

# Conveying Structure

*Maneesh Agrawala*

CS 294-10: Visualization  
Fall 2007

## Final project

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### Design new visualization method

- Pose problem, Implement creative solution

### Deliverables

- Implementation of solution
- 8-12 page paper in format of conference paper submission
- 2 design discussion presentations

### Schedule

- Project proposal: 10/24
- Initial problem presentation: 10/24, 10/29 or 10/31
- Midpoint design discussion: 11/19, 11/21 or 11/26
- Final paper and presentation: To be determined

### Grading

- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

11/19

Wesley  
Robert

11/21

Robin  
Mark  
Jimmy Andrews  
Amanda

11/26

Jerry and Jimmy  
Ken-ichi Andrew and Nate  
David Purdy and Daisy Wang  
Jonathan  
Kenghao

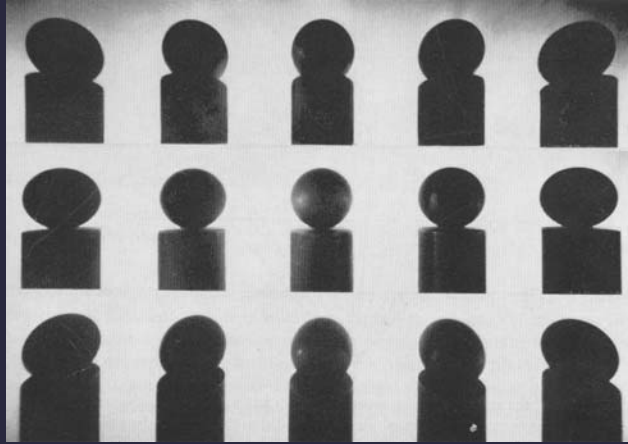
**Using Space Effectively: 3D**

## Perspective distortion

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Wide angle projection

Does not preserve subjective size



## Fish-eye vs. wide angle

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## Multiviewpoint Panoramas

### How to Depict All Buildings on Street?

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## How to Depict All Buildings on Street?

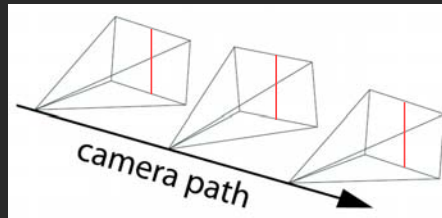
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## How to Depict All Buildings on Street?



Pushbroom panorama [Roman 04]



## A Better Approach



Michael Koller [www.seamlesscity.com](http://www.seamlesscity.com)

## Why is this better?

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Perhaps because local sense of perspective is preserved



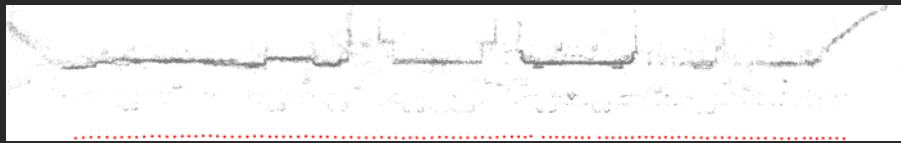
## Input – 107 Hand Held Photographs

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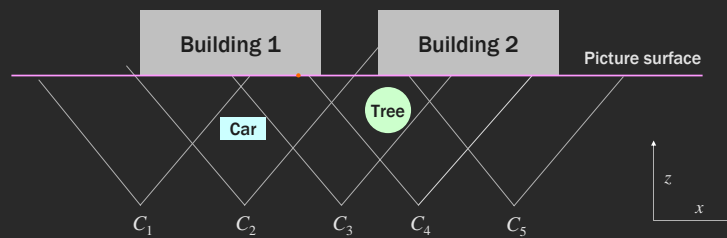


# Approach

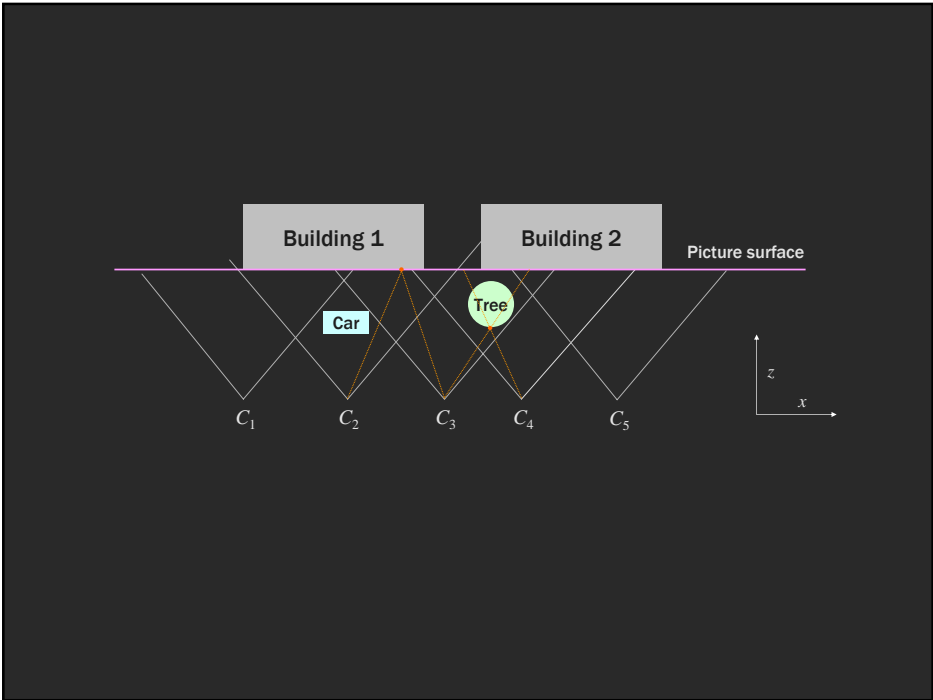
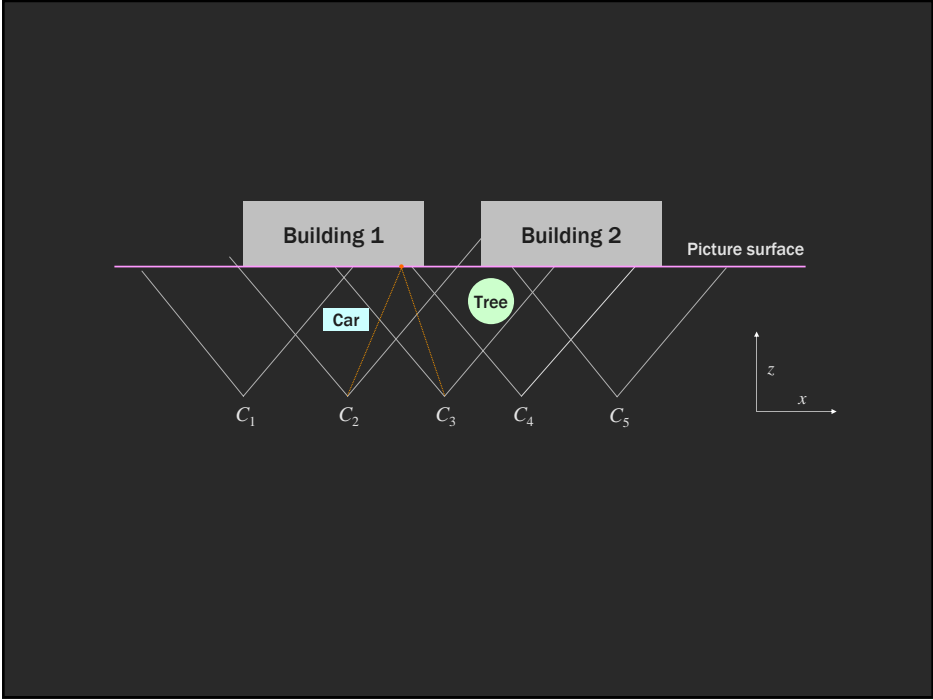
1. Estimate camera pos. & depths of feature pts (SFM)



