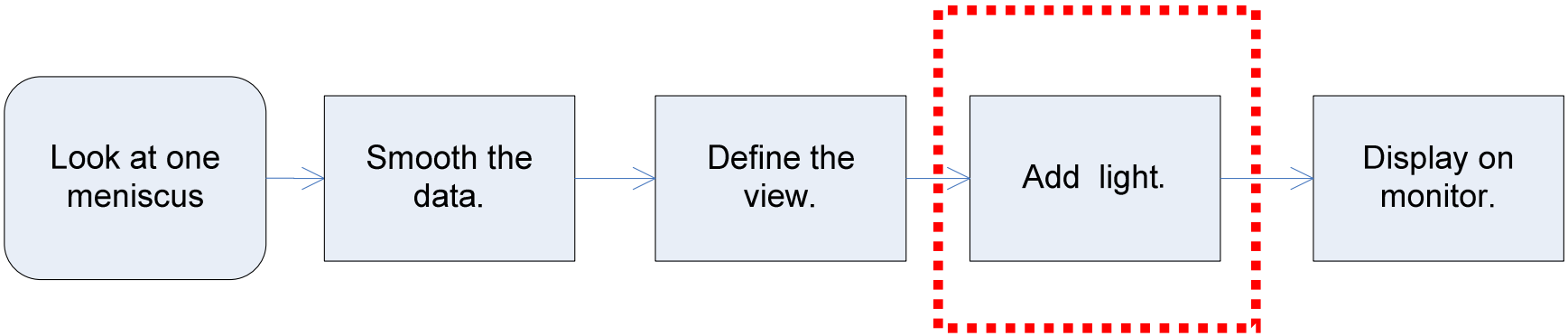


View

- Set Target

- Set Camera Position

Graphics Block Diagram

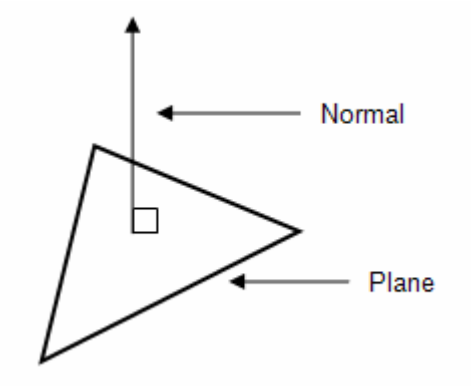


Light

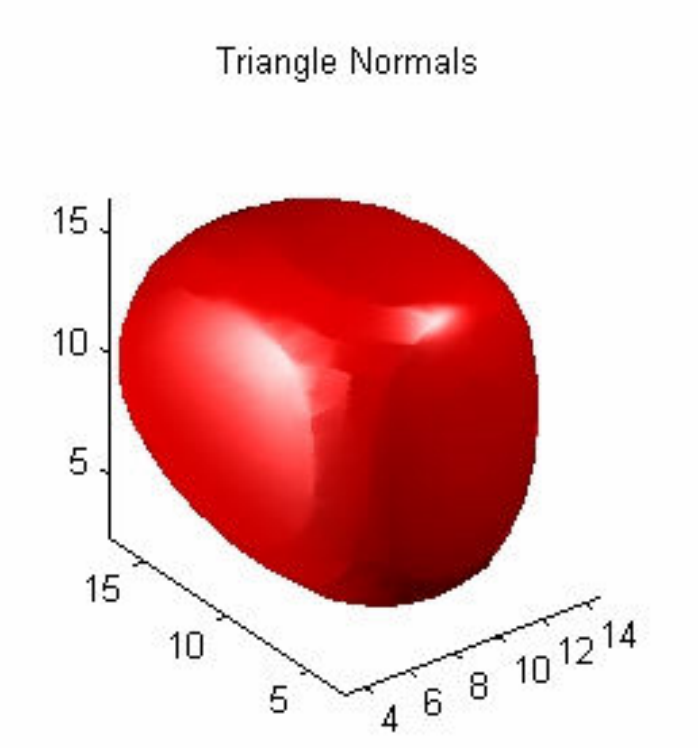
- Properties
  - Ambient Strength
  - Specular Exponent
  - Specular Strength
  - Diffuse Strength
  - Lighting – Phong
- Set Position of Light

