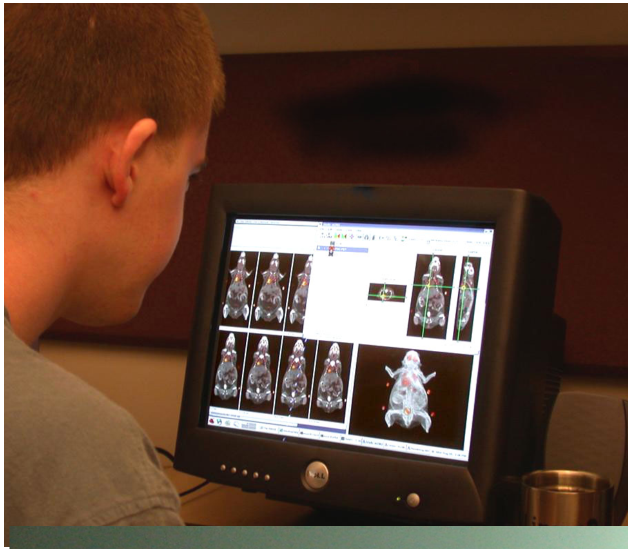
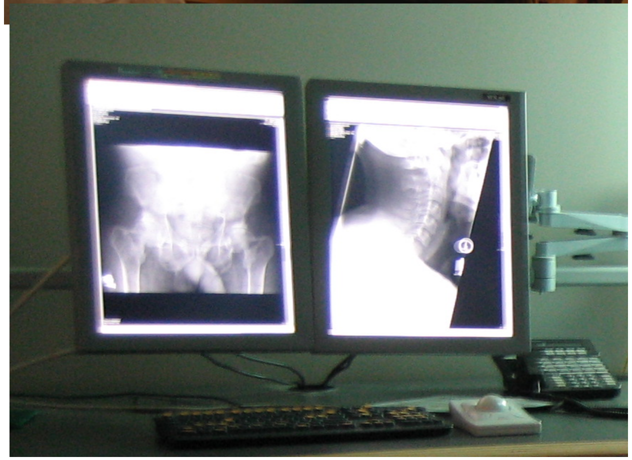
Module #14b:
Large-scale Display Systems

Limitations - Resolution

- Advances in acquisition systems:
  - increased dataset's resolution, scale, complexity
  - made the back-end display technology a crucial informational bottleneck
  - out-paced capabilities of current end-user display systems

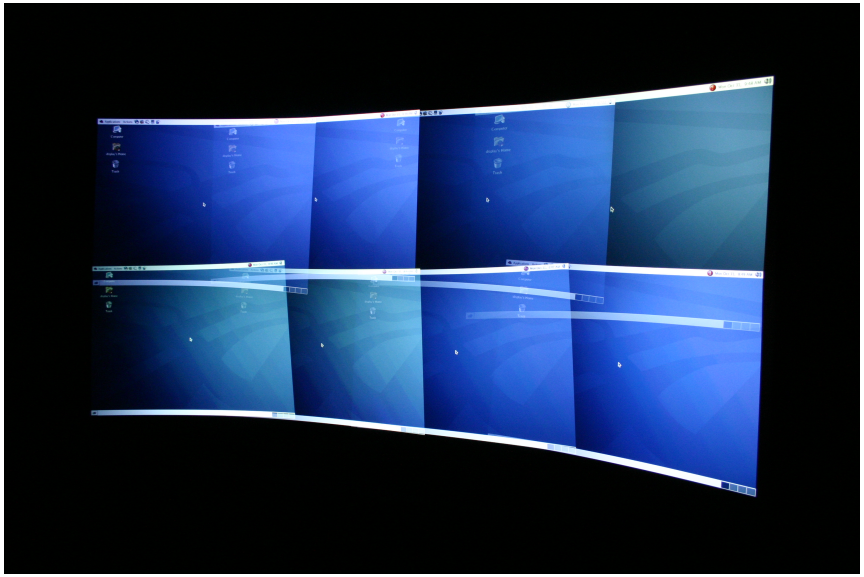




Images from EVL

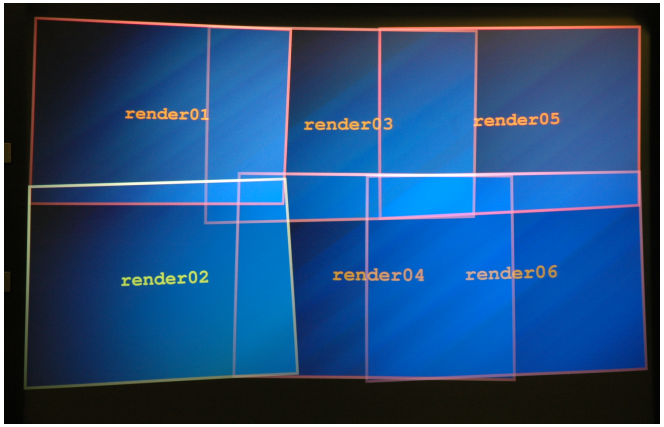
Problems with Sort-First and Multi-Projectors

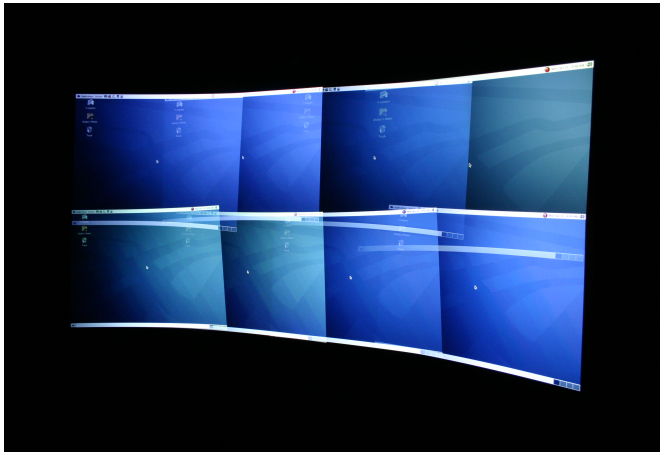
- Aligning the projectors manually is a challenging issue.
- Vibration, weight, and lamp-changing necessitates frequent re-calibration of projectors.
- One may spend hours aligning the system again.