2. Project images onto user chosen picture plane
3. Use graph cut to “seamlessly” merge images

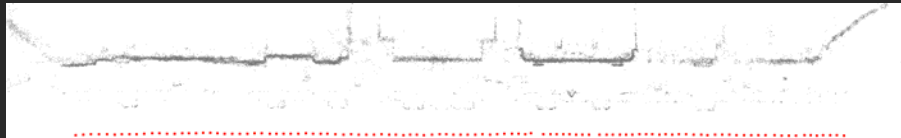






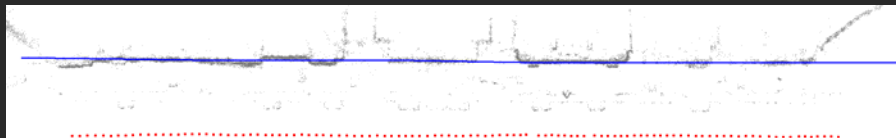
## Structure From Motion

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## User Specifies Picture Plane

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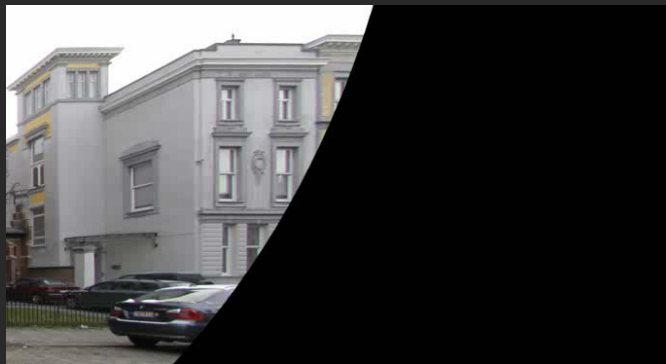
Source photograph



Projected onto picture surface

## Projected Sources

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## Average Projected Sources

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## Apply Graph Cut

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$$C(L) = \sum \text{image objective} + \sum \text{seam objective}$$

## Result

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## A Longer Street

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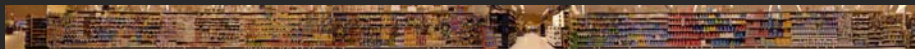
## Grocery store aisle

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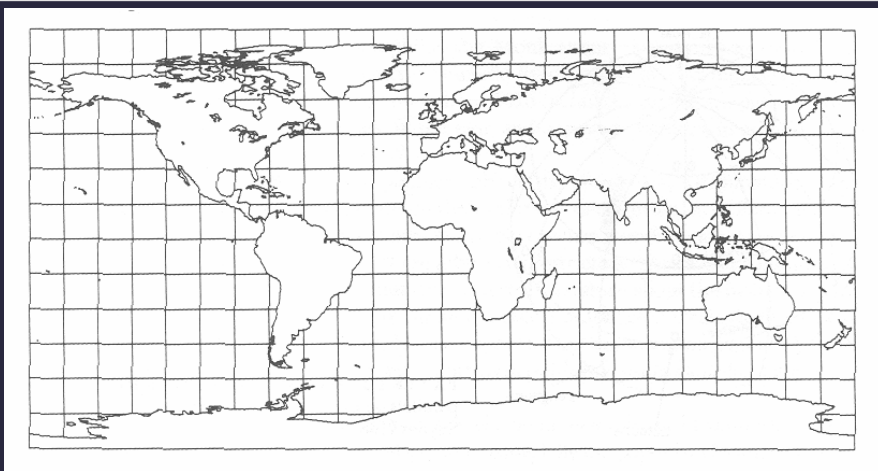
## Grocery store aisle

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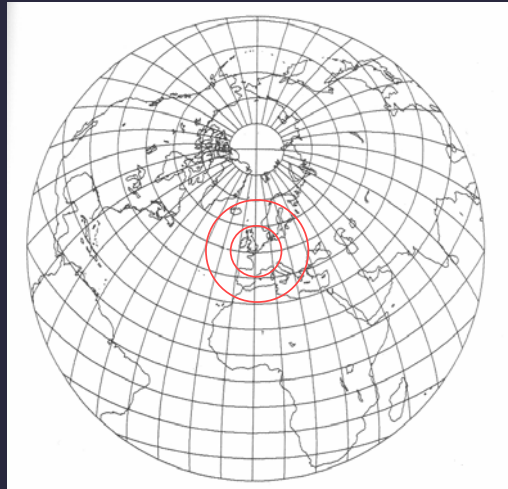
# Cartographic Projections