Surface Normals

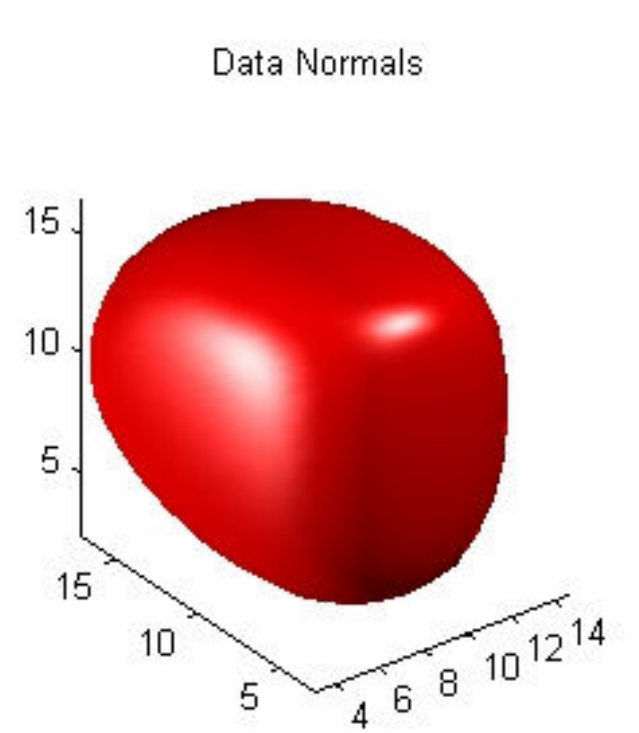
- Normal to plane of surface
- Surface normals greatly effect visual appearance of lit isosurfaces



