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ISPRS WG V/6
MEDICAL IMAGE ANALYSIS, HUMAN MOTION AND BODY MEASUREMENT
The Aristotle University
Thessaloniki, Greece

Photogrammetric analysis of static and moving human characters

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- Human body modeling (image-based)
- Static human digitization
- Motion capture (MOCAP)
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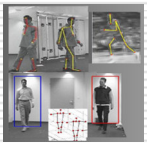
- Conclusions





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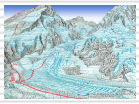
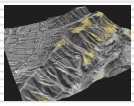
1. Introduction

- **Photogrammetry** = precise metric information from images
  = convert images into 3D models

- Recover precise information from image data

- Applications = Inspection, Mapping, Documentation, Animation, …


- Photogrammetry for human body modeling (3D shape + 3D movements)

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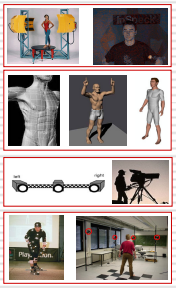
2. Human body modeling

- Human modeling = recover geometry and movements
- Human animation = recreate/simulate the movements

3D Shape
- Active Sensors
- Computer Animation Software

Movements
- Markerless Videogrammetry
- Motion Capture



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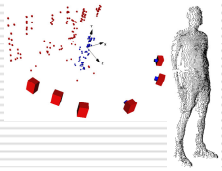
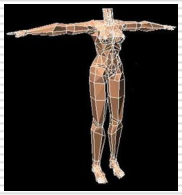
3. Static human shape digitization

- active sensors (laser scanners, stripe projection systems, etc.)
- passive sensors (image-based)
- computer graphics software (Maya, 3DMax, etc.)

VITRONIC GmbH





3D Studio Max

- more on active sensors the next presentation `**3D surface scanning technologies**`

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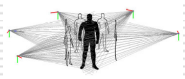
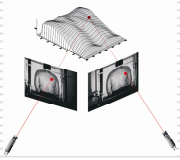
3. Static human shape digitization

3.1 Image-based approach

- Single camera approach
- Multi-camera approach



- Visual hull - Silhouette extraction and intersection
- Camera model - Dense point matching



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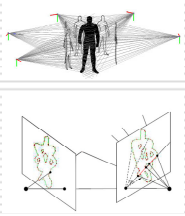
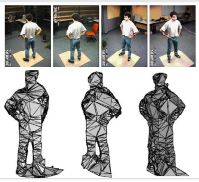
3. Static human shape digitization

3.1 Image-based approach – *multi-camera*

- Visual hull - silhouette extraction and intersection





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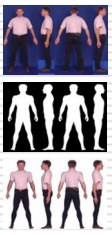

Surrey University, UK

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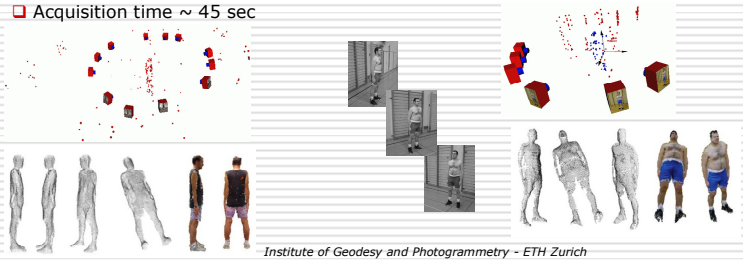
3. Static human shape digitization

3.1 Image-based approach – *single-camera*

- One camera moved around a standing person
- Accuracy ~ 2-3 mm
- Acquisition time ~ 45 sec



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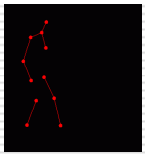
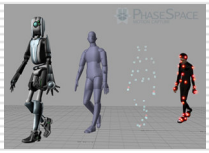
4. Human movement digitization

- Monocular vs Multi-camera approach
- With markers vs Markerless

- 3D joint coordinates, trajectories, movements
- 3D shape





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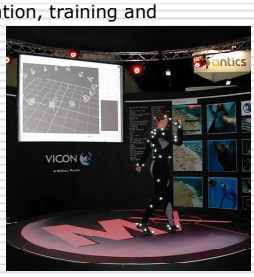
4.1 Motion capture

- **MOCAP** = technique of digitally recording movements for entertainment, sports and medical applications. It started as an analysis tool in biomechanics research, but has grown increasingly important as a source of motion data for computer animation as well as education, training and sports and recently for both cinema and video games.