## Latitude-longitude projection



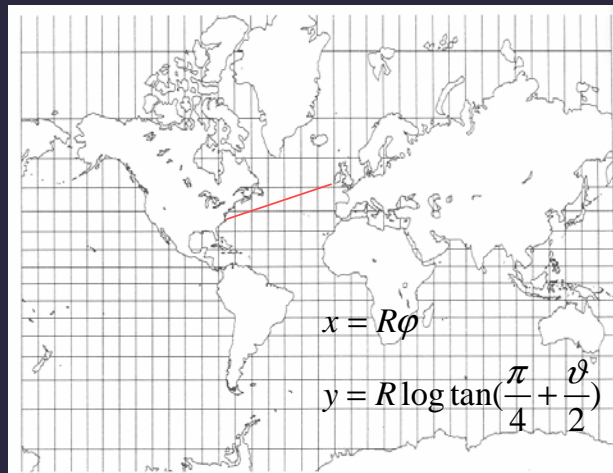
[Figure 1.3, *Flattening the Earth*, Snyder]

## Azimuthal equidistance



[Figure 3.4, *Flattening the Earth*, Snyder]

## Mercator projection (equiangular)

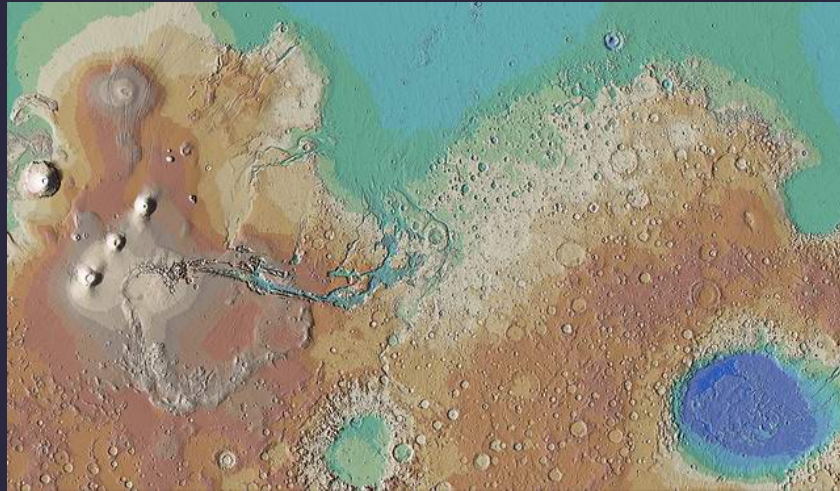


[Figure 1.35, *Flattening the Earth*, Snyder]



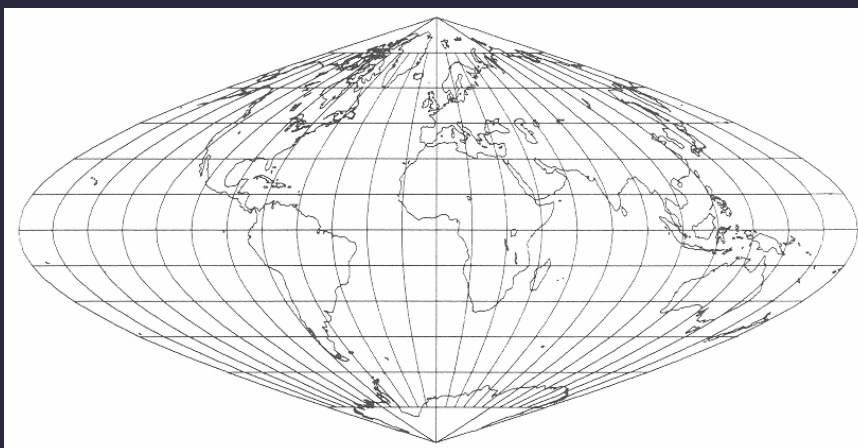
# Mercator projection

Circular craters map to circles



USGS Map of Mars

# Sinusoidal equiareal projection



[Figure 1.39a, *Flattening the Earth*, Snyder]

## Summary

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### **Tension between properties of projections**

- Orthographic projections preserve different properties than perspective projections
- Equiarea implies not equiangular
- Modern projections seek compromise

### **People tolerate distortion -- to an extent**

- Maintain important information
- Avoid extremes

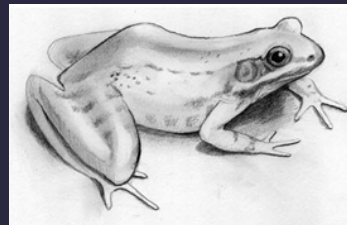
## Conveying Structure

## Complex 3D objects



- Architectural models
- Mechanical assemblies
- Biological specimens
- ...

## Photographs and illustrations



Reveal external shape, do not expose internal structure

## Problem: Occlusion

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### Can't see beyond frontmost surface

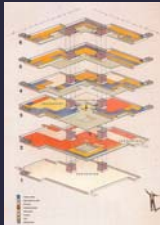
- Fundamental property / limitation of vision

### Exterior surfaces hide internal structure

- Normally we exploit this in computer graphics

## Exploded views, cutaways, ghosting...

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How it's built / How it works / What it does

## **Topics**

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**Framework for conveying structure**

