Motion Capture

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Outline

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   - *Popular systems*
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   - *Special device for motion capture*
   - *Motion capture for performance control*
   - *Markerless motion capture*
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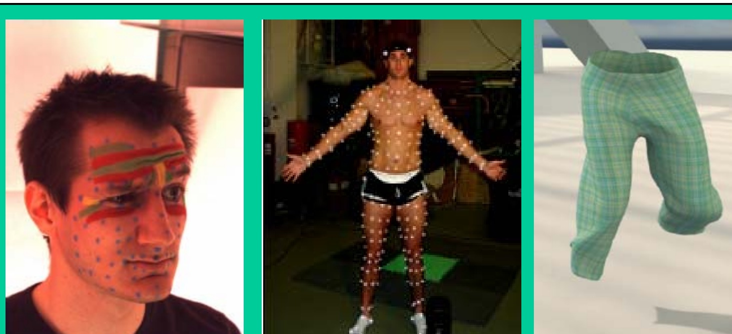
Motion capture: goal

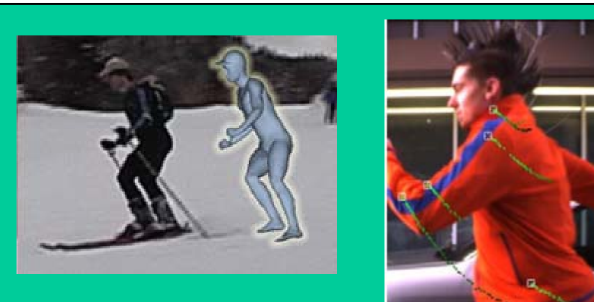
According to Rick's textbook:

Motion capture involves ***sensing, digitizing, and recording*** the object in motion.

Study of the field is growing in a fast pace:



(1) Motion capture for Special effects



(2) Motion capture with special device

(3) Motion capture for performance control and human-computer interaction, etc

(4) Markerless optical motion capture systems

… and more intelligent processing and applications of motion captured data

Motion capture: related SIGGRAPH papers

Year	topics	paper list
2007	Performance Capture	***(1) Multi-Scale Capture of Facial Geometry and Motion, Bickel et al*** ***(2) Capturing and Animating Occluded Cloth, White et al*** ***(3) Practical Motion Capture in Everyday Surroundings, Vlasic et al*** ***(4) Prakash: Lighting-Aware Motion Capture Using Photosensing Markers and Multiplexed Illumination, Raskar et al***
2006	Motion Capture	(1) Interaction Capture and Synthesis, Kry et al ***(2) Capturing and Animating Skin Deformation in Human Motion, Park et al*** (3) Compression of Motion Capture Databases, Arikan (4) Motion Patches: Building Blocks for Virtual Environments Annotated With Motion Data, Lee et al
2005	Motion Capture Data: Interaction and Selection	(1) Action Synopsis: Pose Selection and Illustration, Assa et al (2) Efficient Content-Based Retrieval of Motion Capture Data, Mueller et al ***(3) Performance Animation From Low-dimensional Control Signals, Chai et al*** (4) Dynamic Response for Motion Capture Animation, Zordan et al
2004	Data-Driven Character Animation	(1) Speaking With Hands: Creating Animated Conversational Characters From Recordings of Human Performance, Stone et al (2) Synthesizing Physically Realistic Human Motion in Low-Dimensional, Behavior-Specific Spaces, Safonova et al (3) Style-Based Inverse Kinematics, Grochow et al (4) Synthesizing Animations of Human Manipulation Tasks, Yamane et al
2003	Human Bodies	***(1) Free-Viewpoint Video of Human Actors, Carranza et al*** (2) Continuous Capture of Skin Deformation, Sand et al
2002	Animation From Motion Capture	(1) Motion Textures: A Two-Level Statistical Model for Character Motion Synthesis, Li et al (2) Motion Graphs, Kovar et al (3) Interactive Motion Generation From Examples, Arikan et al (4) Interactive Contol of Avatars Animated With Human Motion Data, Lee et al (5) Motion Capture Assisted Animation: Texturing and Synthesis , Pullen et al