+ MOCAP is faster than animator works
+ MOCAP can accurately acquire any kind of movement
- MOCAP requires special HD and SW to record and process the data
- Difficult to acquire MOCAP data on animals

Applications: video games, movies, biomechanics, etc.



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4.1 Motion capture

Available systems:

Optical systems (e.g. Motion Analysis, Vicon, etc.):
- network of cameras (>20) imaging signalized (retro-reflective) spheres on the body
- freedom of movements
- interaction of actors is possible

Magnetic systems (e.g. Ascension, Polhemus, etc.):
- it uses electromagnetic sensors connected to a computer unit
- wire and wireless systems are available

Electro-magnetic (e.g. Analogus):
- the person has to wear special suit with integrated electro-mechanical sensors that register the motion of the different articulations
- real-time data transfer from the sensors to the computer
- less expensive than other methods

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4.1 Motion capture

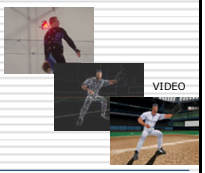
Movie - Animations

VIDEO

Video games - Animations

VIDEO

VIDEO



VIDEO

Motion Analysis Corp - http://www.mationanalysis.com
Vicon - http://www.vicon.com
Qualisys - http://www.qualisys.com
Ascension - http://www.ascension-tech.com
...

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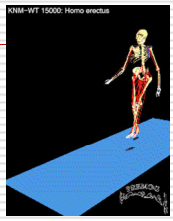
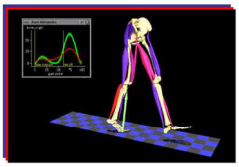
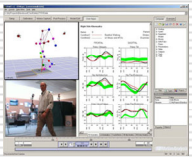
4.1 Motion capture

Medicine – gait analysis

- analysis of walking abilities / abnormalities
- humans and animals







VIDEO

VIDEO

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4.2 Markerless Motion Capture

- Analysis of video sequences where people have NO markers
- Monocular vs Multi-camera approaches
- Use old / existing videos to study the movements of unavailable persons
- Worst accuracy compared to methods with markers
- Visualization, animation, middle accuracy applications

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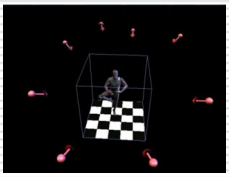
4.2 Markerless Motion Capture

4.2.2 Multi-camera approach

- uniform background – easier segmentation
- fix environment – calibrated system
- pattern on the floor – easier registration
- up to 50 cameras involved



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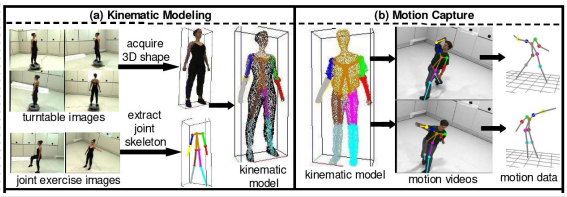
4.2 Markerless Motion Capture

4.2.2 Multi-camera approach

- 3D shape acquired with silhouette methods
- Learning process to determine joints and limbs
- Motion capture with tracking approach



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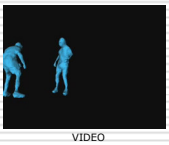
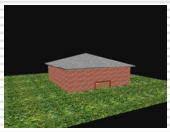
4.2 Markerless Motion Capture

4.2.2 Multi-camera approach

- ca 50 cameras for the simultaneous acquisition of the data


VIDEO


VIDEO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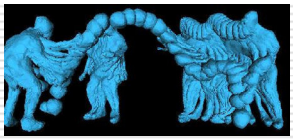

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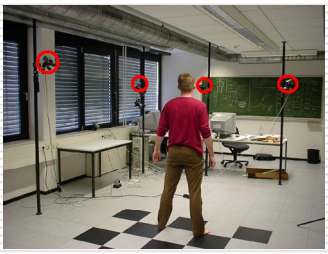
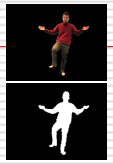
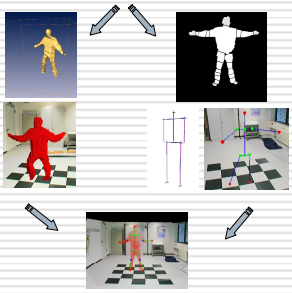
4.2 Markerless Motion Capture