Flexible High-Resolution Display Systems

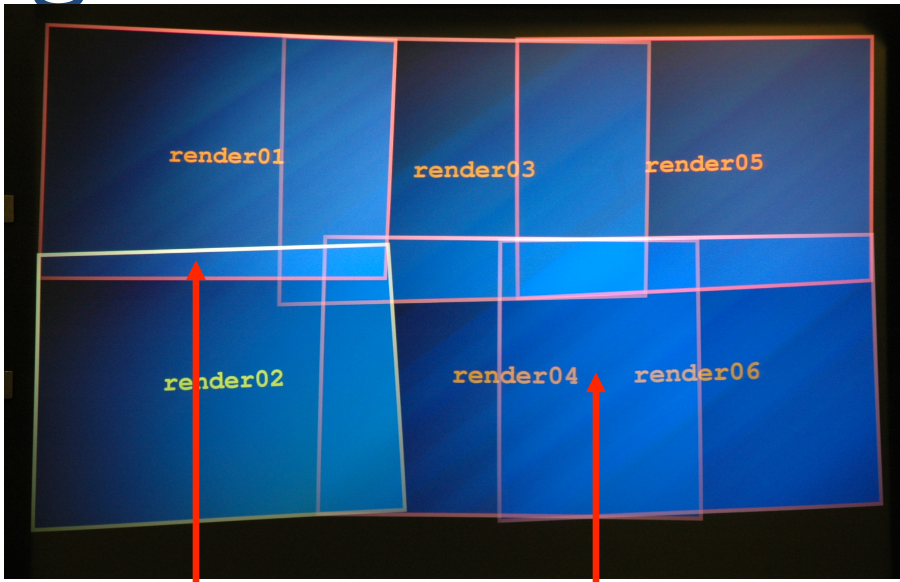
- An array of casually aligned projectors to cooperatively increase overall resolution and brightness
- Projectors are arranged in a tiled configuration
- Images from a set of projectors in their narrowest zoom are combined at a shared projection surface
- Thus increasing the global "pixels per inch" (PPI) of the display environment.
- Flexibility is addressed by
    - scalable deployment
    - cost-effective through a commodity hardware-based design





Challenges

- Two primary challenges:
    1. geometric calibration
    2. photometric calibration



Geometric Problems

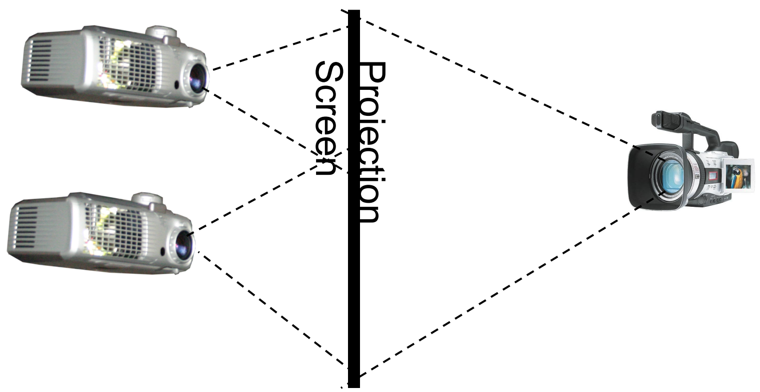
Photometric Problems

Geometric Calibration

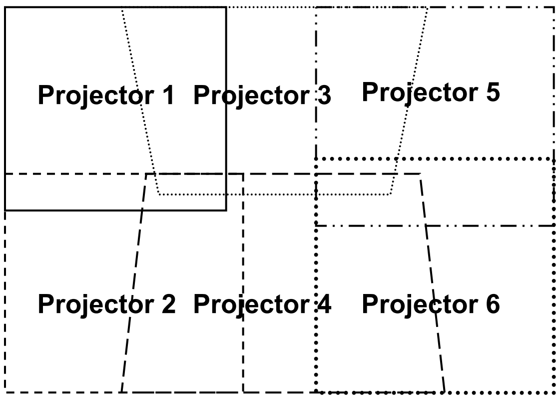
- Alignment
  - Aligning the projectors manually is very challenging.
- Geometrically correct
  - geometric primitives in the displayed imagery appear correct to the viewer
  - Regardless
    - projector positions
    - relative geometry
    - underlying display surface

Approach - Geometric Calibration

- Diagram
  - Six projectors that are casually positioned
  - Using a single camera that can view the whole display, we can calibrate the system to create a seamless display.

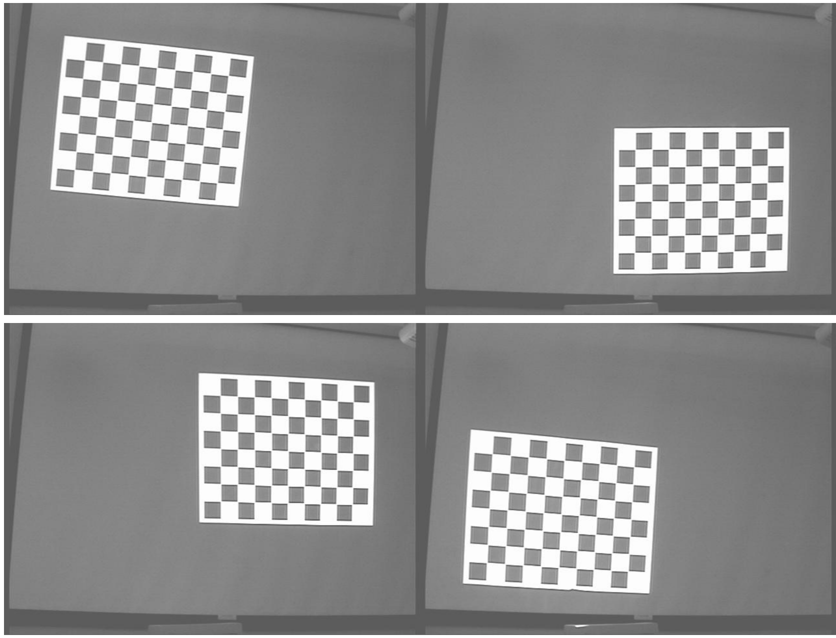


- We have created calibration mechanisms
  - planar surfaces
  - arbitrary surfaces



