Augmented Vision –
Scanning of scenes, objects and people

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DFKI: German Research Center for Artificial Intelligence

Bremen Site

- Safe & Secure Cognitive Systems
- Robotics & Intelligent Technical Systems

since 11/2005

Kaiserslautern Site

- Knowledge Management
- **Augmented Vision**
- Embedded Intelligence
- Intelligent Factory Systems

Saarbrücken Site

- Intelligent User Interfaces
- Language Technology
- Institute for Information Systems (IWi)

since 07/1988

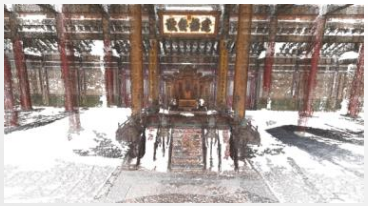
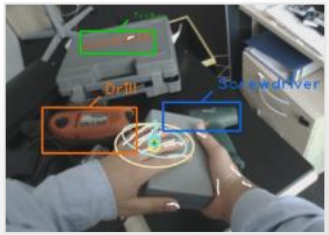
Berlin Office

since 05/2007

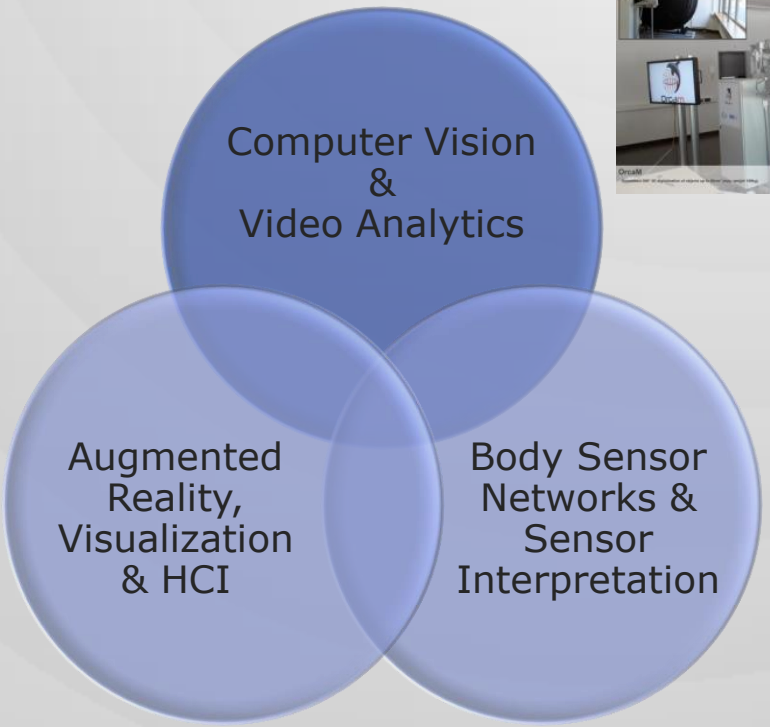
DFKI is a non-for-profit private research company with international shareholders

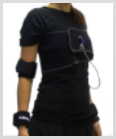
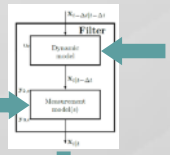
Department Augmented Vision @ DFKI

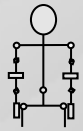
- Head: Prof. Didier Stricker
- Founded in July 2008
- 30 fulltime researchers
- 3 strongly connected research areas

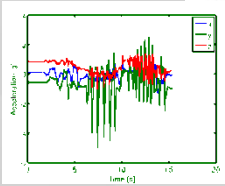
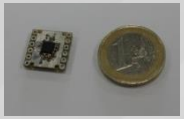






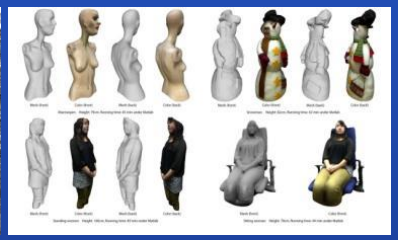





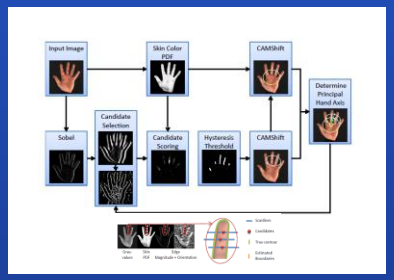



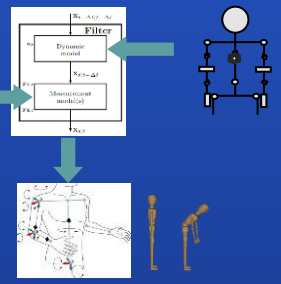
augmented VISION

3D Scanning & Reconstruction



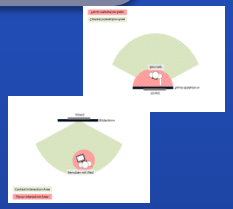
Hand & Body Tracking





Research Topics

Object Recognition & Tracking

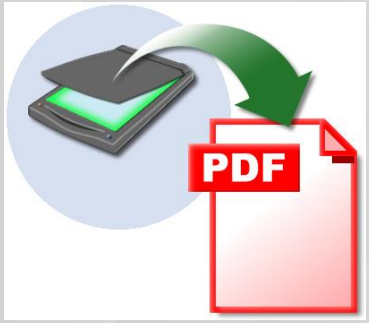


Human Computer Interaction

3D Scanning and Digitalization

„Anything that can go digital, will go digital“

Scanning, copying, taking picture, printing

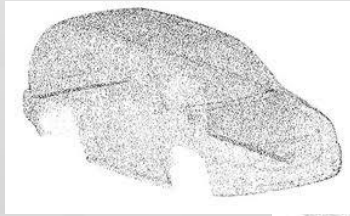


Easy…

And cheap…

3D Scanning

- Devices
  - Laser-Scanners
  - Stripes system
  - …

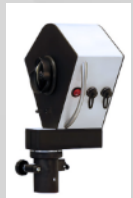


- Many different software packages

- Current state
  - **Fragmented** „landscape“
  - From scanning to 3D visualization over Internet…?!

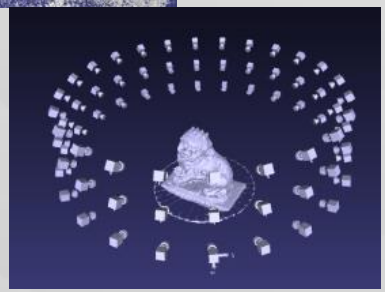
3D digitalization: full pipeline

Digitalization






Geometry and appearence modeling

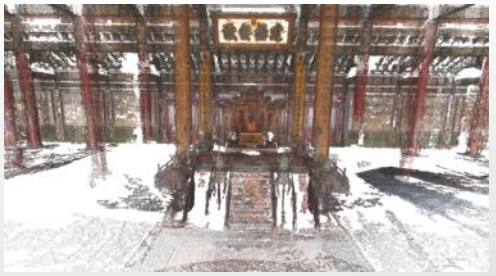



Visualization



Computer vision: 3D Reconstruction

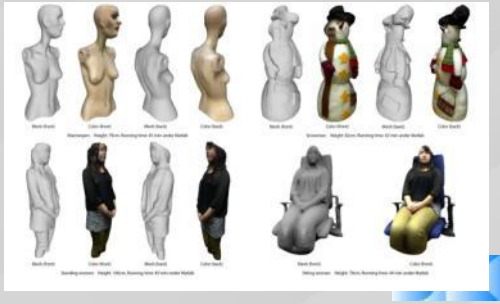
1. Large scale modeling
   - Large buildings (inside)
   - Buildings / streets / cities (outside)