**Choosing good views**

**Layering**

**Cutaways and sections**

**Exploded views**

**Framework**



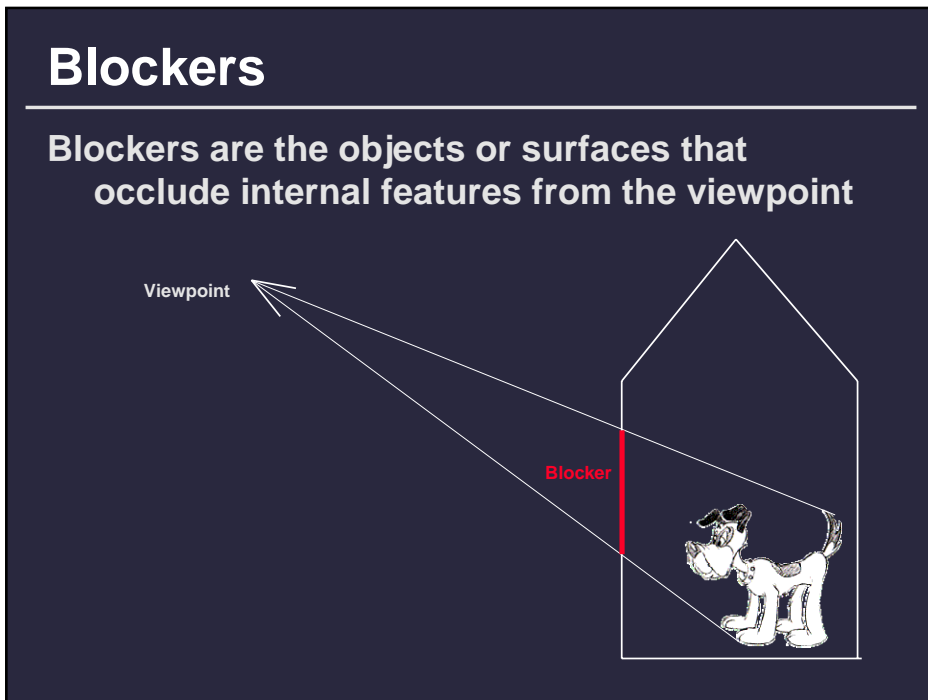
## Viewpoint

Where is observer looking from?



## Blockers

Blockers are the objects or surfaces that occlude internal features from the viewpoint



## **Blocker transformation**

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**Choose transformations that de-emphasizes blockers and emphasizes internal features?**

- Cull
- Move
- Transparency
- Modify drawing style
- Rotate object (or transform viewpoint)

**Visualization should clearly indicate transformation**

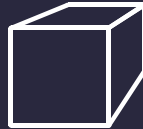
## **Choosing Good Views**



## Generic vs. accidental views

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**Generic:** A view of an object that does not change drastically under small changes in viewpoint



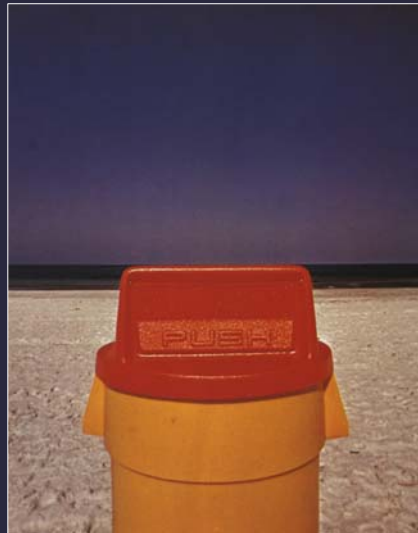
**Accidental:** A special view of an object for which small perturbations in viewpoint drastically change appearance



## Accidental view

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**Alignment of trash  
and sea**



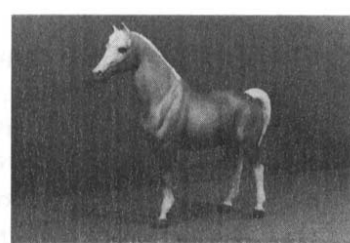
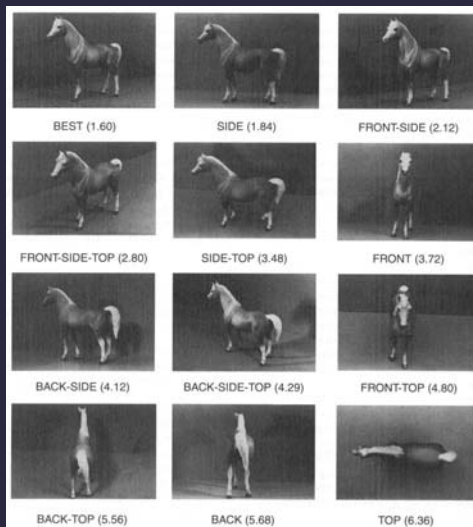
[Turner]

## Generic vs. accidental view



## Which view is best? [Palmer, Rosch, Chase 81]

### Rate views



BEST (1.60)

# Canonical view [Palmer, Rosch, Chase 81]

Features must be salient

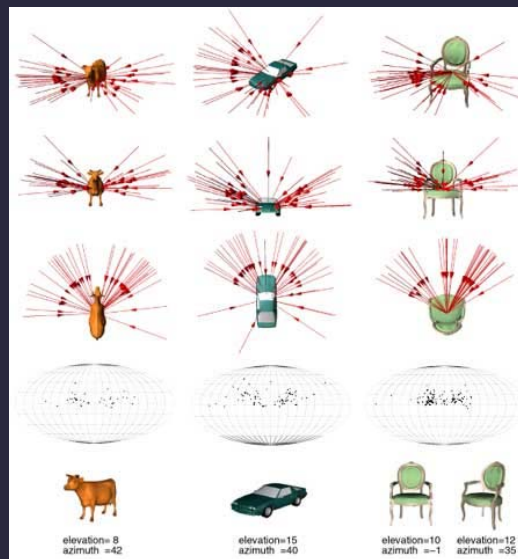
Generic view

Oblique view

- Frontal view from above
- $\frac{3}{4}$  up view



# Canonical Views [Blanz, Tarr Bulthoff 99]



# What is a good view?

## Canonical views

- Oblique views from above
- Avoid accidental views

## In our case – to reveal internal structure

- Separation of internal features in image plane

# Viewpoint transformations



Street level view



Overhead view

## Sometimes a good viewpoint will expose features

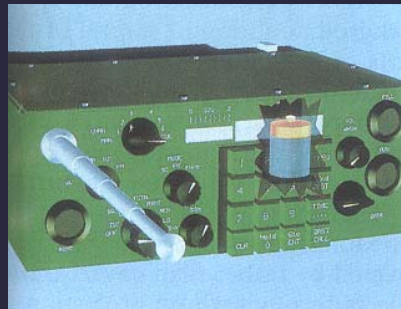
- Street view does not show overall city plan
- Overhead view exposes more of the city plan