4.2.2 Multi-camera approach


8-10 cameras


Visual hull
from each camera



Max-Planck-Institut für Informatik, Germany

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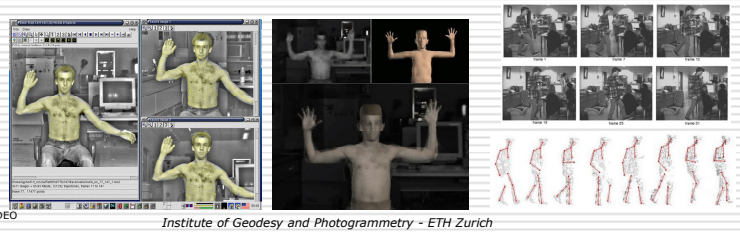
4.2 Markerless Motion Capture

4.2.2 Multi-camera approach

- 3D shape based on deterministic approach (camera model)
- Tracking of point cloud trough the sequence
- Identification of joints and 3D trajectories determination



VIDEO

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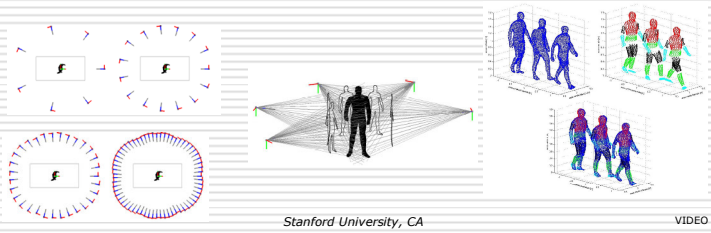
4.2 Markerless Motion Capture

4.2.2 Multi-camera approach

- Up to 64 cameras
- Visual hull generation
- Anthropometric parameters definition



Stanford University, CA

VIDEO

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4.2 Markerless Motion Capture

4.2.3 Monocular approach

- Analysis of monocular video is ill-posed problem
- No stereo view => complex to recover 3D info
- Use of constraints or fitting processes
- Old videos allow to recover info of unavailable persons

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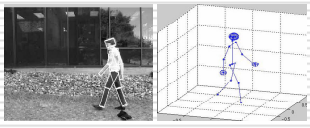
4.2 Markerless Motion Capture

4.2.3 Monocular probabilistic approach

- 2D analysis of image data
- Fitting of predefined 3D human model onto the images
- Heavy minimization processes involved



VIDEO *[KTH, Sweden]*

[INRIA, France] VIDEO

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4.2 Markerless Motion Capture

4.2.3 Monocular deterministic approach

- 3D shape based on deterministic approach (camera model)
- Monocular => no stereo => 3D by means of constraints
- Fitting of predefined 3D human model onto the recovered 3D data
- Possibility to retrieve movement from old / existing videos

VIDEO

VIDEO

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4.2 Markerless Motion Capture

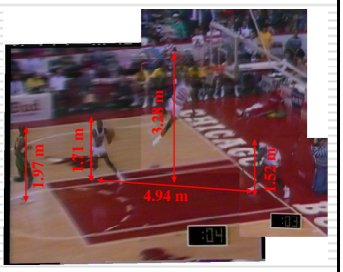
4.2.3 Monocular deterministic approach

- Study of the human movements

Kind of length/distance	*Length (m)*	*Accuracy (cm)*
height of the player at the beginning of the jump	1.71	± 2.2
height of the player at the end of the jump	1.52	± 2.3
length of the jump (distance b_1b_3)	4.04	± 3.7
height of the jump (ball)	3.28	± 3.0
height of the jump (waist)	2.02	± 2.8
height of the second player	1.97	± 2.8

Accuracy computed with error propagation law

- Jumping player height: 1.98 m
- Second player height: 2.01 m



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5. Conclusions – 3D shape

- Image-based methods less used compared to active sensors
  - less expensive
  - less precise
  - only in research area
- Active sensors are the most used (see next presentation)

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5. Conclusions – 3D movements

- MOCAP (optical or magnetic) systems for highly precise movement analysis
  - Expensive HD and SW
  - only movements, no 3D shape
- Markerless multi-camera systems for middle accuracy application
  - no markers involved
  - 3D from stereo
  - special HD required
- Markerless monocular systems for middle accuracy application
  - no markers involved
  - 3D recovered using constraints
  - analysis of unavailable persons