2. Object modeling with images
   - Heavy objects
   - Fixed position objects

3. Object modeling with structured light
   - Extremely precise
   - Movable objects


4. Object modeling with depth camera
   - Low-cost, real-time scanning
   - For normal users

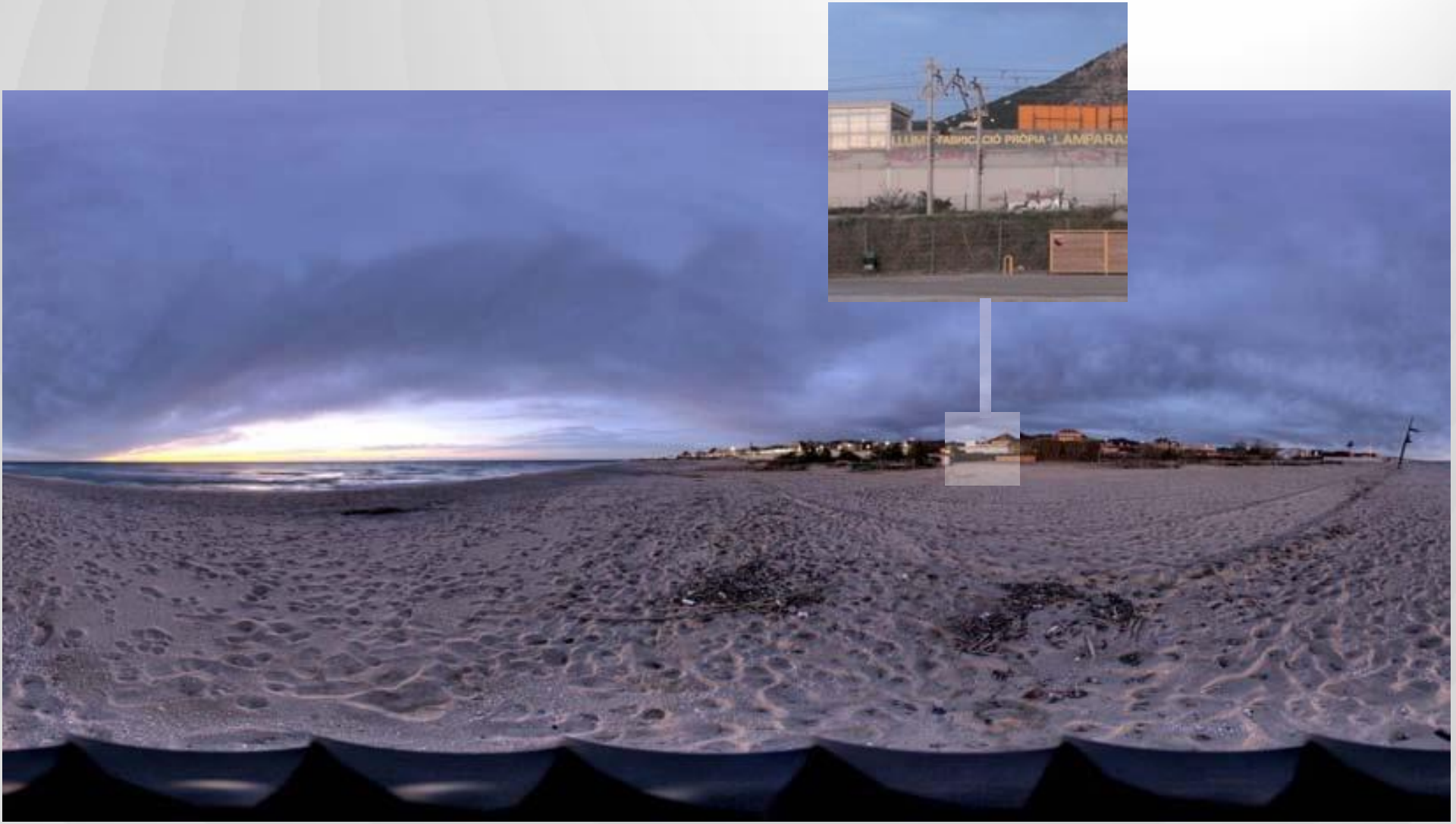




Large scale modeling

High-quality camera (one gigabyte large)

- 100 Million Pixels
- Spherical images
- High dynamic range

Towards Giga-Pixel image-processing

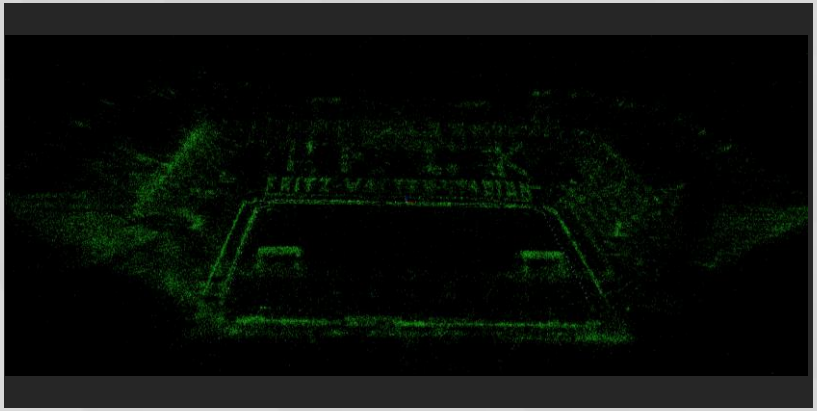


3D Reconstruction from spherical images

Fritz-Walter-Stadion

Input images

Calibrated cameras	76
Sparse points	803,231
Reconstructed points	240,101,306
Measures	215m x 170 m