Geometric Calibration – Planar Surfaces

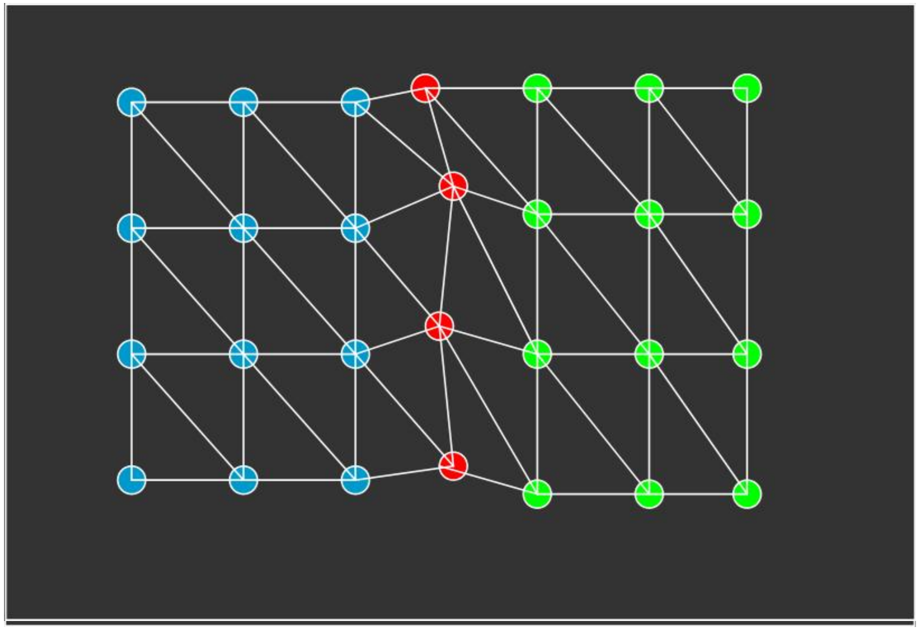
- Planar Calibration:
  - Our planar calibration software is based on the work of Raskar et al.
  - Each projector displays a chessboard calibration pattern
  - Four or more points correspondence are automatically detected
  - Compute the homography matrices between projector image and the camera image plane.
  - The planar calibration and the pixel mapping between uncalibrated projectors problem relies on computing the following homographies
    - camera-to-projector
    - projector-to-projector
    - display-to-projector