Surface Normals on the Visual Appearance of Lit Isosurfaces

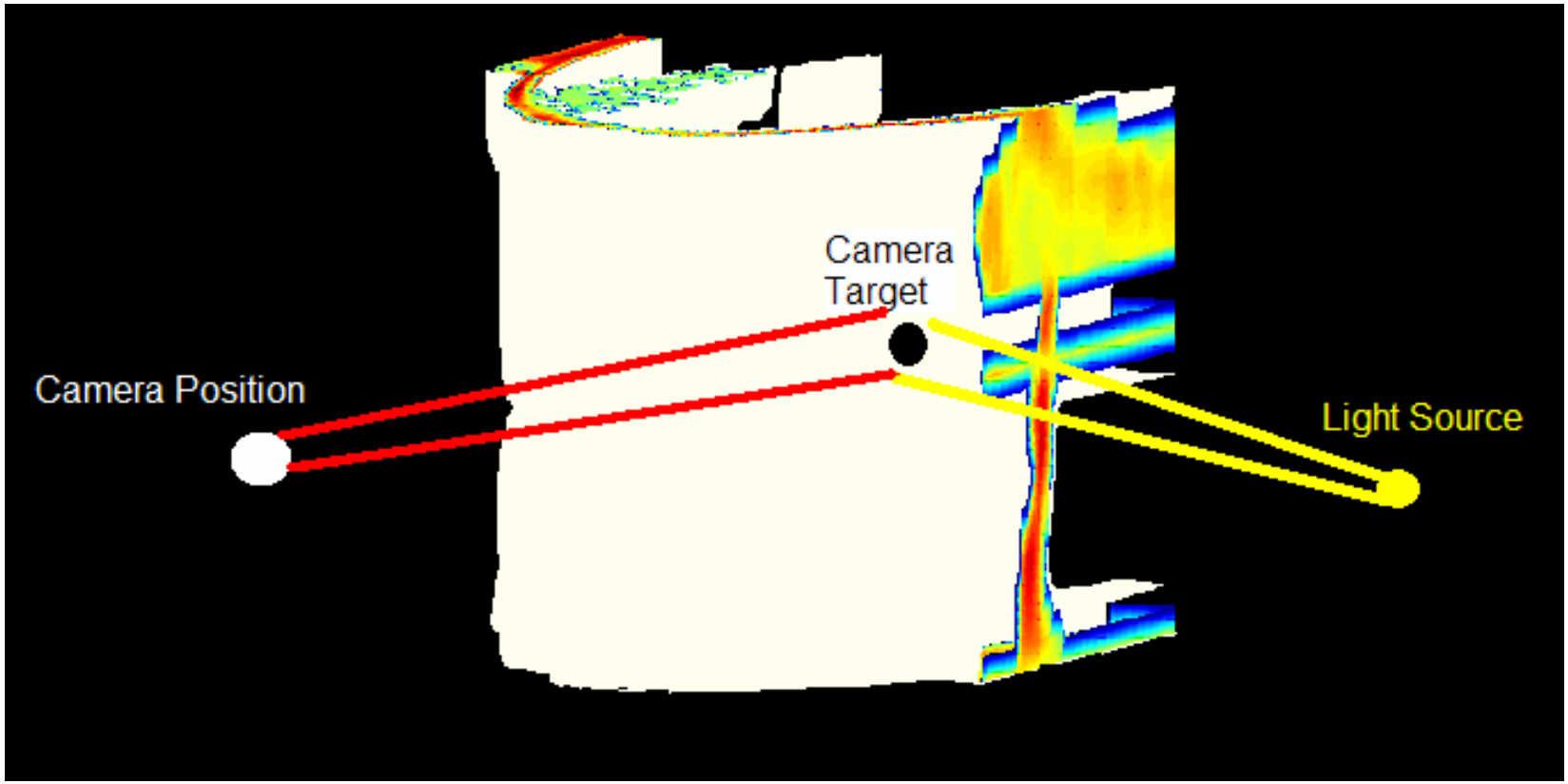


triangles lit identically

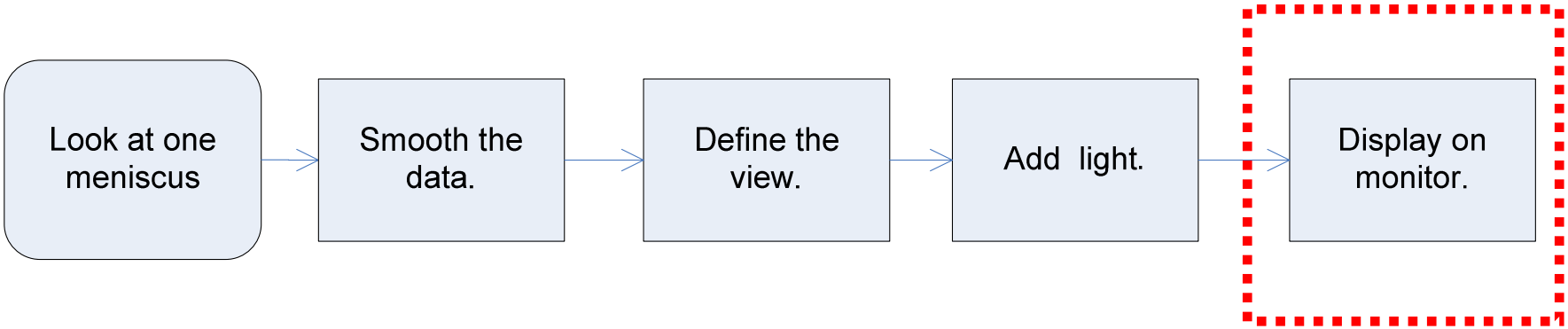