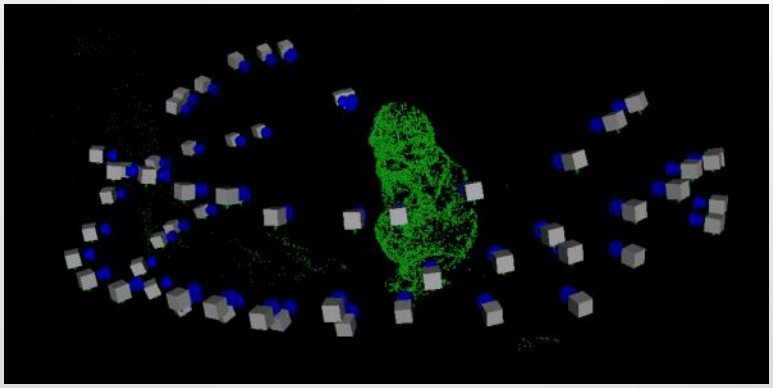


Structure From Motion

Dense pointcloud

Object modeling with perspective images

Input images



Structure From Motion

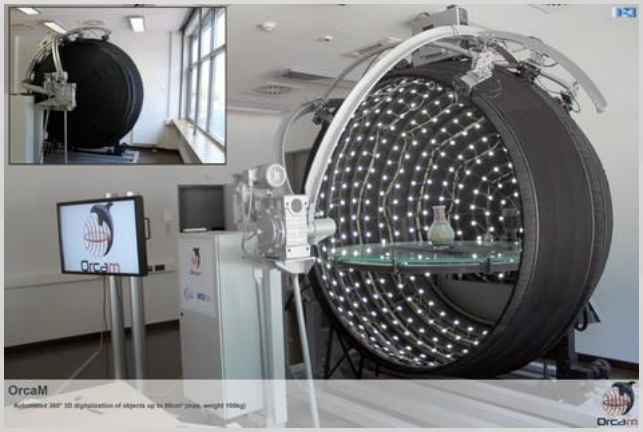
Multiple View Stereo

3D model

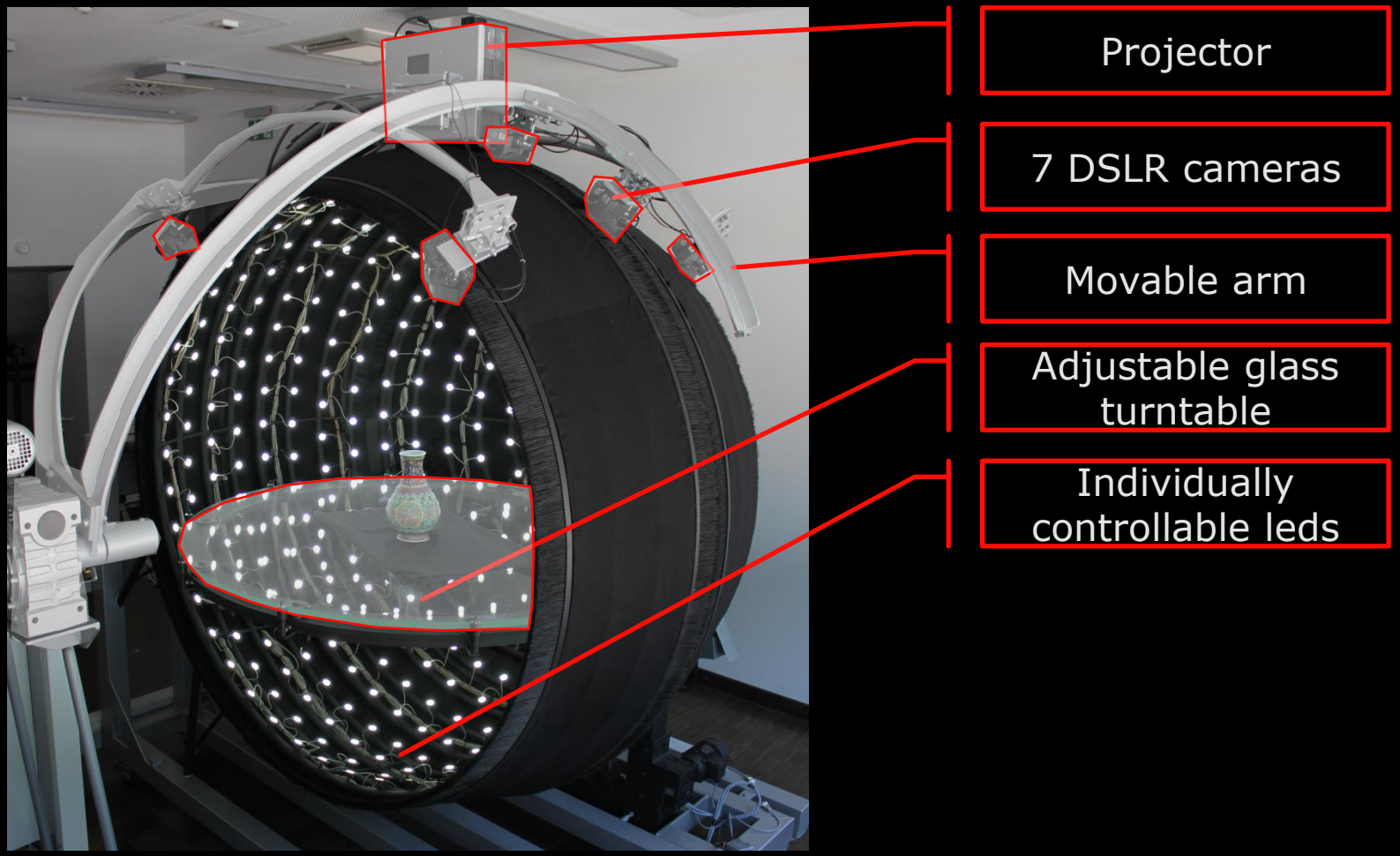
Systematic & fast scanning

- OrcaM – Orbital camera system

- **Photo-realisitic scanning**
  - One-button solution!
  - 3D model and color (texture)
  - High quality visualization in web-browser
- Applications
  - 3D archiving of cultural assets
  - 3D digitalization for 3D online shop!
  - …