# Layering

## Transparency



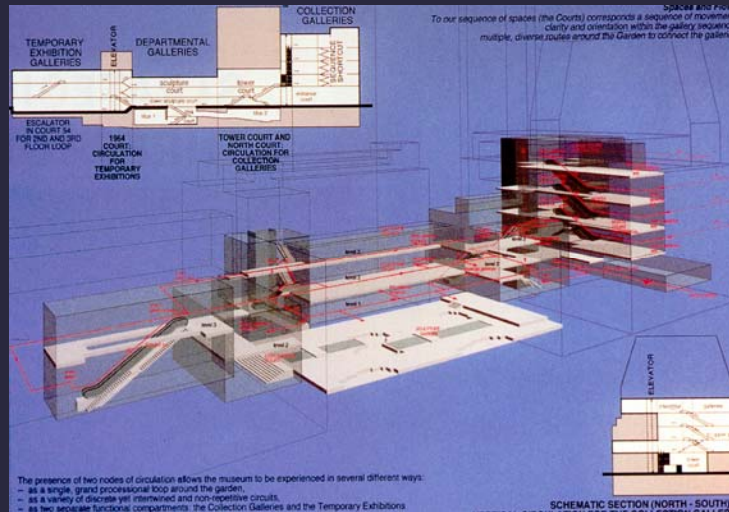
Blocker completely transparent



Blocker semi-transparent

Location of battery in army radio [Feiner & Seligmann 92]

# Transparency



MoMA design entry [Tschumi 99]

# Ghosting

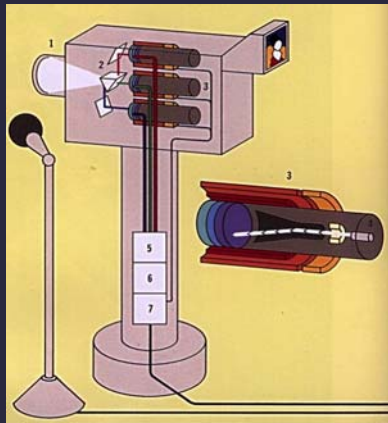


Army radio [Feiner & Seligmann 92]

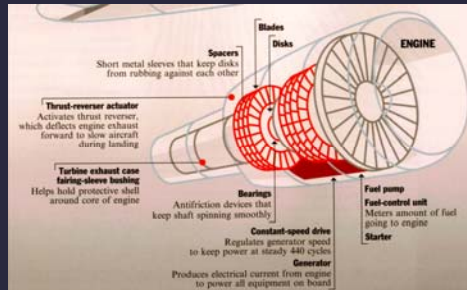


Bus [Thomas [www.jttechart.com](http://www.jttechart.com)]

## Draw blockers as wireframes

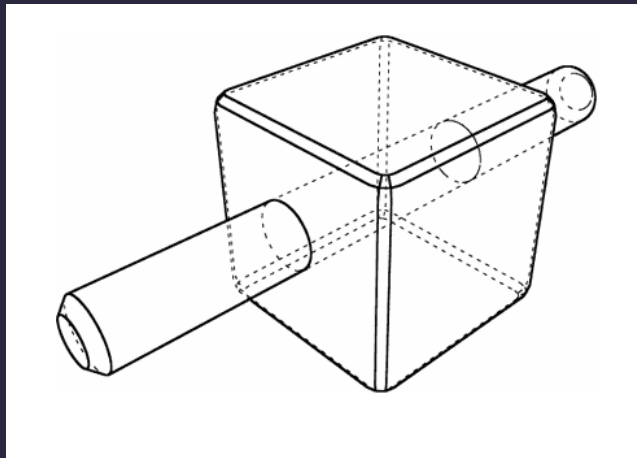


Video camera [from Homes 93]



Airplane engine [from Holmes 93]

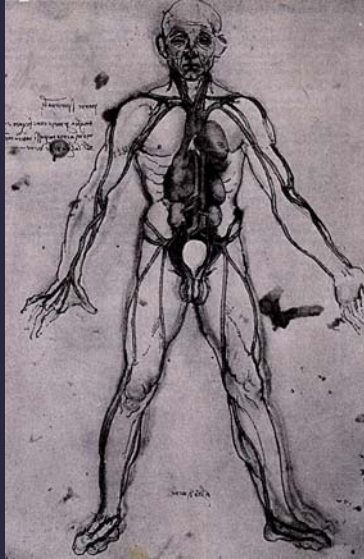
## Dotted lines



Dotted lines expose hidden features

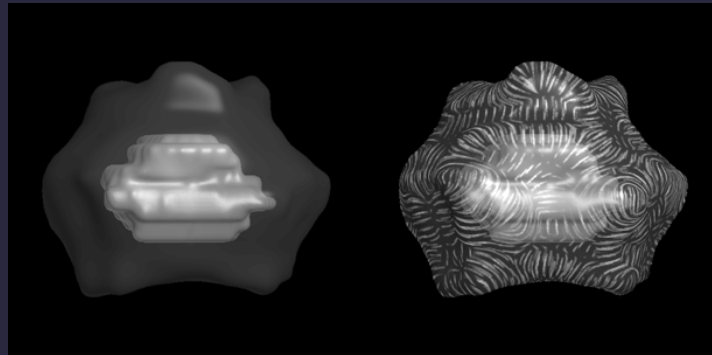
## Leonardo Da Vinci circa 1490

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## Interrante – Siggraph 97

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Blocker surface indicated via thin lines in direction of principal curvature