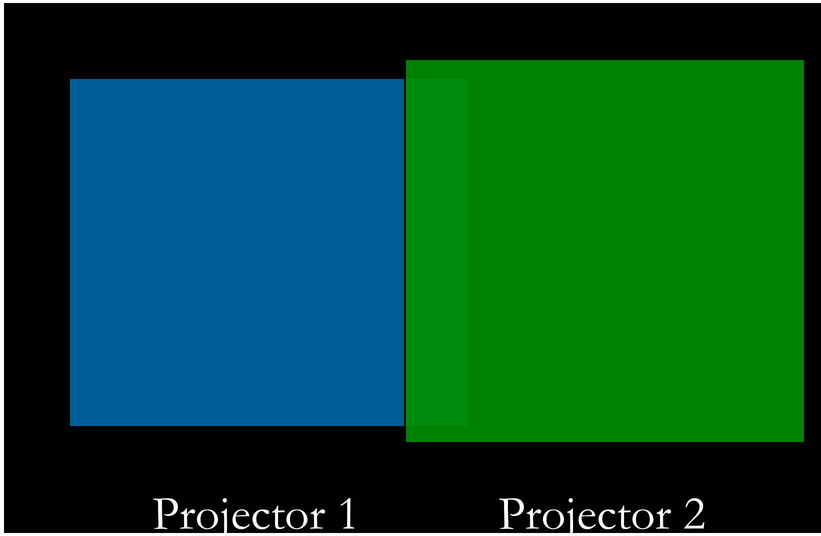


Geometric Calibration – Arbitrary Surfaces

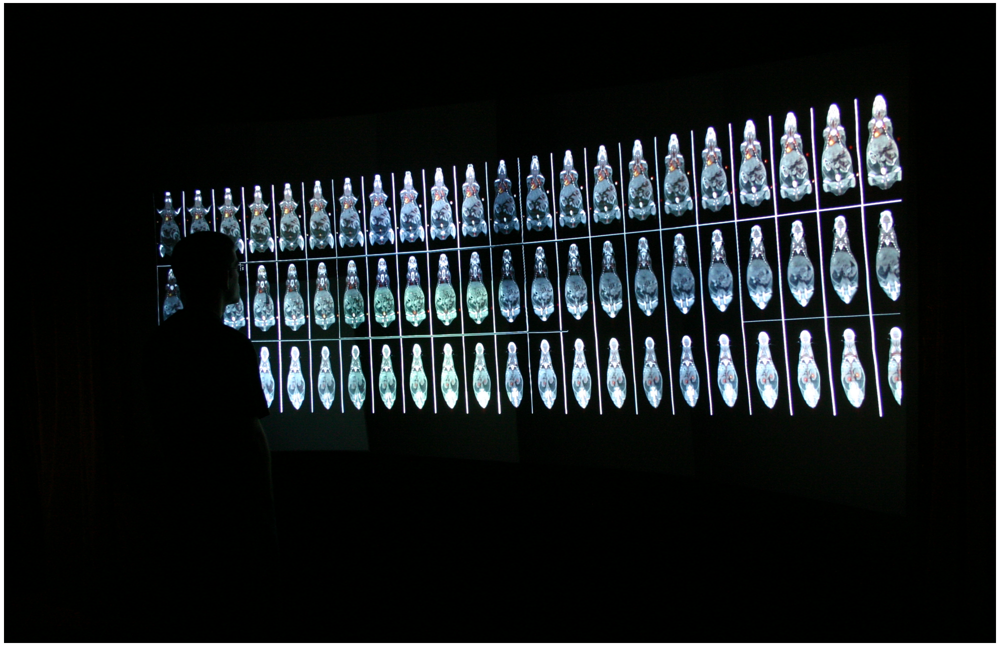
- We cannot assume the display surface are always planar
- Steps:
  - position camera where viewer would be seated
  - project a number of equally spaced fiducials onto the display surface from each projector involved in the system
  - display Gaussian blobs
  - detect fiducials and logically connect them to form a tessellated grid
  - The tessellated mesh is determined at the camera's image plane