Our Acquisition Hardware



Orcam: Orbital Camera

Object 1

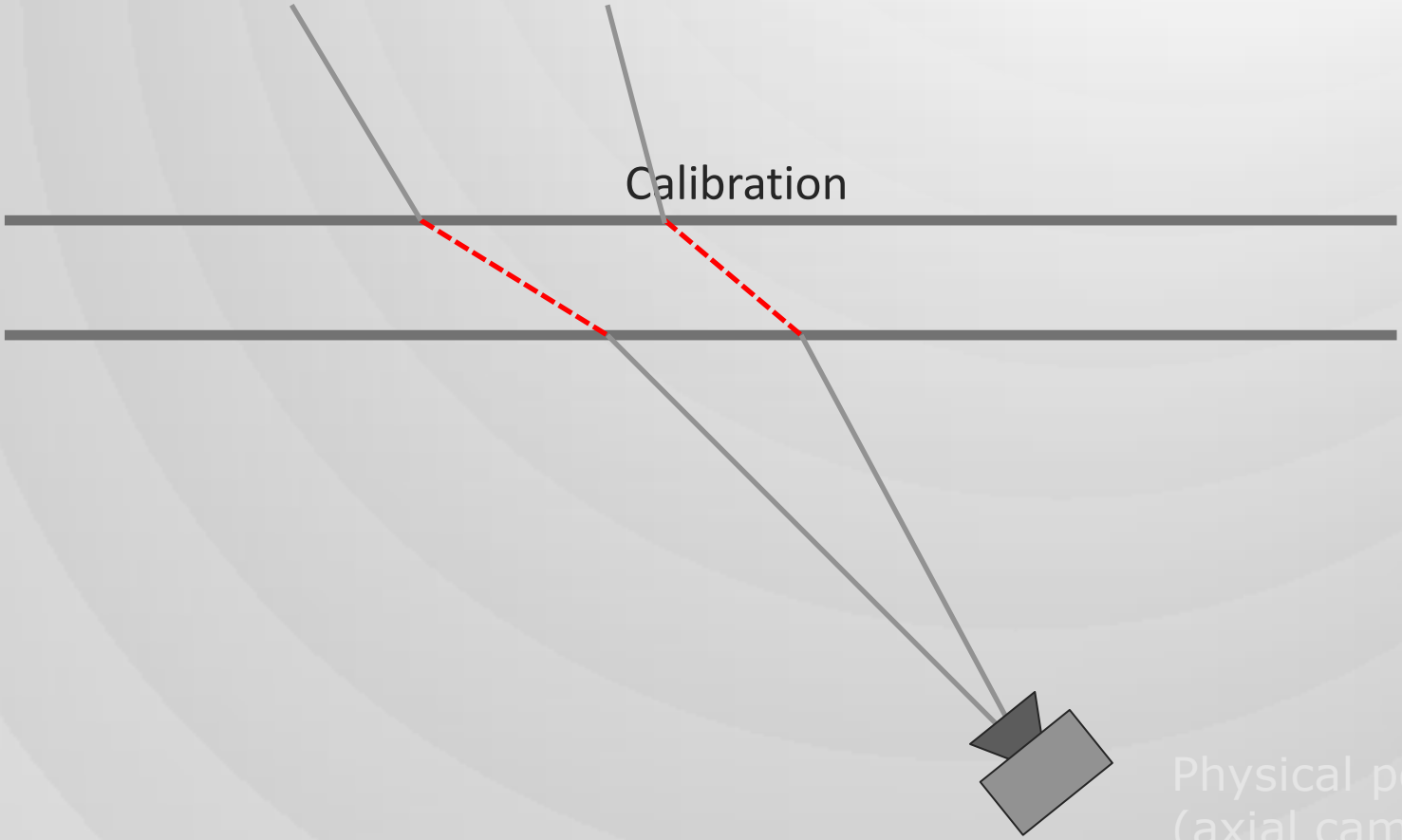
Female Torso

Sizes: 670x400x250 mm

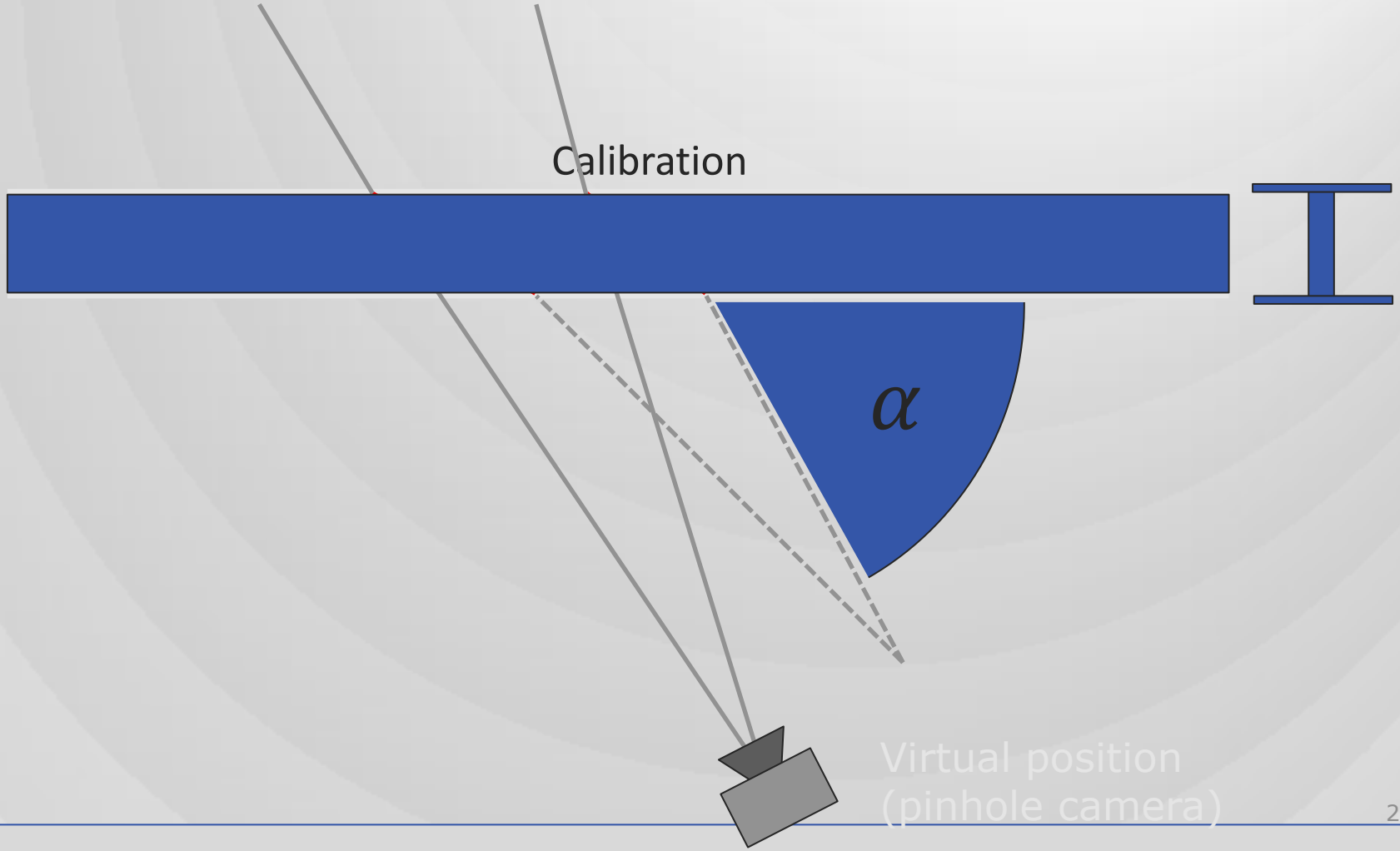
Material: Bronze

Calibration

Glass carrier influence

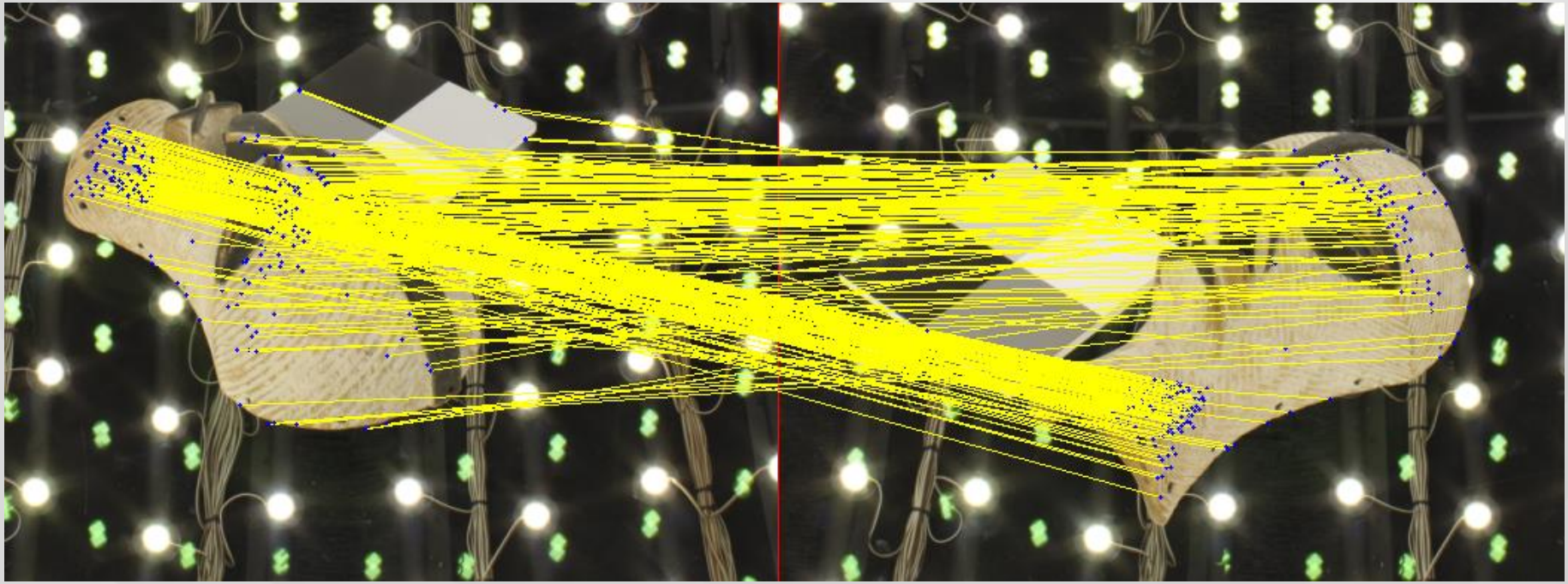


Glass carrier influence

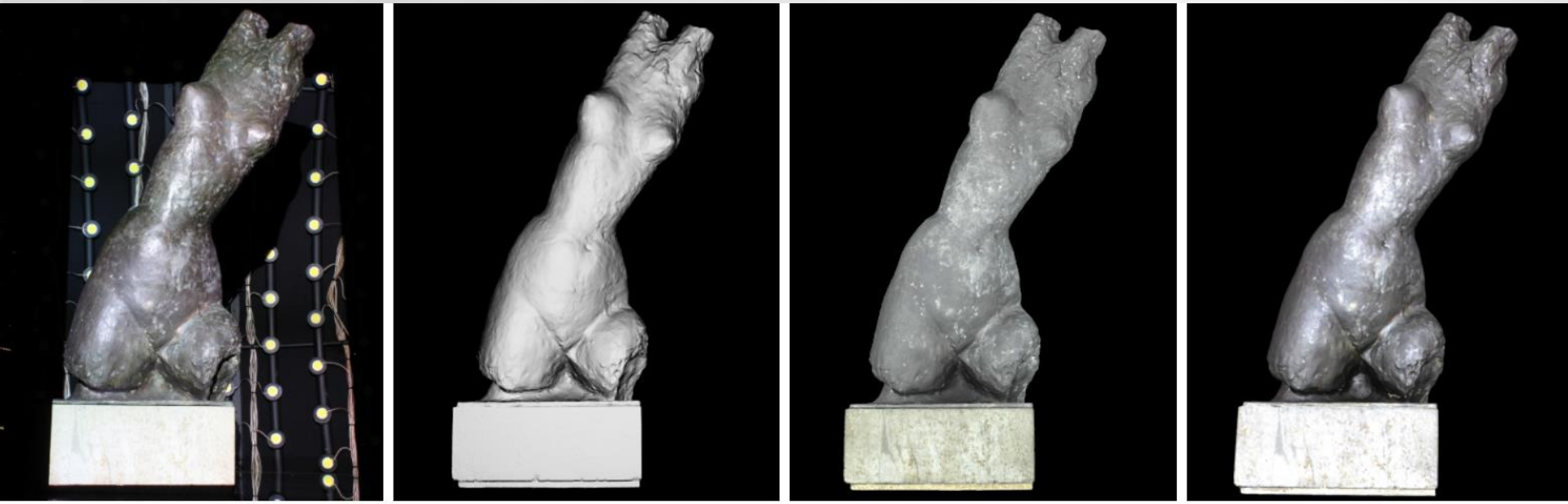


Self-calibration

- Feature detection and matching
- Recovery of the relative camera position / orientation



Appearance Reconstruction



(a) Captured picture (b) Scanned 3D geometry (c) Textured 3D geometry (d) Appearance reconstruction

Appearance Reconstruction

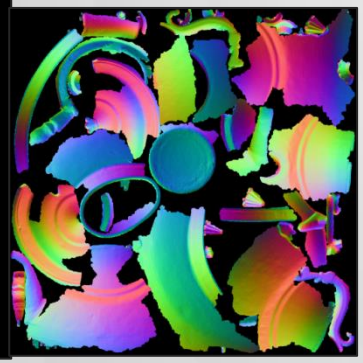
- Up to 133 camera positions
- 19 light position for each camera
- Yielding up to 2.527 camera / light configurations
- On average 200-400 usable appearance measurements surface point

Reflectance Model:
Ward et al. 1992

$$c_{obs} = \frac{c_{dif}}{\pi} + \frac{e^{-\frac{\tan^2(\cos^{-1}(n*h))}{r^2}}}{4\pi r^2\sqrt{(n*l)(n*v)}} c_{spec}$$

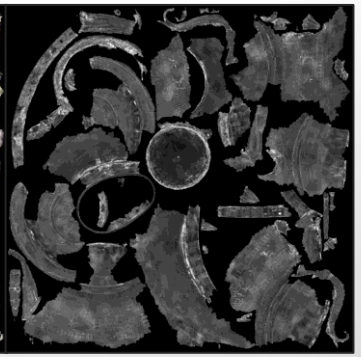
Diffuse color: c_{dif}
Specular color: c_{spec}
Roughness: r


Geometry proxy


Normal map


Diffuse color map


Specular color map


Roughness map

12MB

Results

Allegorie Luxembourg

Our reconstruction

Geometry + Texture only

Reference image

Results

Allegorie Luxembourg

Capture time:	69 Minutes
Processing time:	12:31 Hours
Raw image data:	25.2 GB
Our representation:	16.1 MB

Results

Das kleine Mädchen

Capture time:	39 Minutes
Processing time:	10:55 Hours
Raw image data:	15.9 GB
Our representation:	15.3 MB

Results

Weiblicher Torso

- *W. Lehmbruck, 1918*

Capture time:	57 Minutes
Processing time:	10:28 Hours
Raw image data:	15.6 GB
Our representation:	12.7 MB

Results

Limitations

- Isotropic Ward Reflectance Model

Reference image

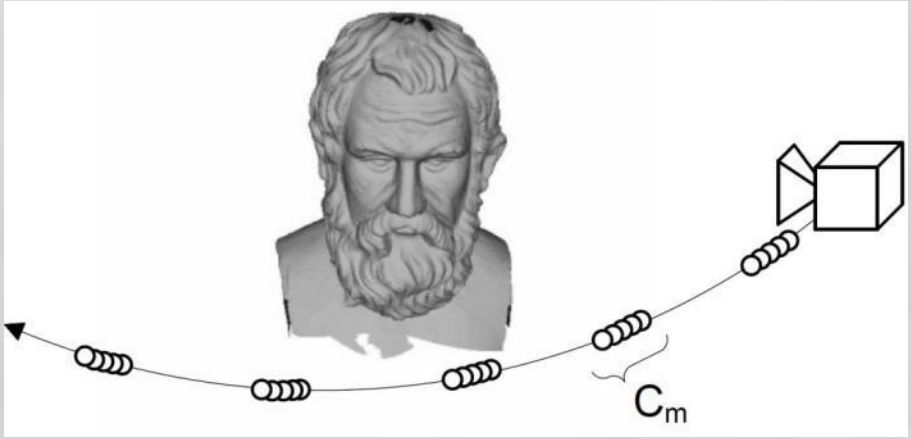
Our reconstruction

Depth Camera

- Time-of-Flight Camera
  - Low resolution (176 x 144)
  - Real-time capture (54 FPS)
  - Video frame with 3D information