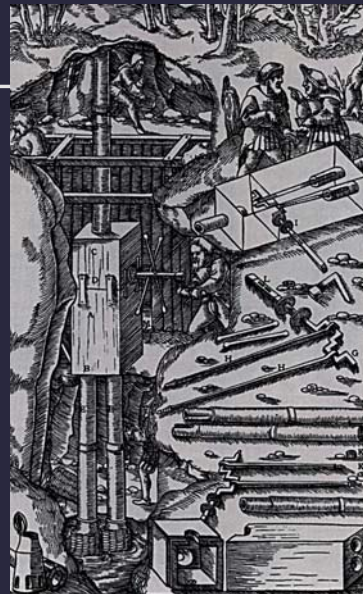
# Cutaways and Sections

## Cutaways

Blockers partially visible

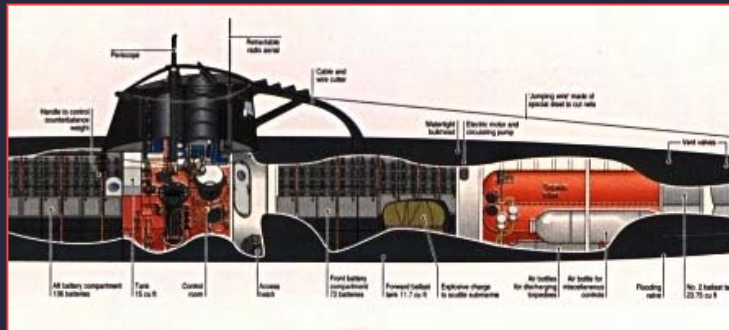
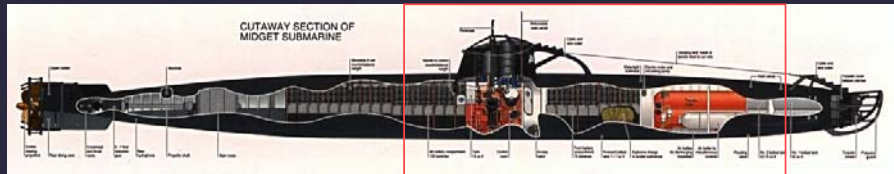
### Edges

- Raggedness emphasizes cut
- Contrast also adds emphasis
- Shape focuses attention
- Spatializes internal stuff



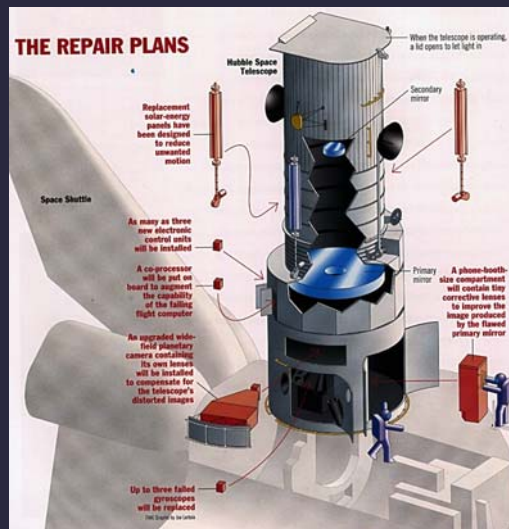
Manually operated reciprocating water pump [Agricola 1556]

# Cutaways: Example



Midget submarine [from Holmes 93]

# Cutaways: Example



Hubble repair [from Holmes 93]

## Sections

### Split along cutting surface

- Usually planar cut
- May not cut all objects in plane

### Orientation

- Principal planes
- Symmetry planes
- Structural elements

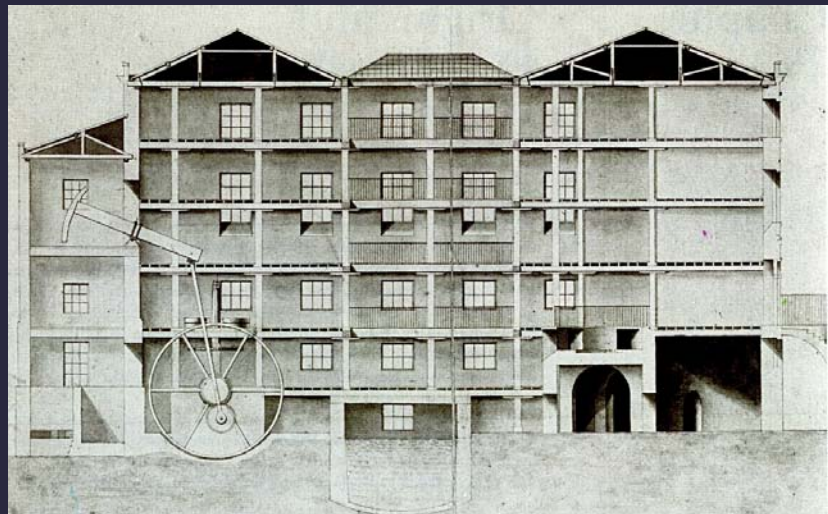
### Convey shape

- Shape of cutting surface
- Auxiliary view showing cut location
- Shape & material of cut volume
- Orthogonal view allows measurement



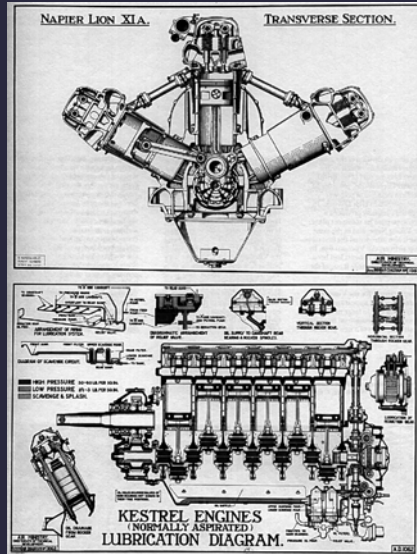
Skulls [Da Vinci ca 1490]

## Architecture



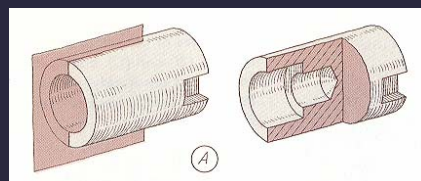
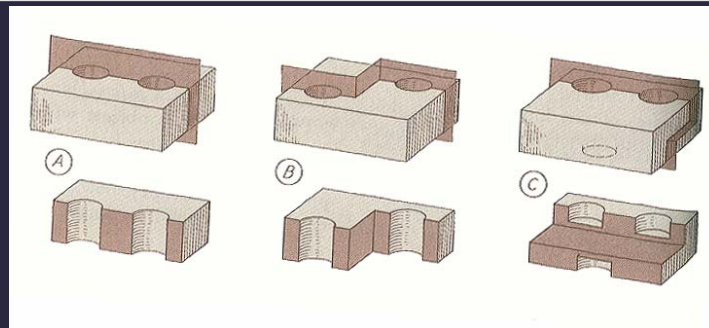
Engine in a large building [Boulton & Watt]