vertex normals used to light each vertex of triangles individually

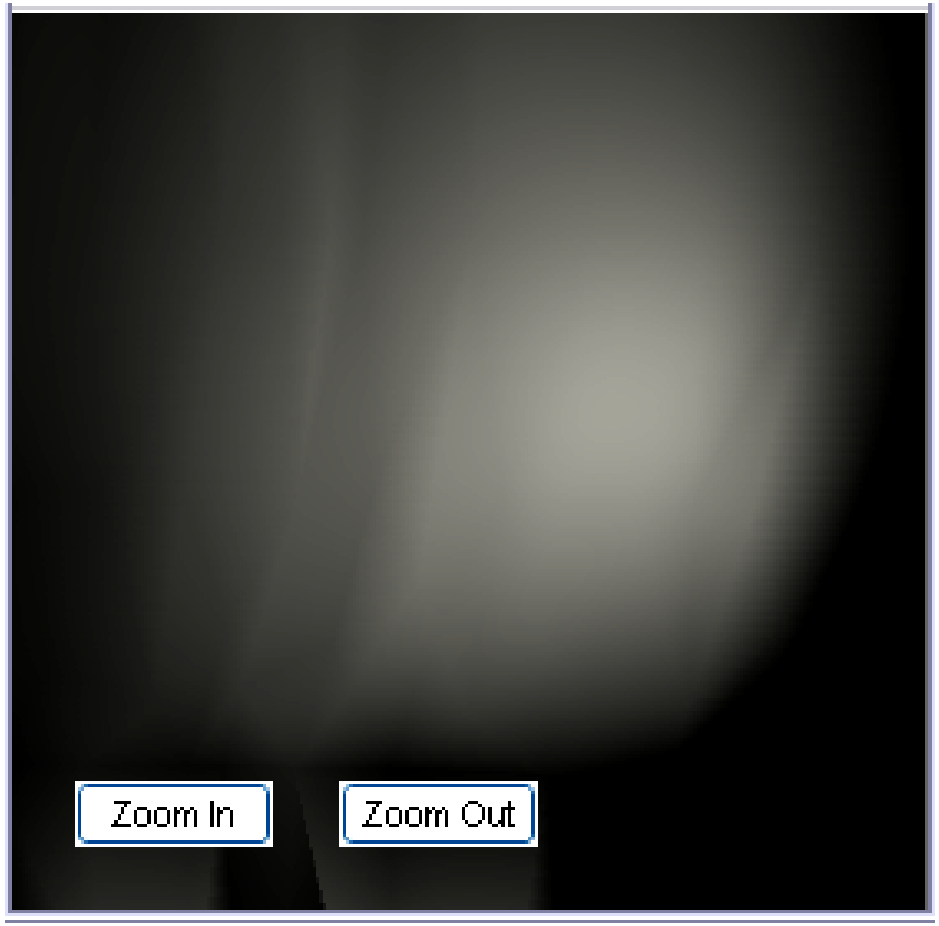
Cartilage Model with Light and Camera Position Set