Swissrange 4000

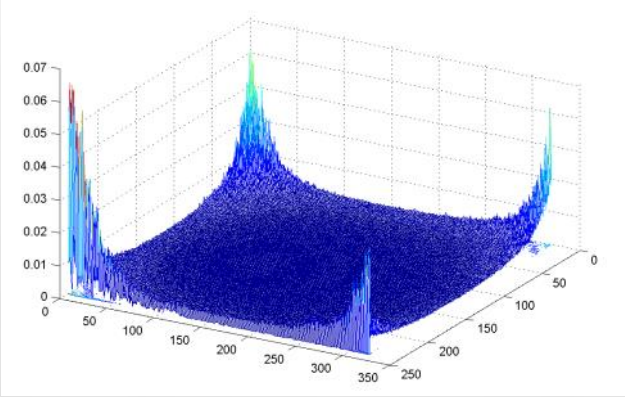
- Real-time 3D reconstruction
  - Scan alignment



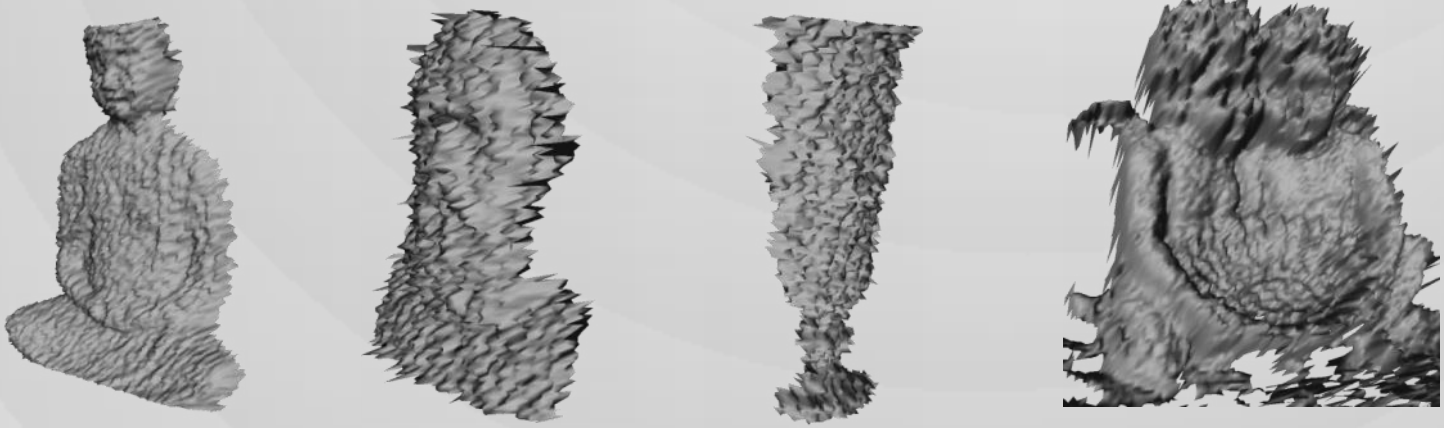
Depth Camera

- Disadvantage:
  1. High noise (+/-15mm)
  2. Low resolution (176*144)
  3. High distortion

+ Advantage:
  1. Real-time capture
  2. Video frame with 2/3D information



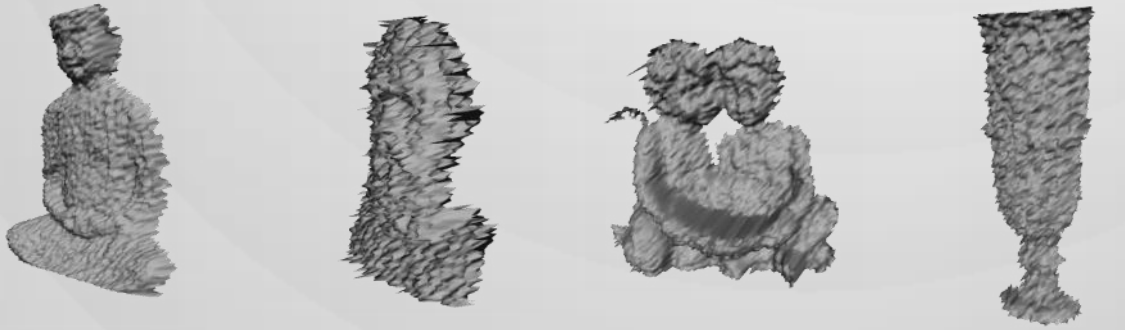
Variance distribution in a depth image taken at approx. 1.5m *average distance from a scene. Depth images* contain heavy noise near the corners.



4. Depth Camera

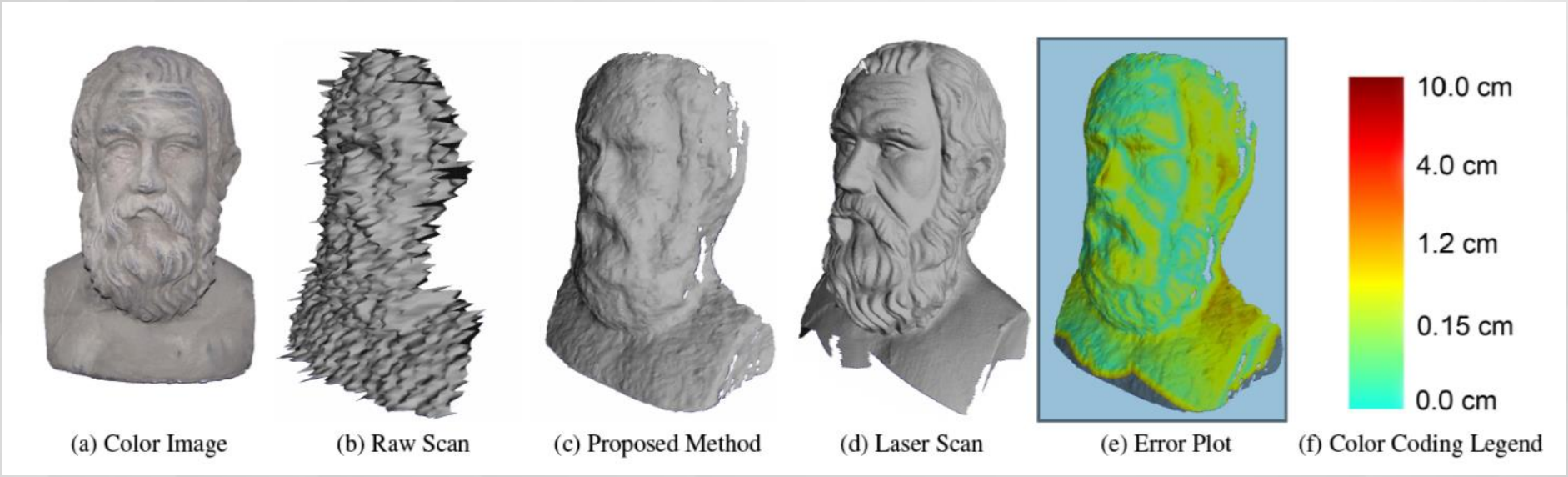
Color objects

Original results



Our results

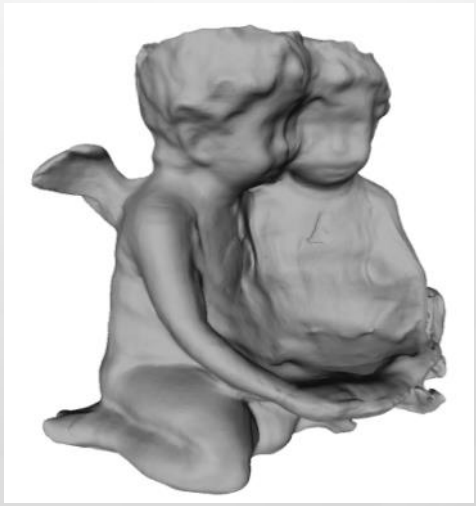
Evaluation

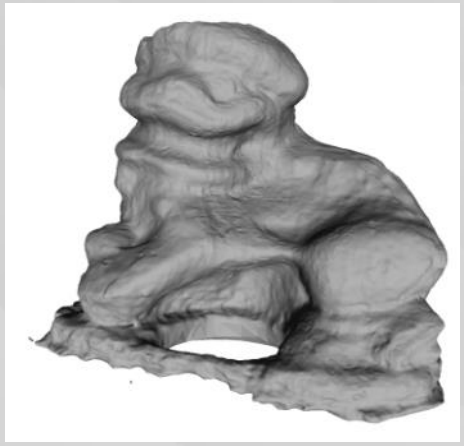


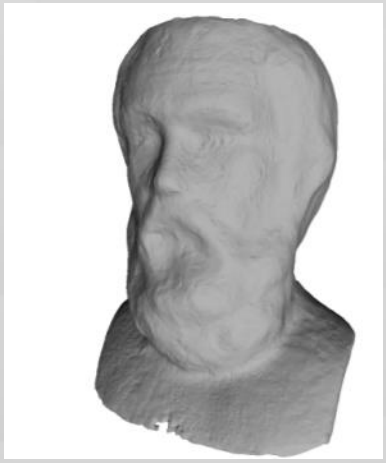
(a) Color Image (b) Raw Scan (c) Proposed Method (d) Laser Scan (e) Error Plot (f) Color Coding Legend