# Technical illustration



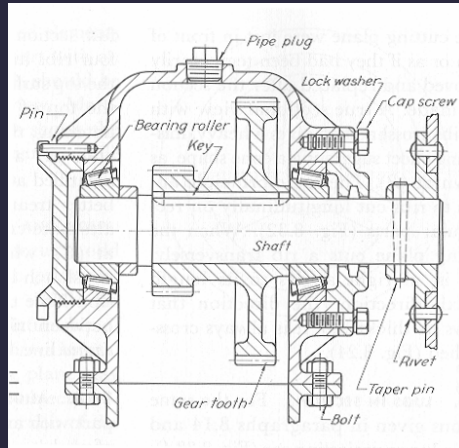
Two sections of engine

# Showing cut location



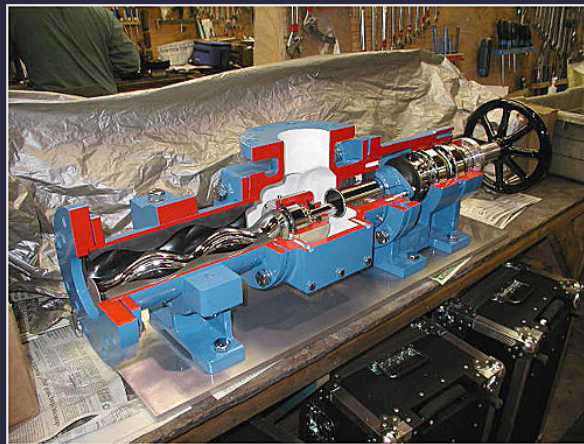
[French & Vierck 60]

## Shape of cutting surface



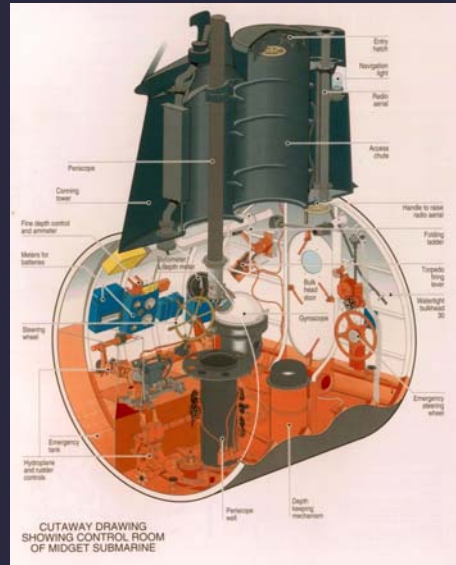
[French & Vierck 60]

## Shape of cutting surface



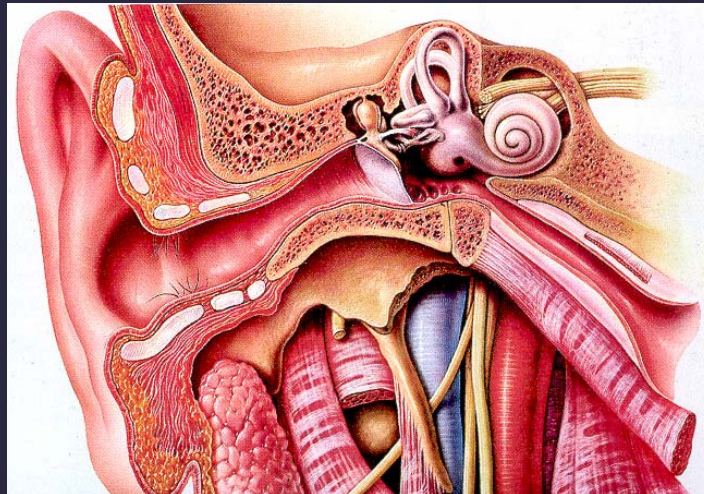
Physical cutaway [CalCo [www.calco cutaways.com](http://www.calco cutaways.com)]

## Shape of blocking surface



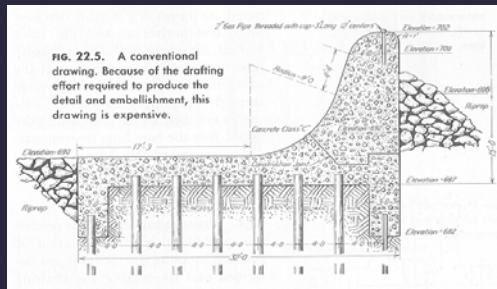
Control room of Midget Submarine  
[from Holmes 93]

## Material of cut volume

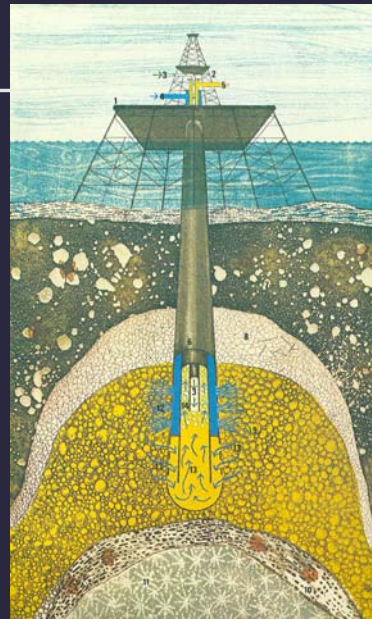


Ear canal [from Mijksenaar 99]

## Material of cut vol.

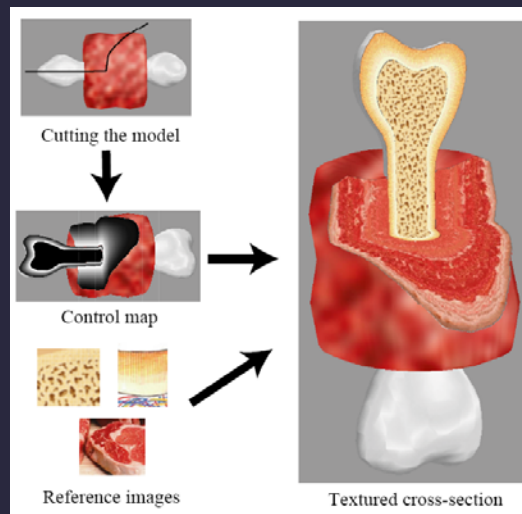


[French and Vierck 60]



Extracting sulphur from deposits [from Herdeg 81]