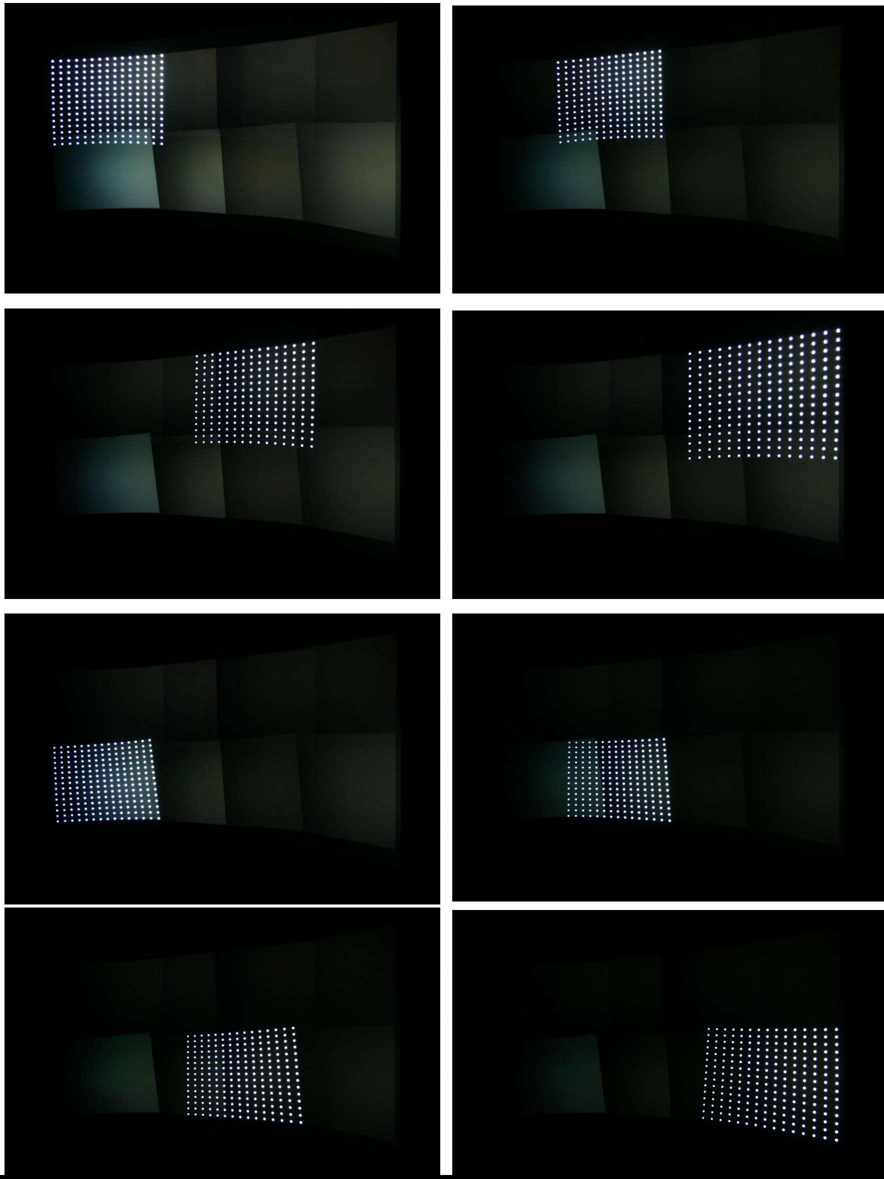
Tessellation





Calibration: Curved Display

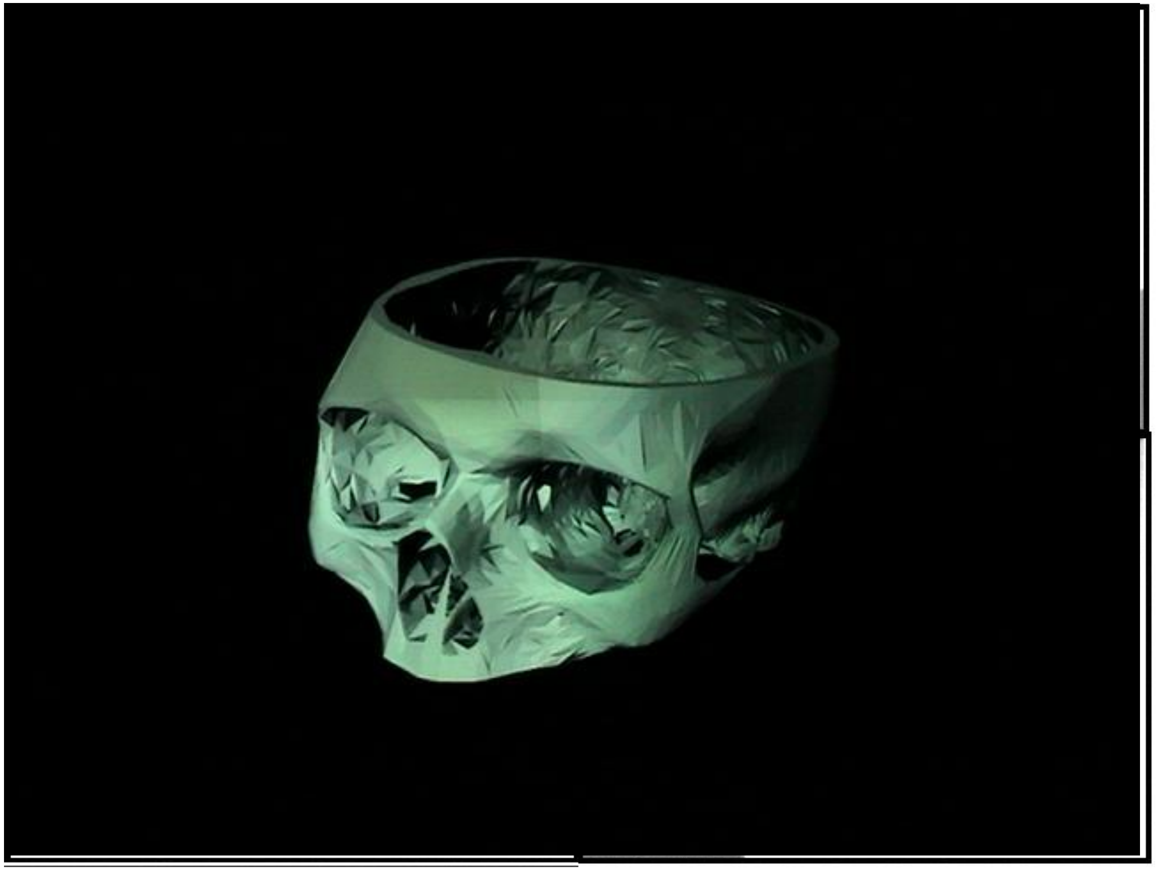




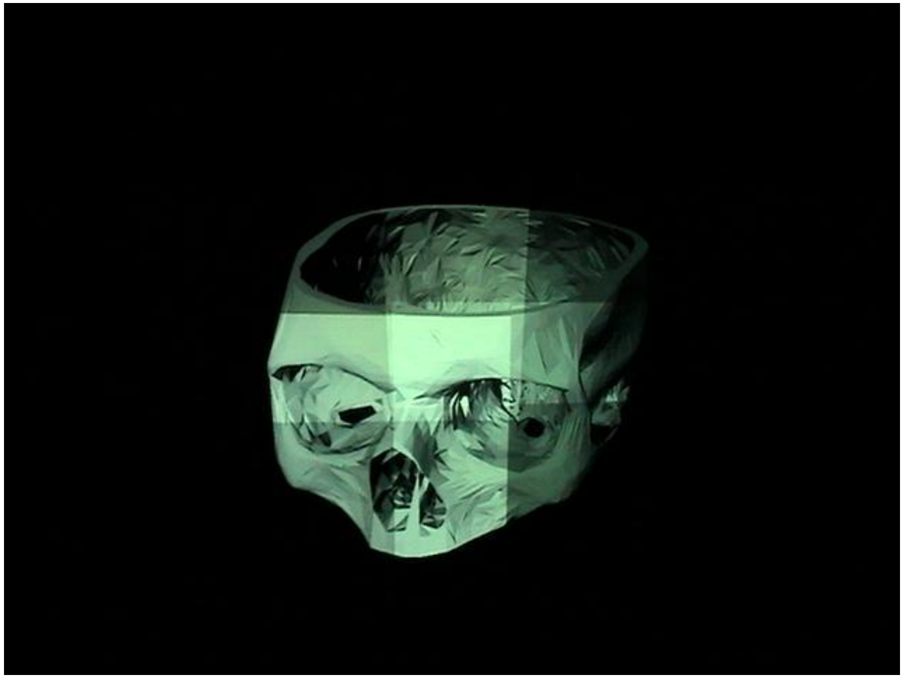
Photometric Calibration

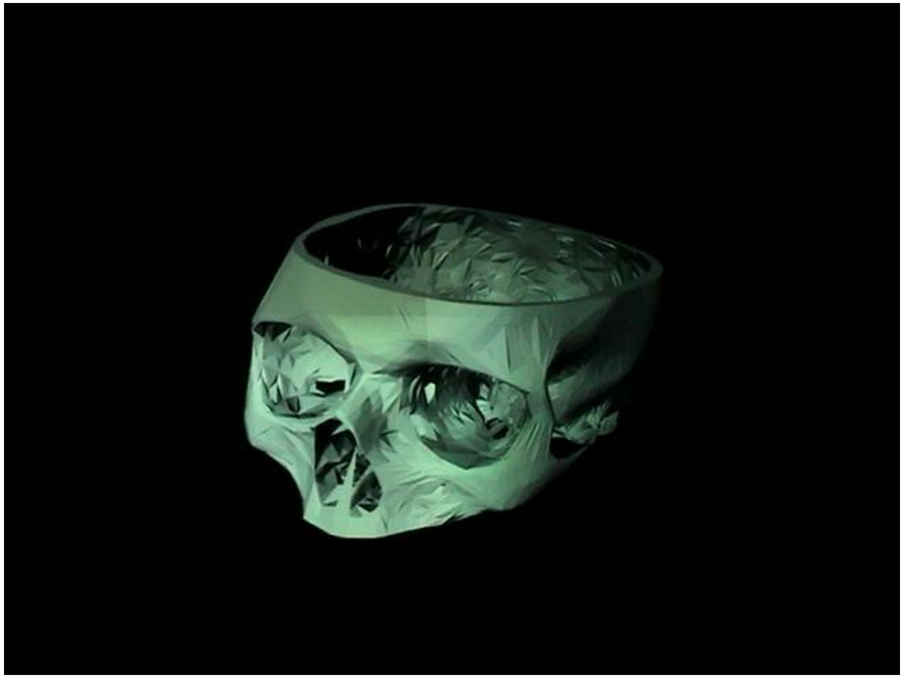
- Problem: areas in the display are noticeably brighter
  - Intensity varies among projectors
  - Overlap regions are multiply-illuminated
- Solution:
  - From the computed projector-to-projector matrices or from the tessellated grid, compute:
    - overlap regions
    - number of projectors that overlay a specific area.
  - By using that information, create an alpha image for each projector to attenuate the brightness of the displayed image