Object modeling with ToF camera

- 3D reconstruction results with Time-of-Flight Camera







Depth Camera (2012/2013)

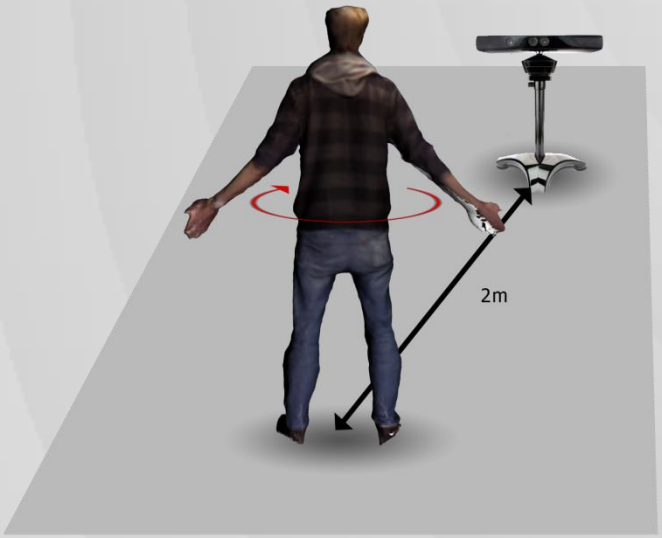
- 20 million Kinect already sold!
  - 66 million Xbox
  - 40 million online users

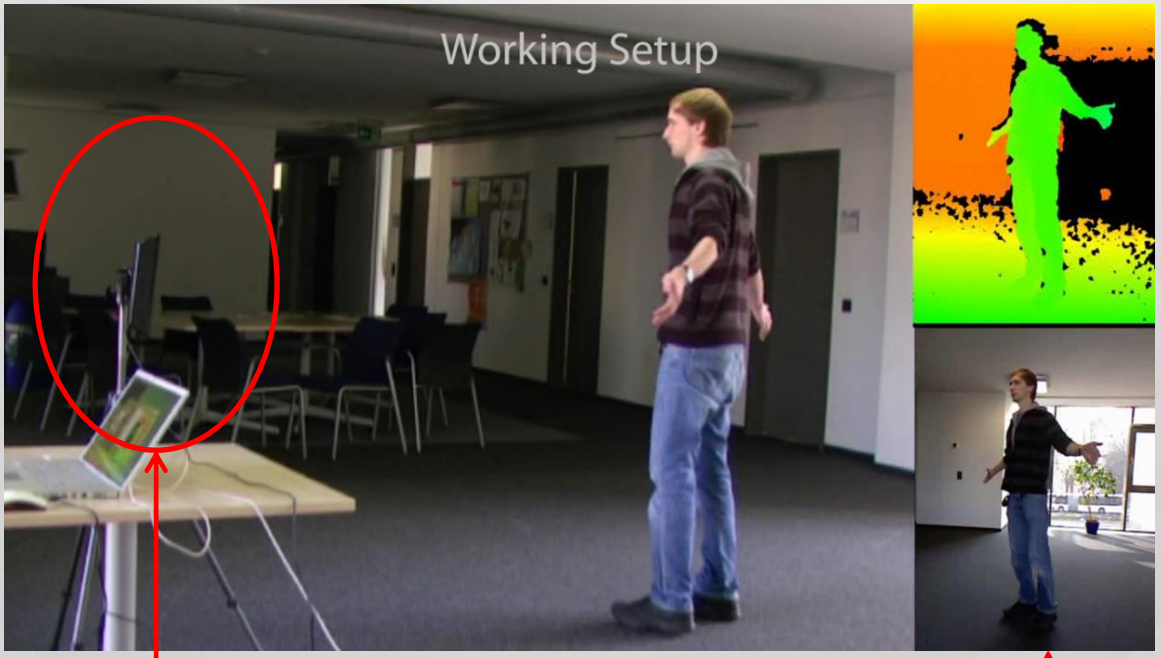
- Microsoft announced Kinect for PC and commercial-use

- Competitors offer products as well, e.g. Xtion from ASUS!

Depth Camera - The basic idea

A single camera but a full body scan!