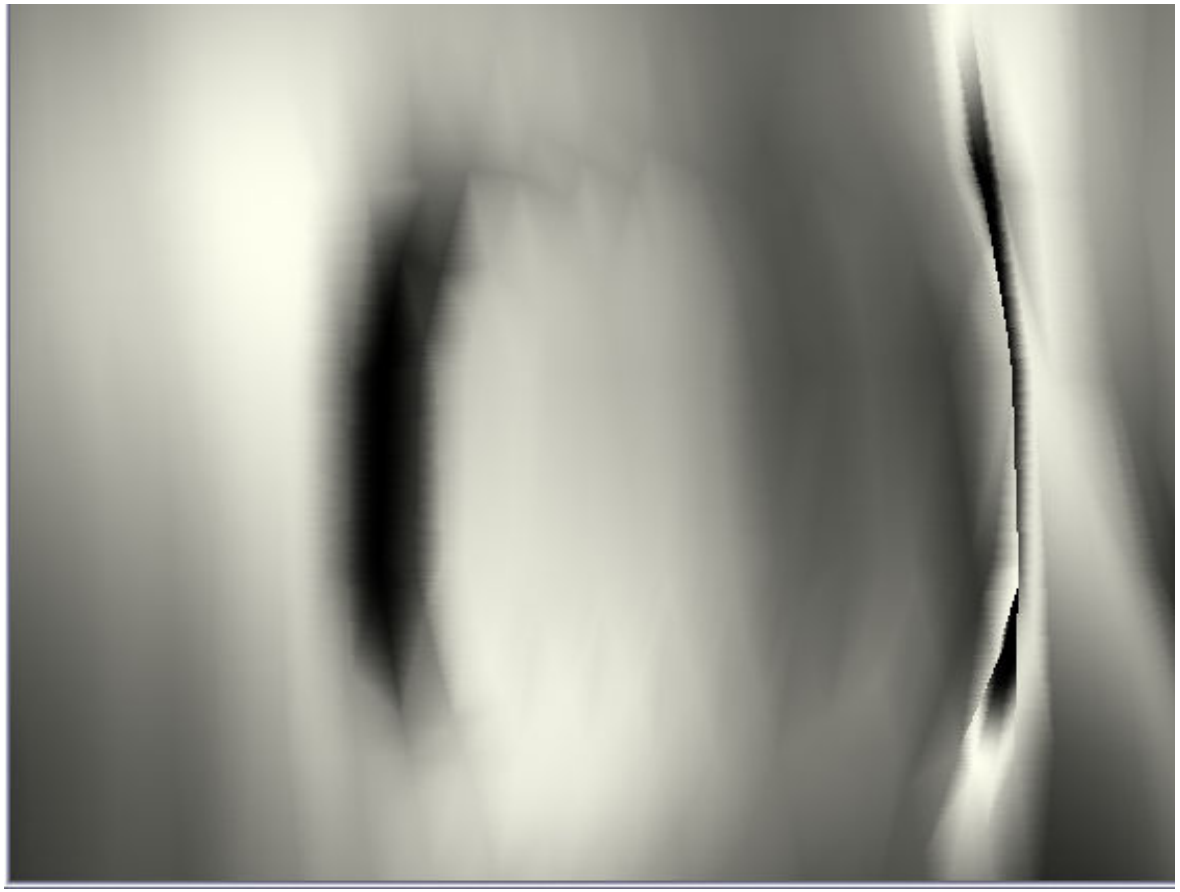
Graphics Block Diagram



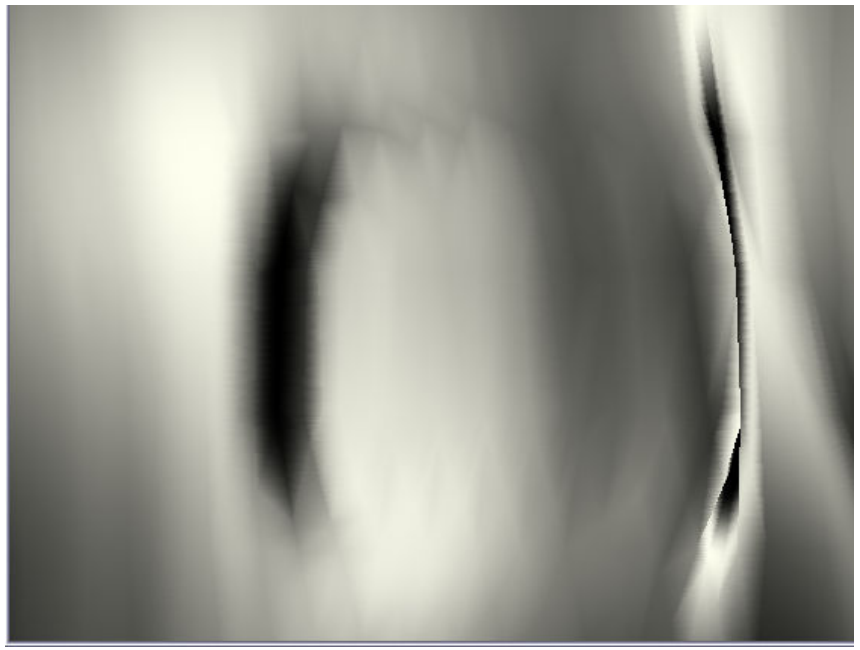
Model of Healthy Cartilage



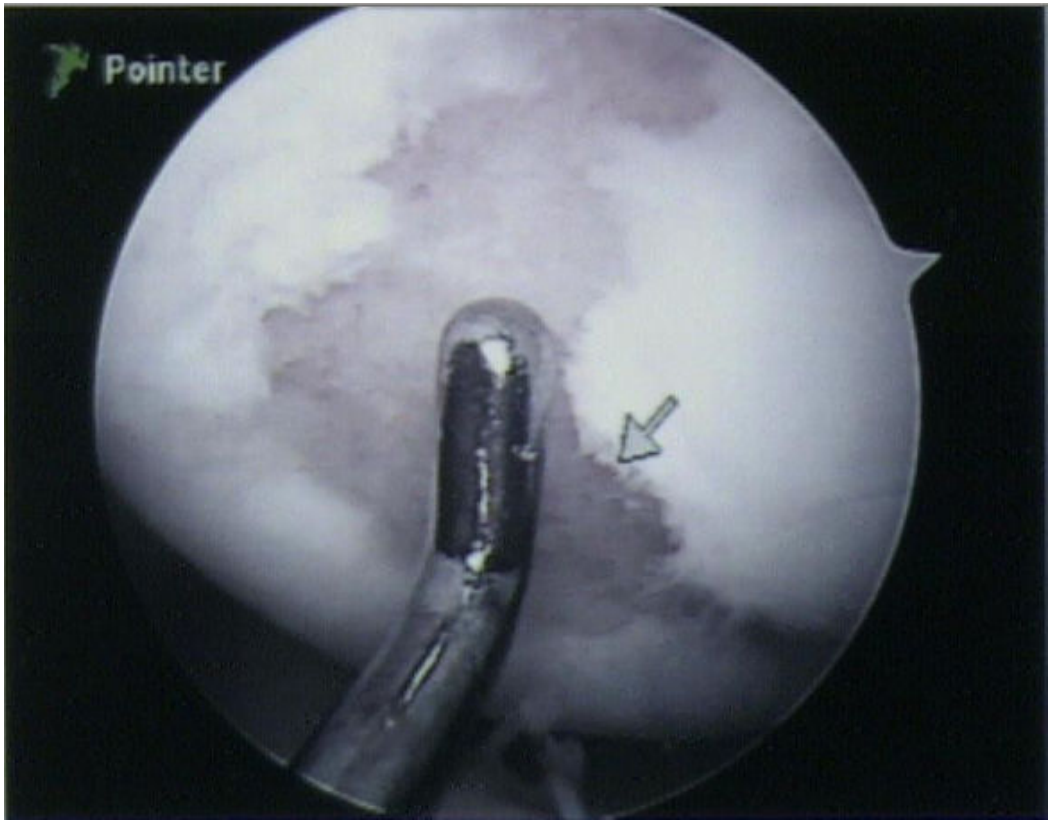