Motion capture: example markerless techniques

Year	topic	paper list
SIGGRAPH03	Back-projection	***(1) Free-Viewpoint Video of Human Actors, Carranza et al***
CVIU06	VisualHull	***(1) Markerless tracking of complex human motions from multiple views, Kehl et al***
TOG05	Machine learning method	***(1) Learning Silhouette Features for Control of Human Motion, Ren et al***
Commercial systems	***OrganicMotion***	***Patented (real-time)***

Motion capture: popular systems

Popular systems:

(1) Electromechanical systems

(2) Electromagnetic systems

(3) Optical motion capture system

(a) Active system: LED-Marker systems

(b) Passive system:

- Reflective-marker systems,
- Markless (non-intrusive) systems,

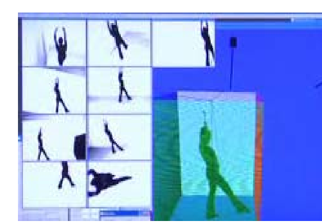
(4) Many others systems you will see…

Electromechanical system from metamotion

Electromagnetic system from xsen

LED-marker system from Phasespace

Reflective-marker system from Vicon



Markerless system from OrganicMotion

Motion capture for special effects

(1) Capturing face motion with wrinkles

(2) Capturing cloth motion

(3) Capturing whole body skin deformation

Multi-Scale Capture of Facial Geometry and Motion
SIGGRAPH07,
Bernd Bickel, Mario Botsch, Roland Angst, Wojciech Matusik, Miguel A. Otaduy, Hanspeter Pfister, Markus Gross

Motivation:

to accurately animate the spatial and temporal behavior of a real person’s facial wrinkles.

Sketch of method:

(1) Face-scanning system from 3QTech to obtain the static, high-resolution face mesh: 500k–700k vertices, reflectance

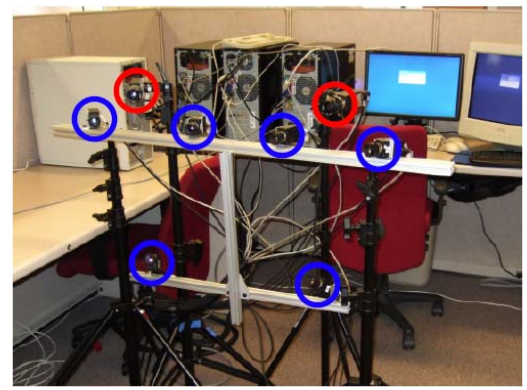
(2) 6 camera to capture blue marker at high frame rate