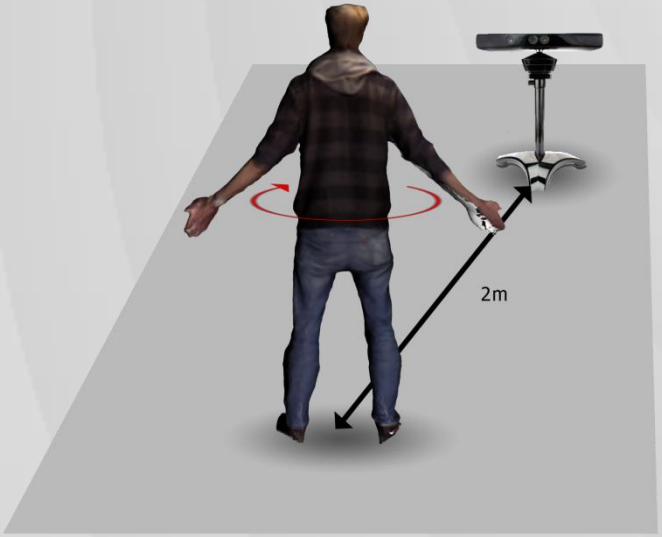




Single Kinect + Laptop Set-Up

Kinect's images

3-D Scanning @ home

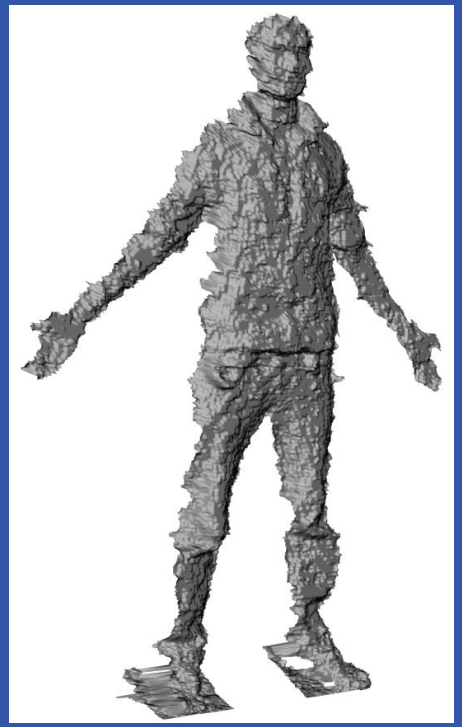


E-commerce

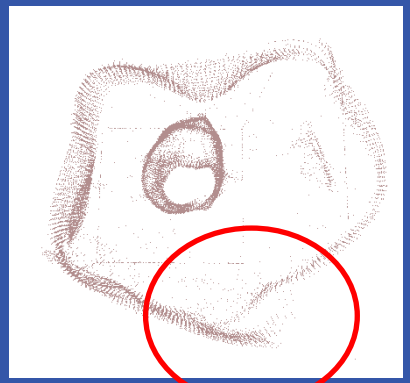
Games

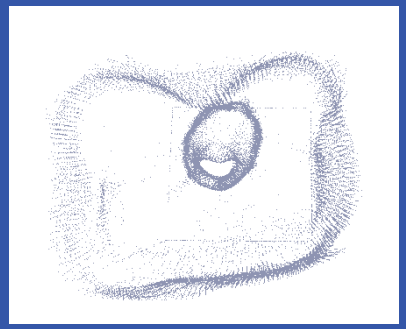
Health

Three major problems



Low resolution
High noise level



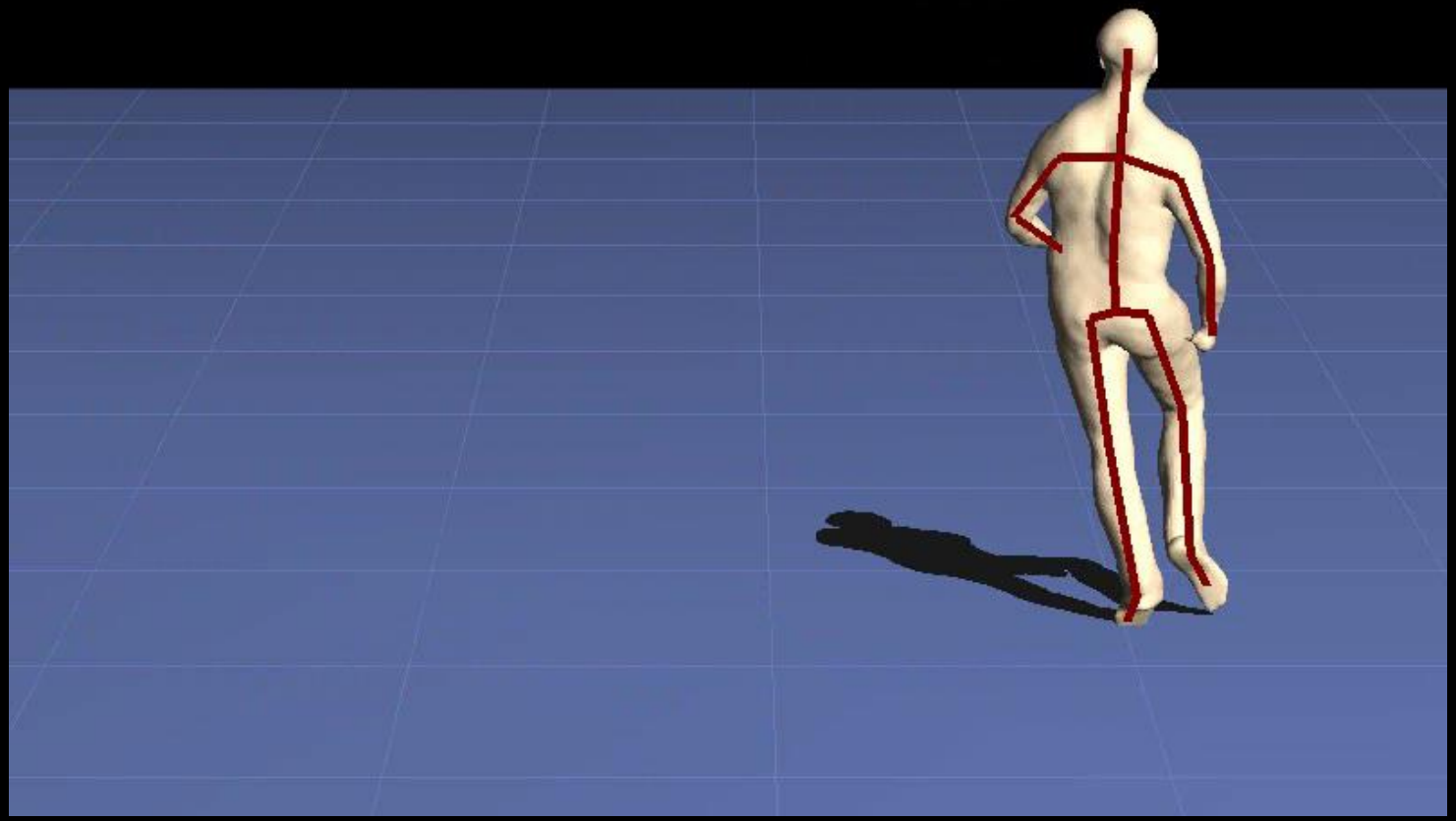


Error accumulation &
Loop-closing

Deformation &
Non-rigidity

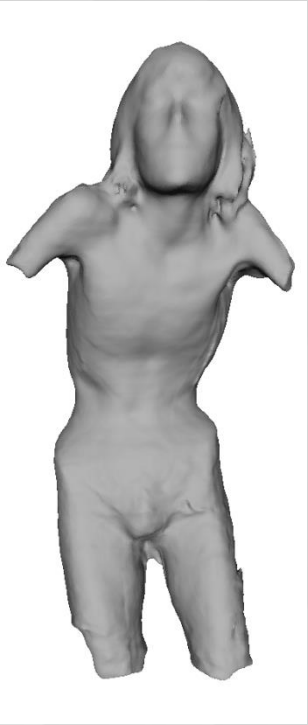
Working Setup

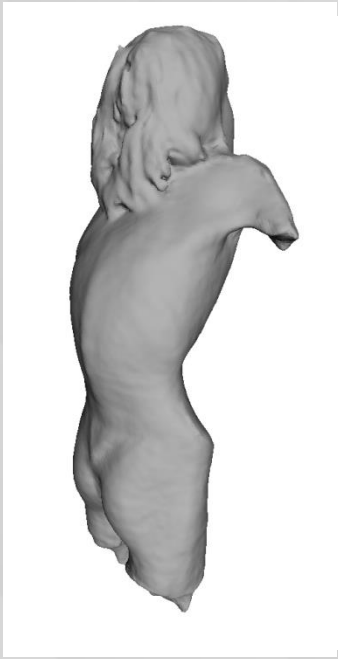
3D animation from scanned models

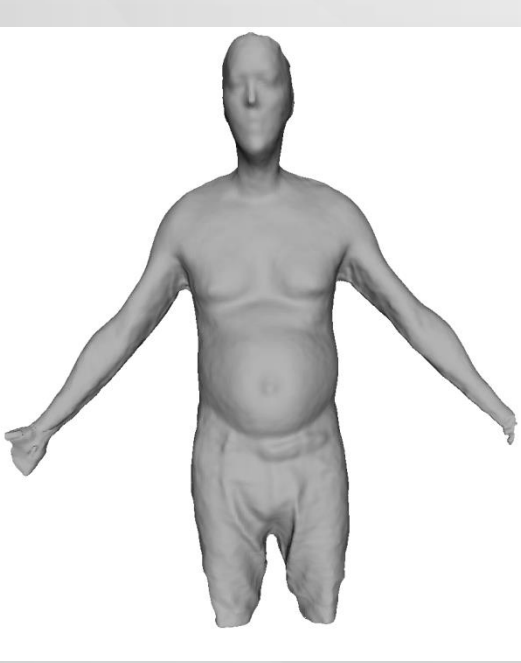


Test: orthopedic applications

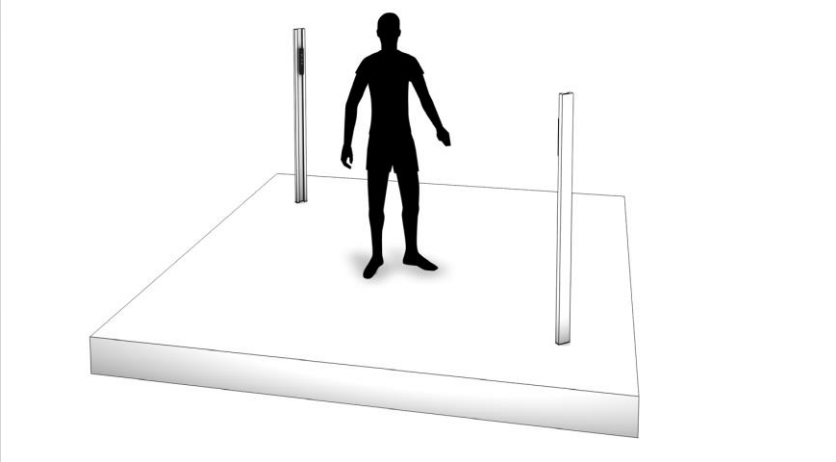
- 3D scanning for prothesis design
- Test for back injuries