Model of Torn Cartilage



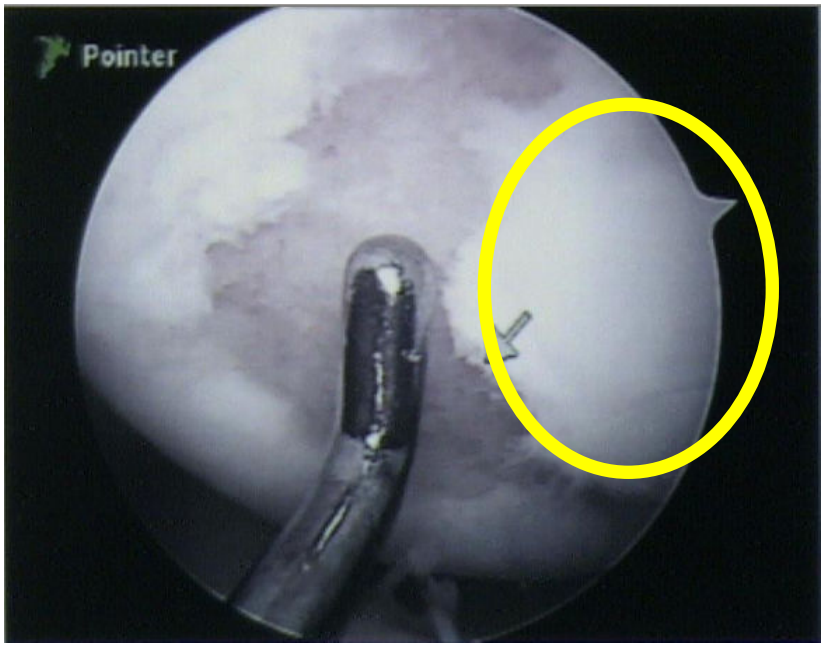
Comparison of Raw Model vs. Final Model

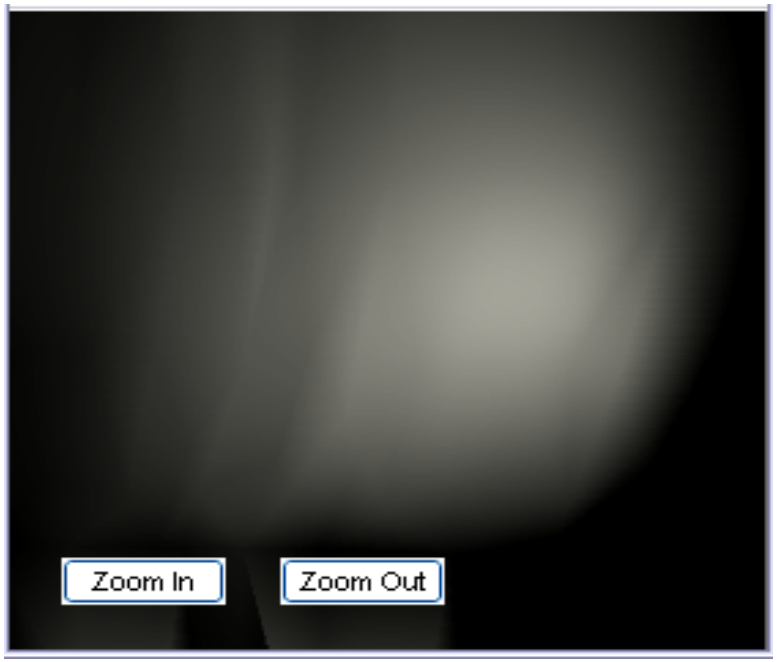