(3) Use RBF to set up correspondence between mocap and face model

(4) Use linear deformation model to capture the large scale face deformation

(5) 2 camera to capture the expression wrinkles width and depth

(6) Use nonlinear deformation model to capture the wrinkles



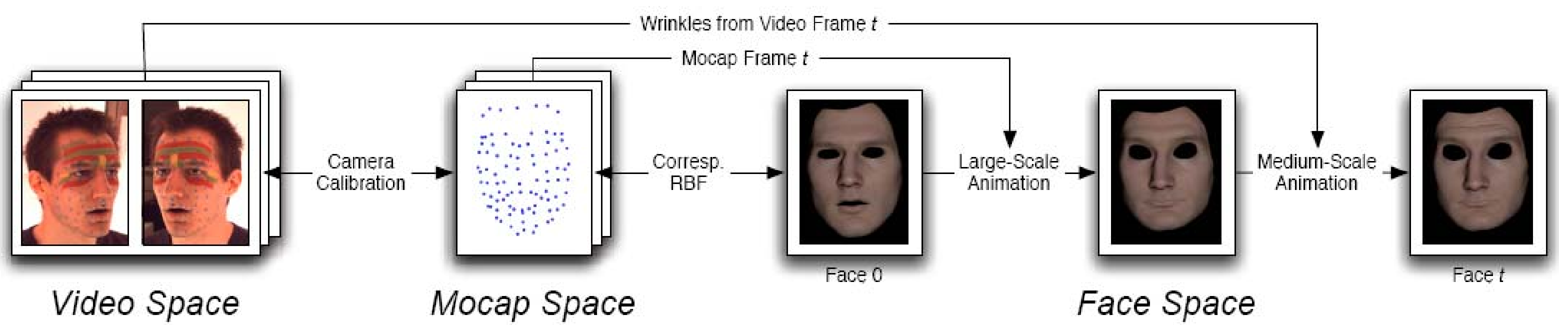


Figure 2: *In our framework we capture a video sequence and motion capture markers of an actor's performance, together with a static, high-resolution face scan. The camera calibration and correspondence function enable the transfer of information between those spaces. Our multi-scale face model first computes a large-scale linear deformation, on top of which medium-scale wrinkles are synthesized.*

Result discussion:

http://graphics.ethz.ch/~bickelb/publications.html

(1) Capture the wrinkles

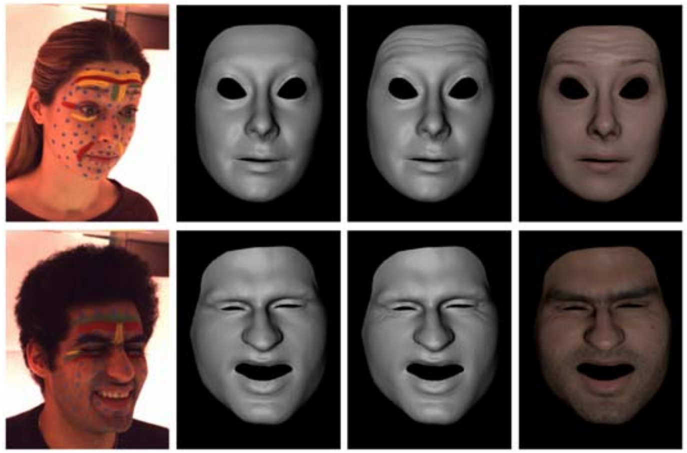


Figure 8: *Performance replay of captured video sequences (left) of two different subjects. The large-scale linear animation first deforms the high-resolution face mesh based on tracked mocap markers (center left). The missing medium-scale expression wrinkles are synthesized by a nonlinear energy minimization (center right). The rightmost column shows high-quality skin rendering including subsurface scattering.*

(2) Exaggerate/Edit the wrinkles

Capturing and Animating Occluded Cloth
SIGGRAPH07,
Ryan White,Keenan Crane,D.A. Forsyth

Motivation:

to capture garments with folds (such as wrinkles around a knee) and scenes with occlusion (one limb blocking another).

Sketch of method:

(1) Multiple synchronized 640x480 cameras at 24 fps

(2) Acquire a 3D point cloud of the cloth surface by printing a colored pattern on the cloth