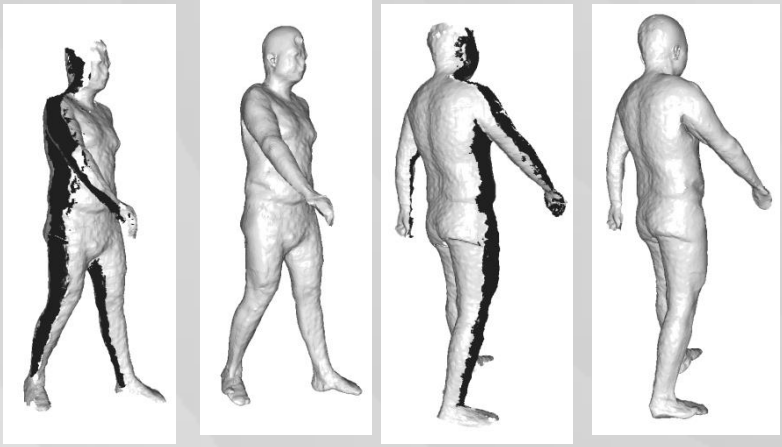


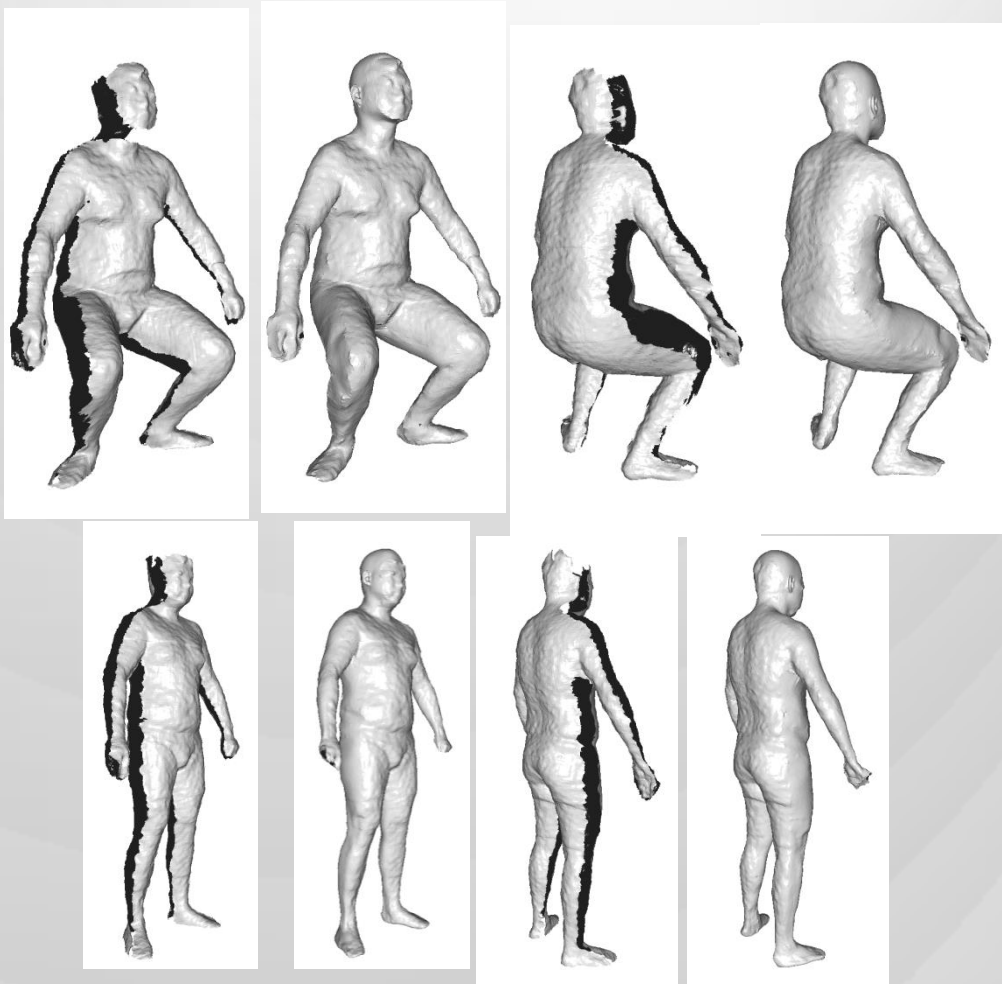




New post-processing methods





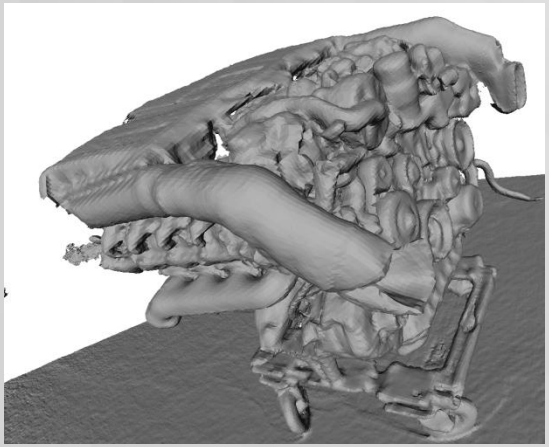


http://youtu.be/GqoGgKiAkTw

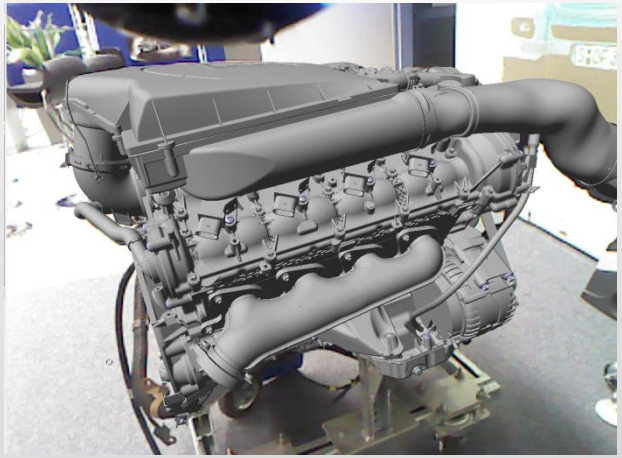
Discrepancy check (Kinect)

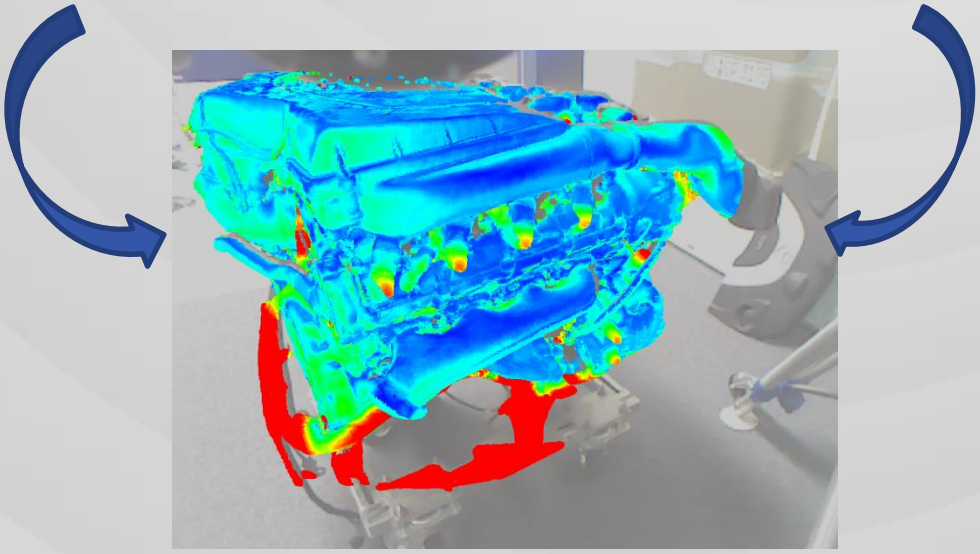
DAIMLER

Scan



CAD

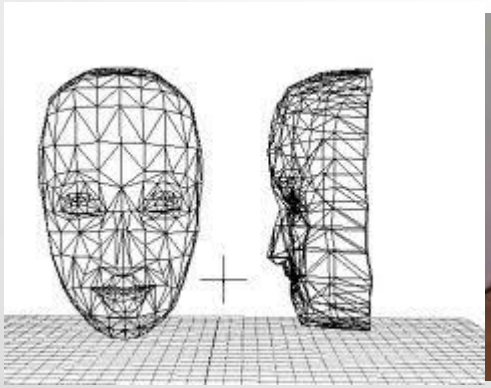


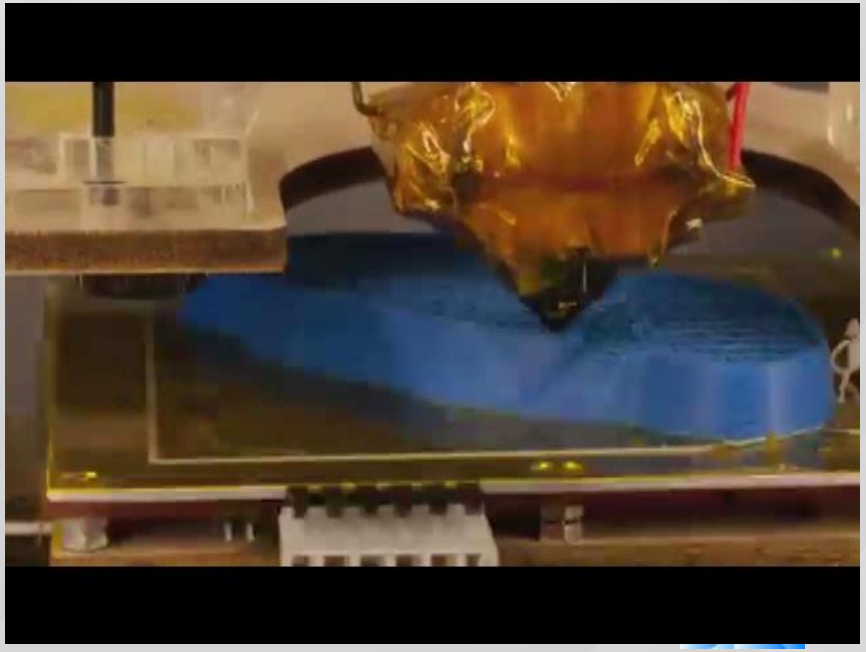


Outlook

Produce and duplicate

- From virtual to real object
- 3D printing





Thank you for your attention!

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