Actual Views of Arthroscopic Knee Surgery

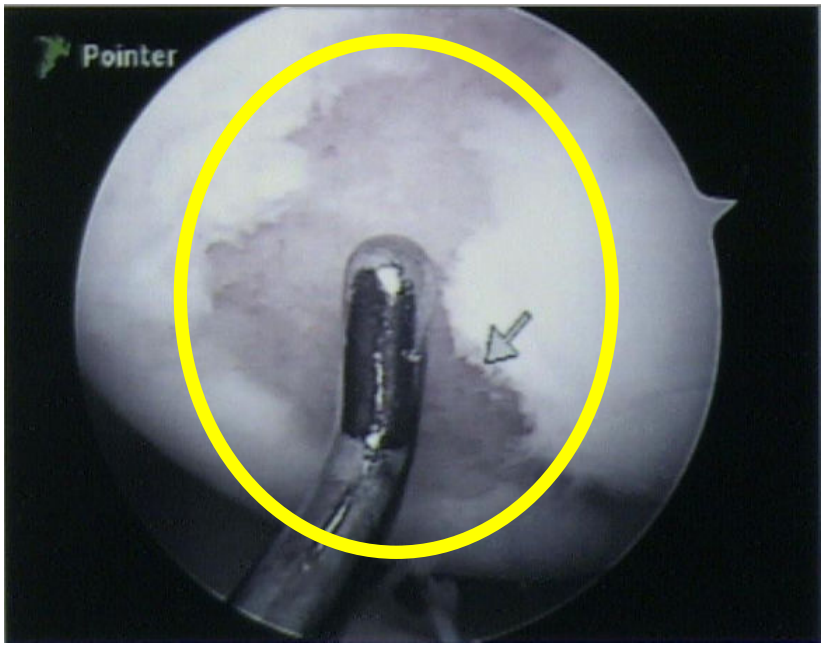


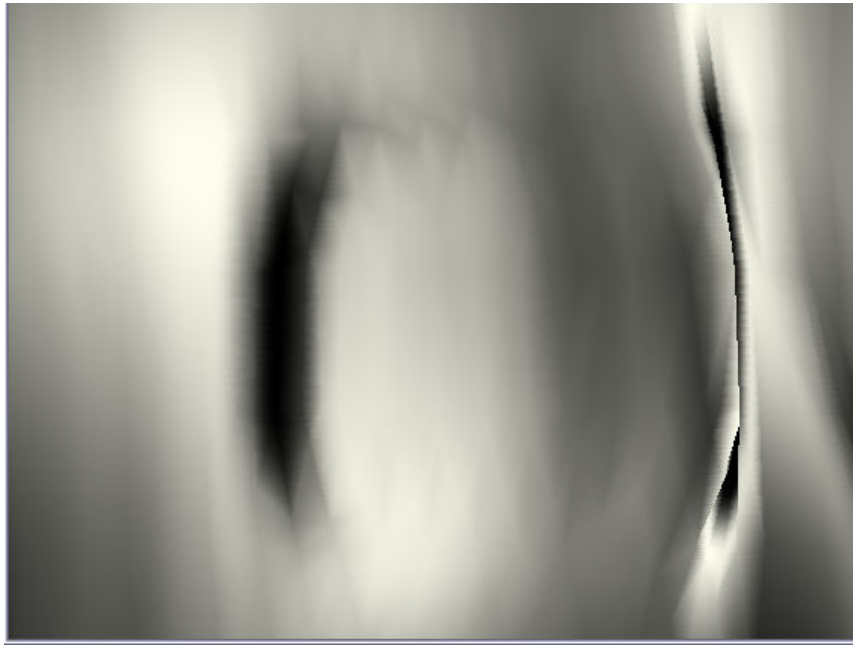
Comparison of Actual vs. Healthy Cartilage Model