Photometric Calibration

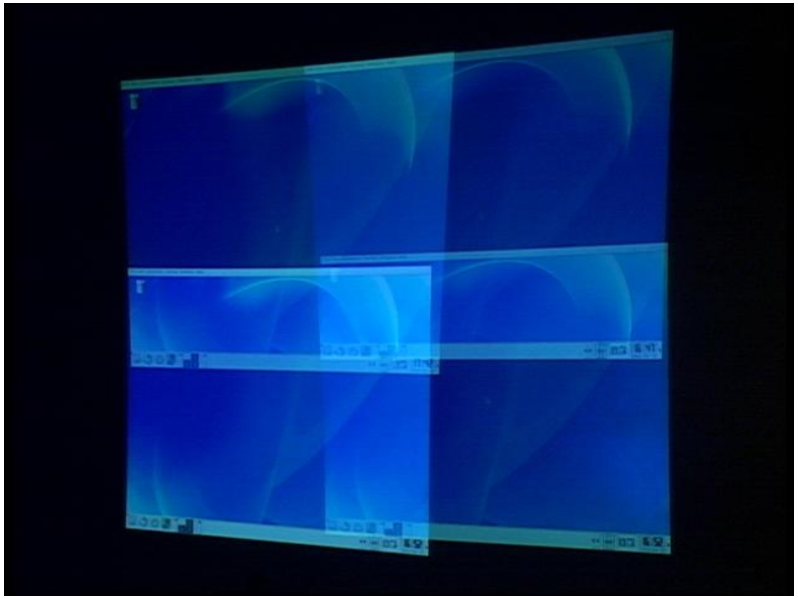


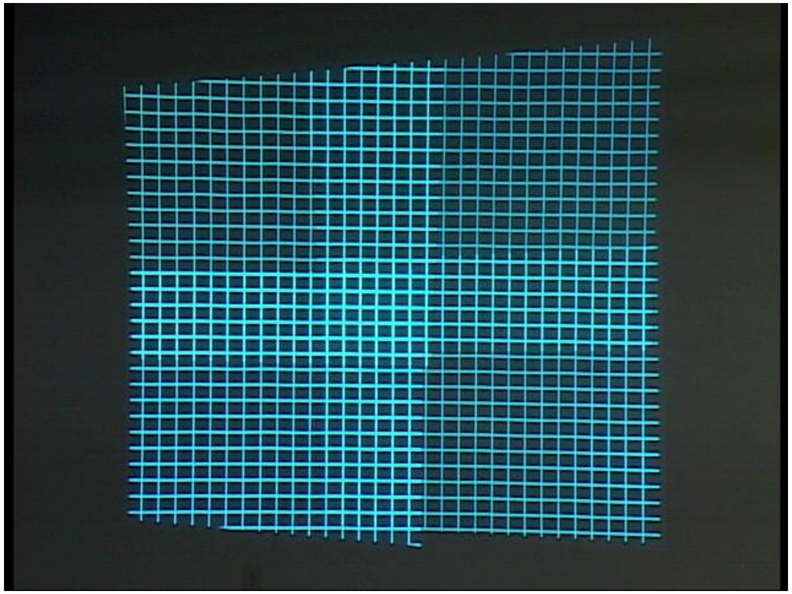
Photometric Calibration

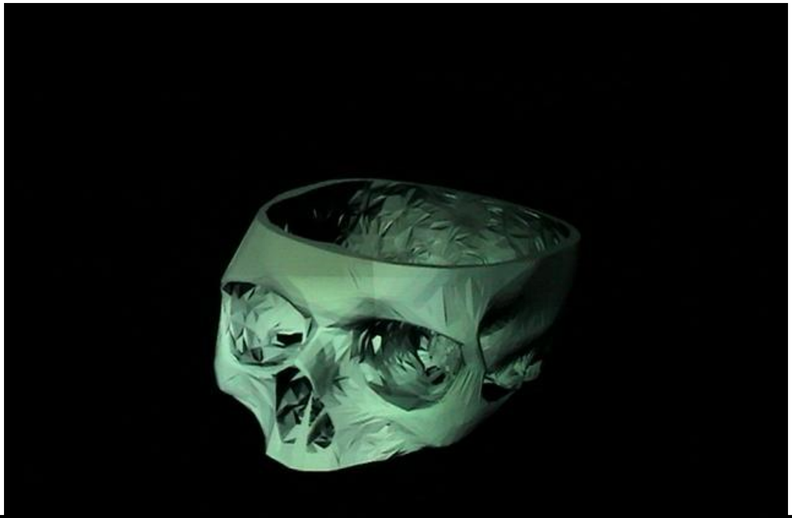




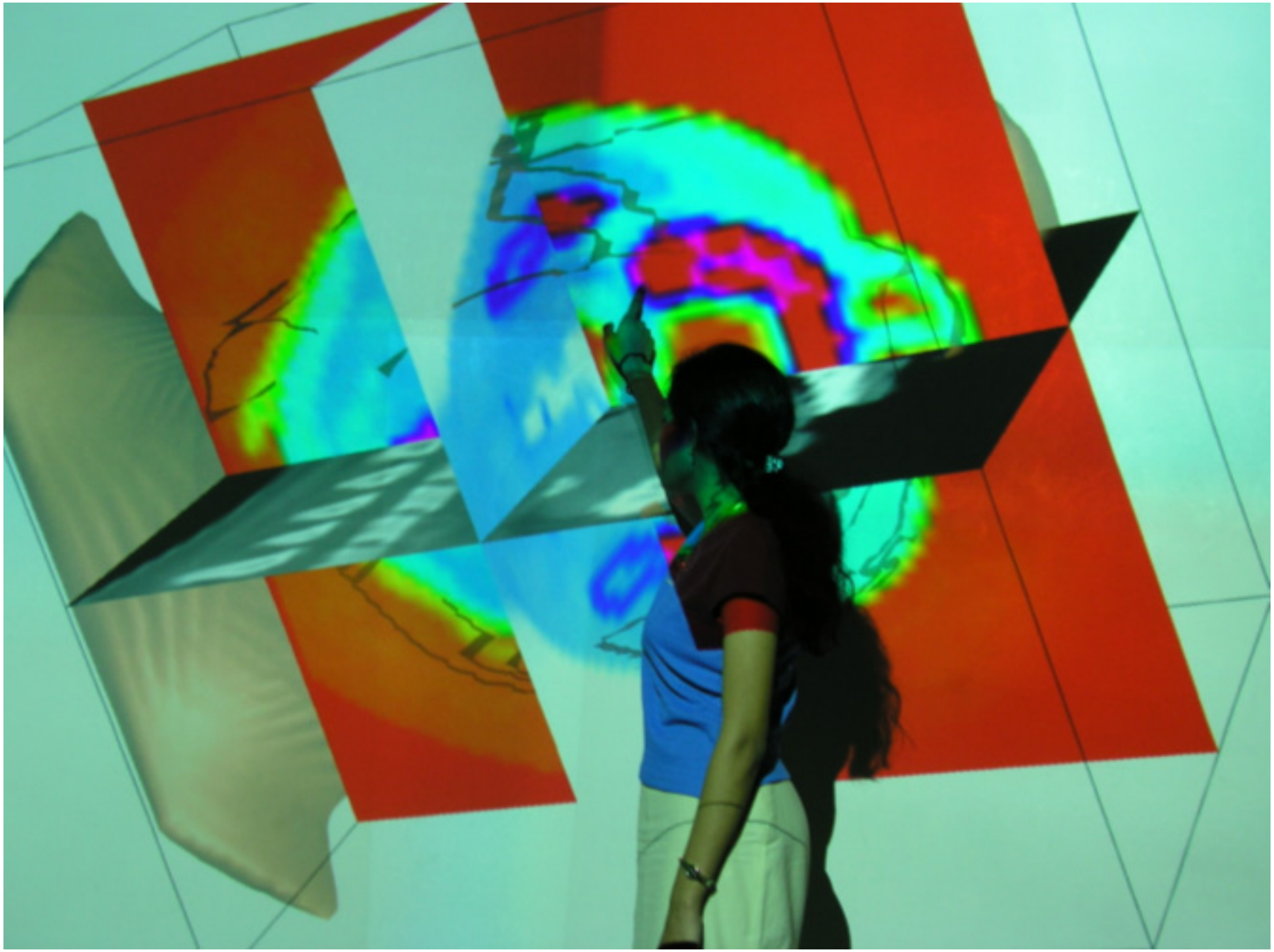
Photometric Correction