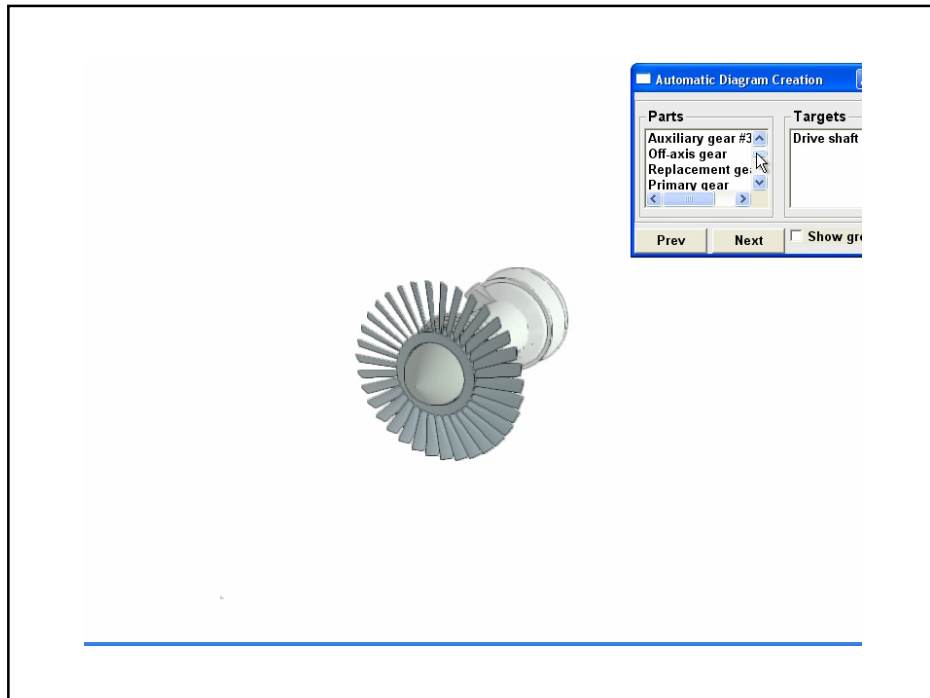
## Synthesizing cut material



Volumetric illustration [Owada 04]

# Interactive Cutaway Illustrations of 3D Objects

Interactive Cutaway Illustrations of Complex 3D Objects. Wilmot Li, Lincoln Ritter, Maneesh Agrawala, Brian Curless and David Salesin. SIGGRAPH 2007.





# Illustration Conventions

## Geometry-based conventions



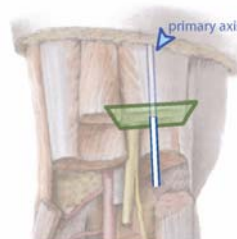
Object-aligned box cut



Window cut

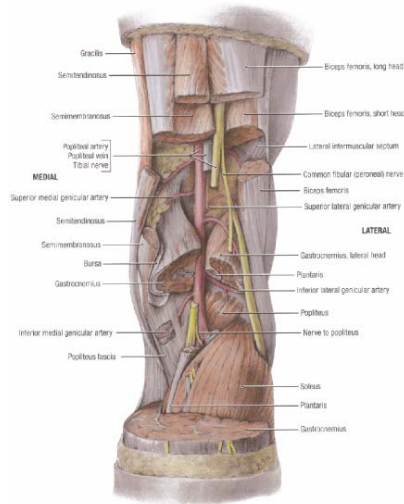


Wedge cut

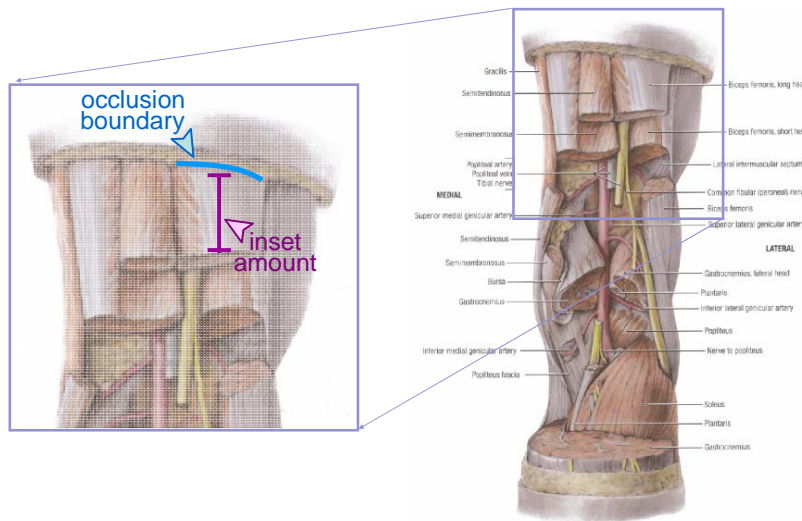


Transverse tube cut

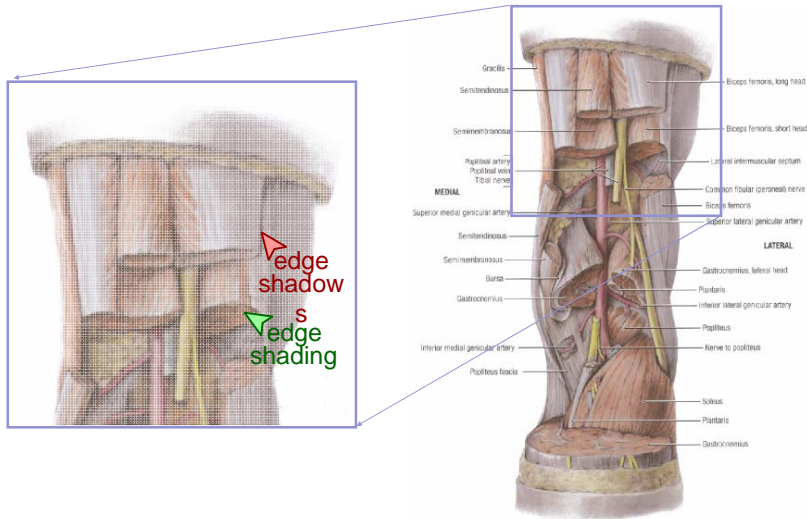
## Viewpoint conventions



## Insetting cuts



## Shading conventions



## Video Demo