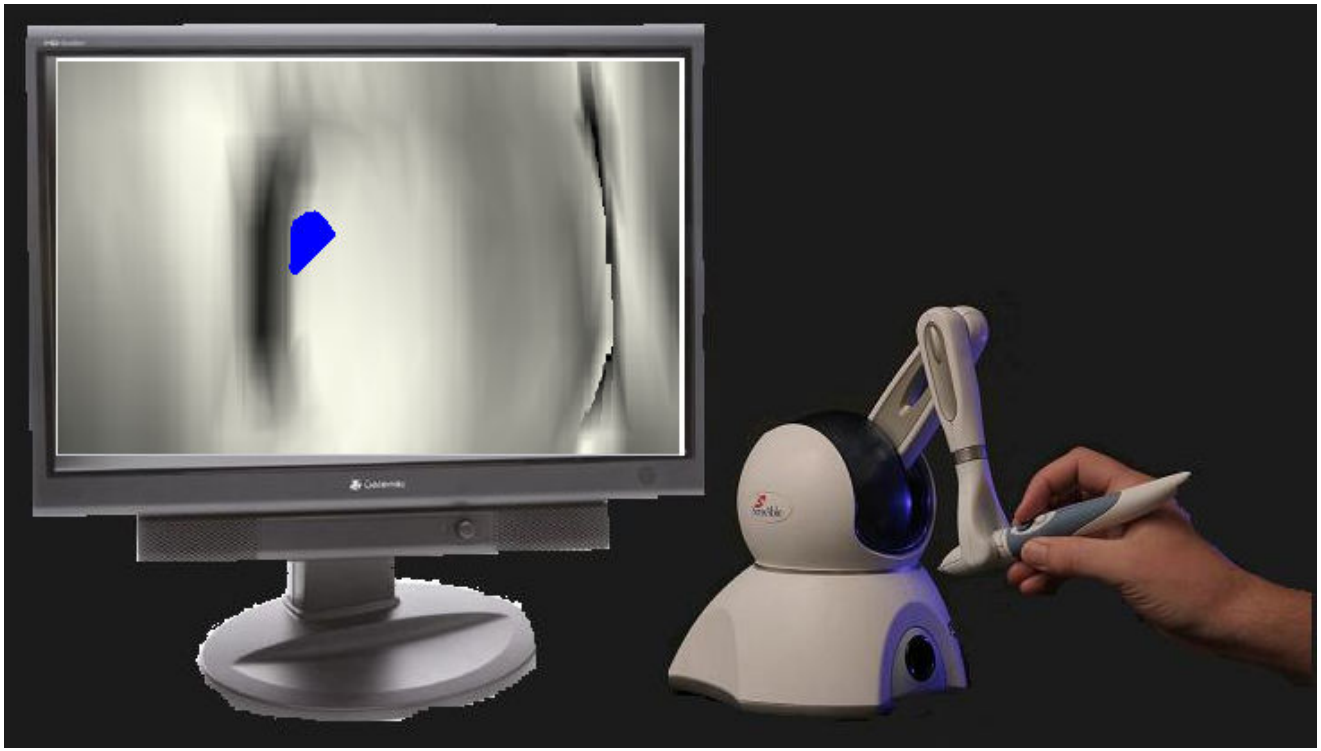


Comparison of Actual vs. Torn Cartilage Model





Future Work



- Medical Simulator for Arthroscopic Knee Surgery
- Implement the view from Matlab with the Haptic Feedback System

Project Summary

- Introduction
- System Block Diagrams
- Software Block Diagrams
- Models of Arthroscopic Surgery Views
- Future Work
- Questions

Questions?

View Femur Matlab Code

```
clc
clear
load('seg_img_femur_knee1','-mat');
newcut=squeeze(cimg6);
clear cimg4
clear cimg5
y=smooth3(newcut);
Ds = smooth3(newcut,'box',[7 7 7]);
Ds(51:62,20:40,12:15)=y(51:62,20:40,12:15);
Ds=smooth3(Ds);
figure,
whitebg('k')
```

View Femur Code Continued

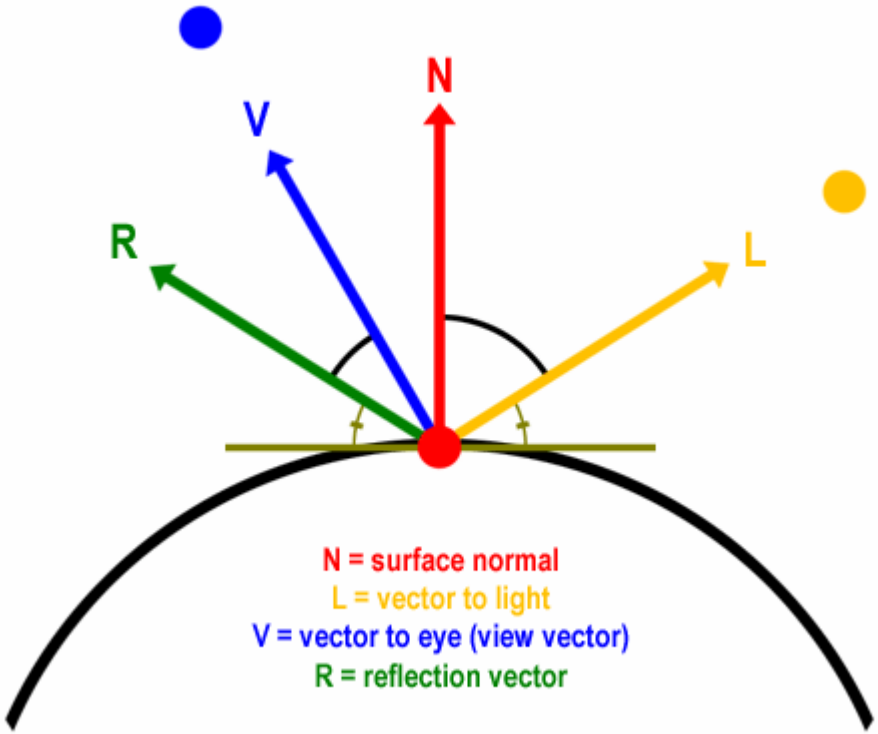
```
hiso = patch(isosurface(Ds,6),...
   'FaceColor',[255/256 255/256
     240/256],...%ivory
  'EdgeColor','none',...
  'AmbientStrength',0,...
  'faceLighting','phong',...
  'SpecularExponent',3,...
  'SpecularStrength',1,...
  'BackfaceLighting','unlit',...
  'DiffuseStrength',0,...
  'SpecularColorReflectance',0);
```

```
reducepatch(hiso, .5)
 lighting phong
isonormals(Ds,hiso);
colormap;
view(45,30)
axis tight
set(gcf,'Renderer',‘zbuffer')
xlabel('x-axis')
ylabel('y-axis')
zlabel('z-axis')
```

View Tear Light Matlab Code

```
light('Position',[30 70 14],'Style','local','Color','w')
camtarget([14 15 14])
campos([3,70,14])
```

Phong's Lighting Equation



The blue dot indicates the camera position, the yellow dot indicates the light source position. The *N* vector represents the surface normal.