Data Visualization



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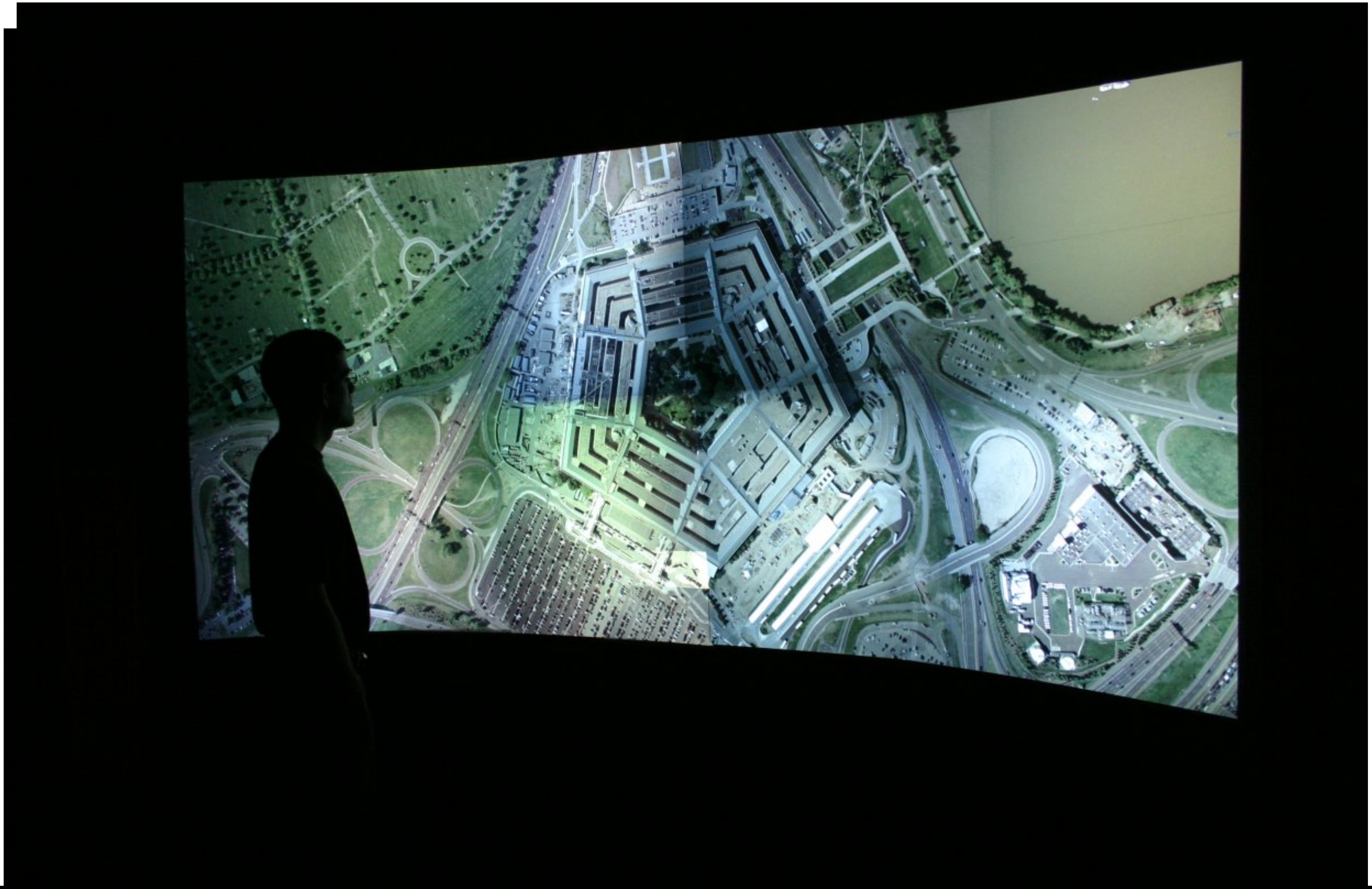

Results

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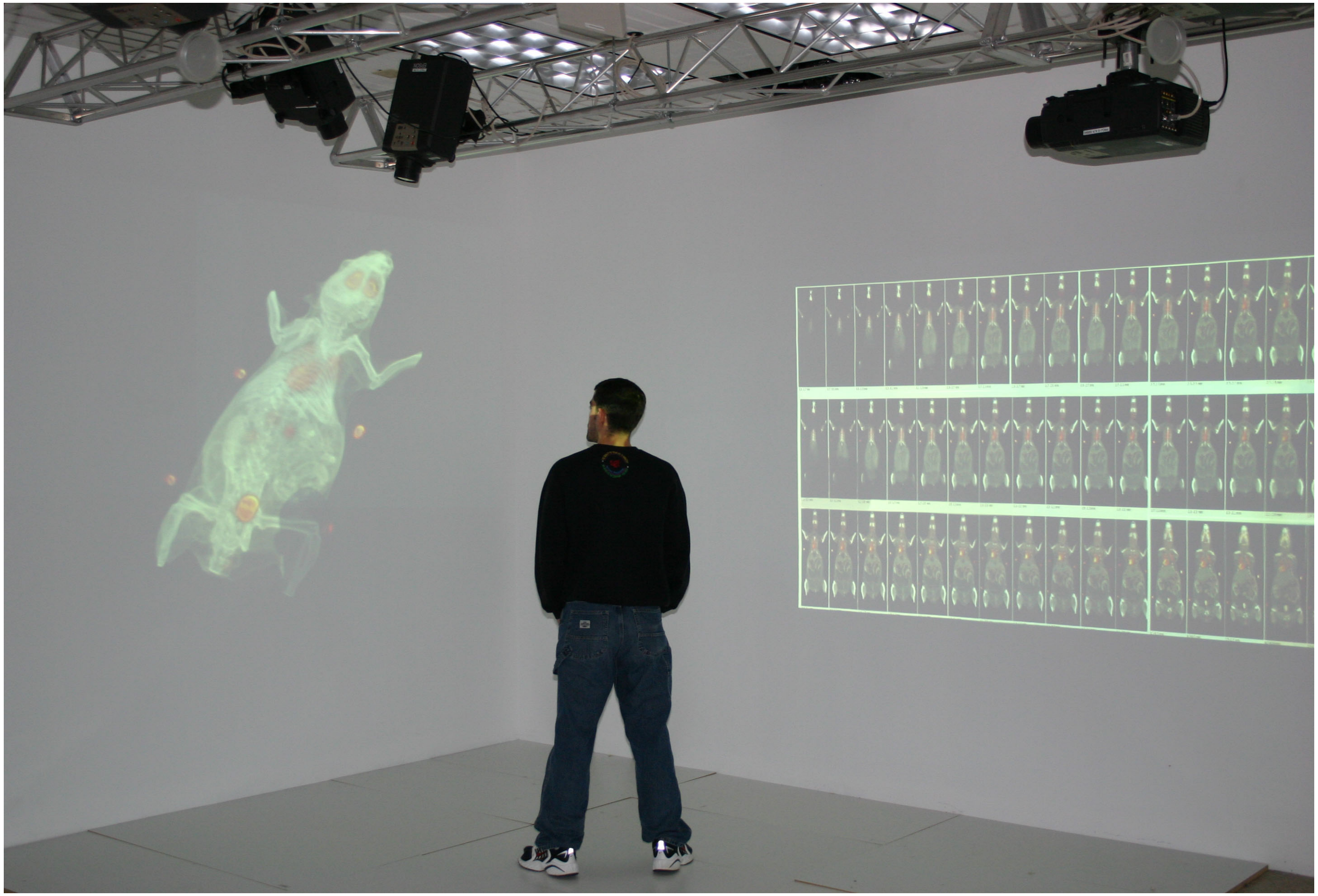

Results