(3) Use MeshIK to fill the hole

(4) Use MeshIK to attach the cloth to skeletal human motion capture data

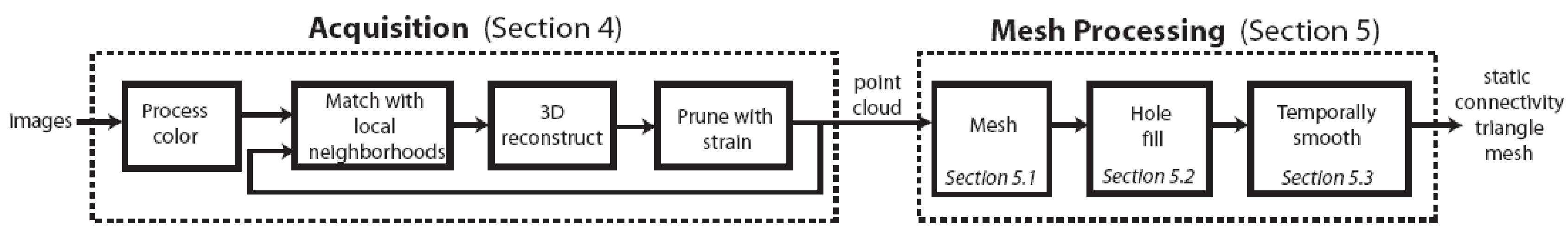


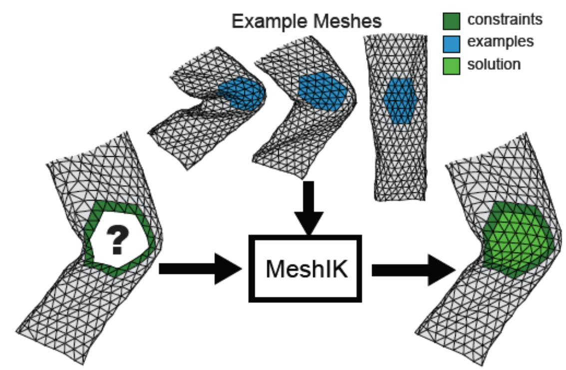
Figure 2: We construct an animated sequence of surface meshes in two stages: acquisition and mesh processing. In acquisition, we convert raw images into a 3D point cloud. In mesh processing, we triangulate the mesh, fill the holes and apply temporal smoothing.

Result discussion:

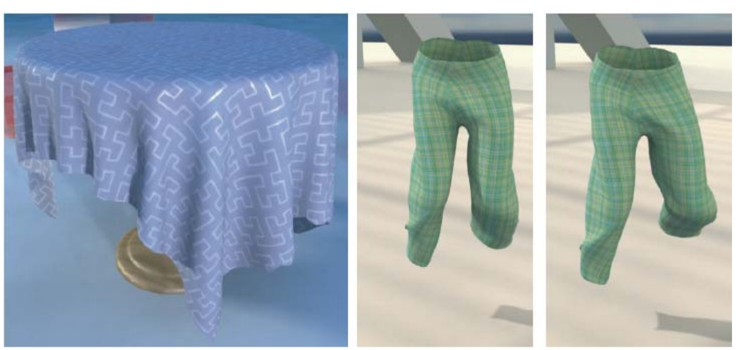
http://www.ryanmwhite.com/research/cloth_cap.html

(1) Cloth 3D reconstruction with printed pattern

(2) Fill the 3D reconstruction holes



(2) Capture the cloth motion



(3) Retarget the cloth motion to human motion capture data

Capturing and Animating Skin Deformation in Human Motion
SIGGRAPH06,

Sang Il Park, Jessica K. Hodgins

Motivation:

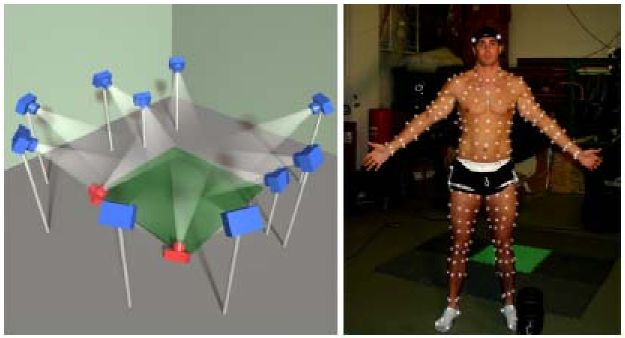
How to capture significant muscle and skin deformation in case of dynamic activities:

–Bending/Bulging

–Jiggling

–Stretching.

Sketch of method:

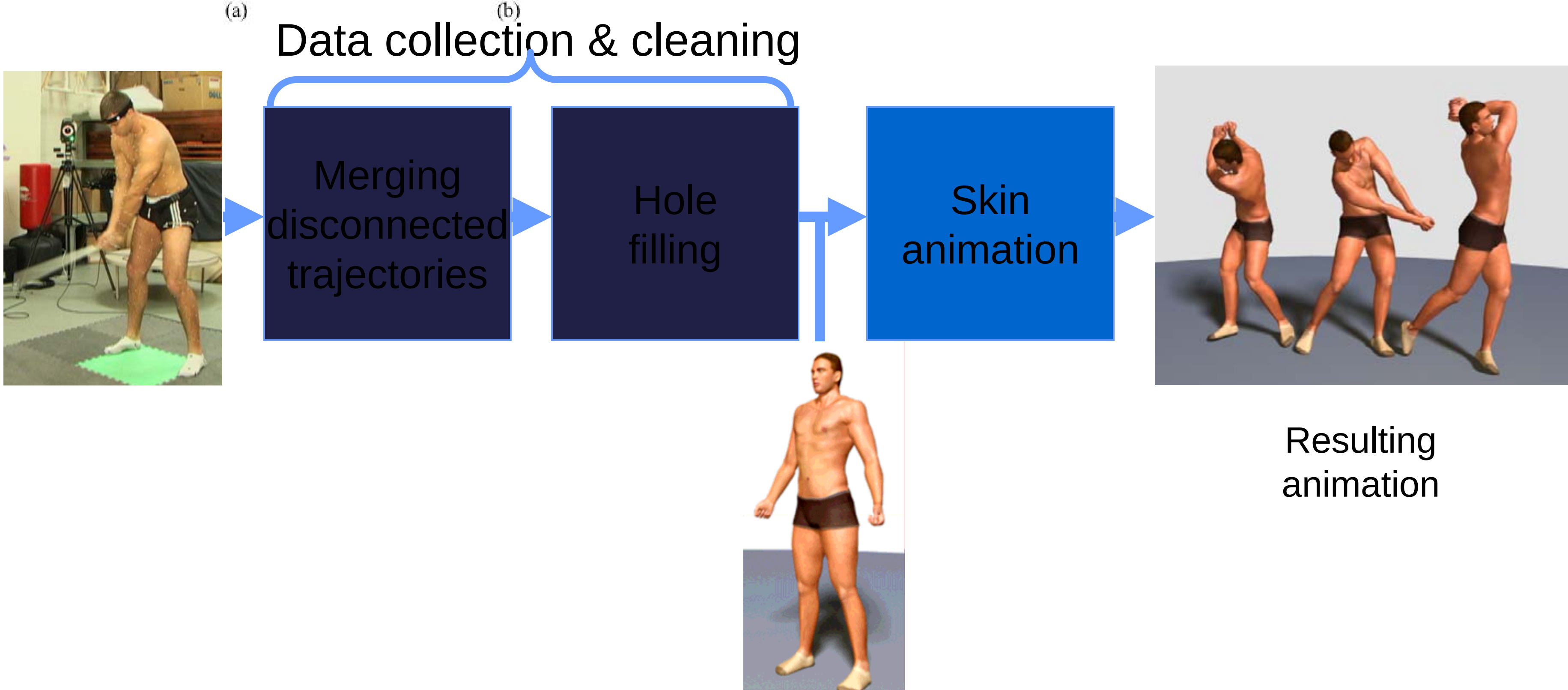


(a) (b)

Camera setup:

(1) Twelve cameras surrounding a small capture region.

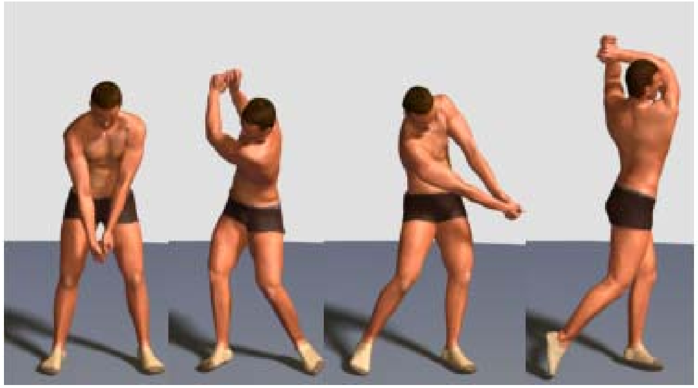
(2) 350 small markers attached to the subject's body.



Result discussion:

http://graphics.cs.cmu.edu/projects/muscle/

(1) Capture the detailed skin deformation for various activities



Special device for motion capture

(1) A portable (low-cost) motion capture system

(2) A high-speed optical motion capture system

Practical Motion Capture in Everyday Surroundings
SIGGRAPH07,

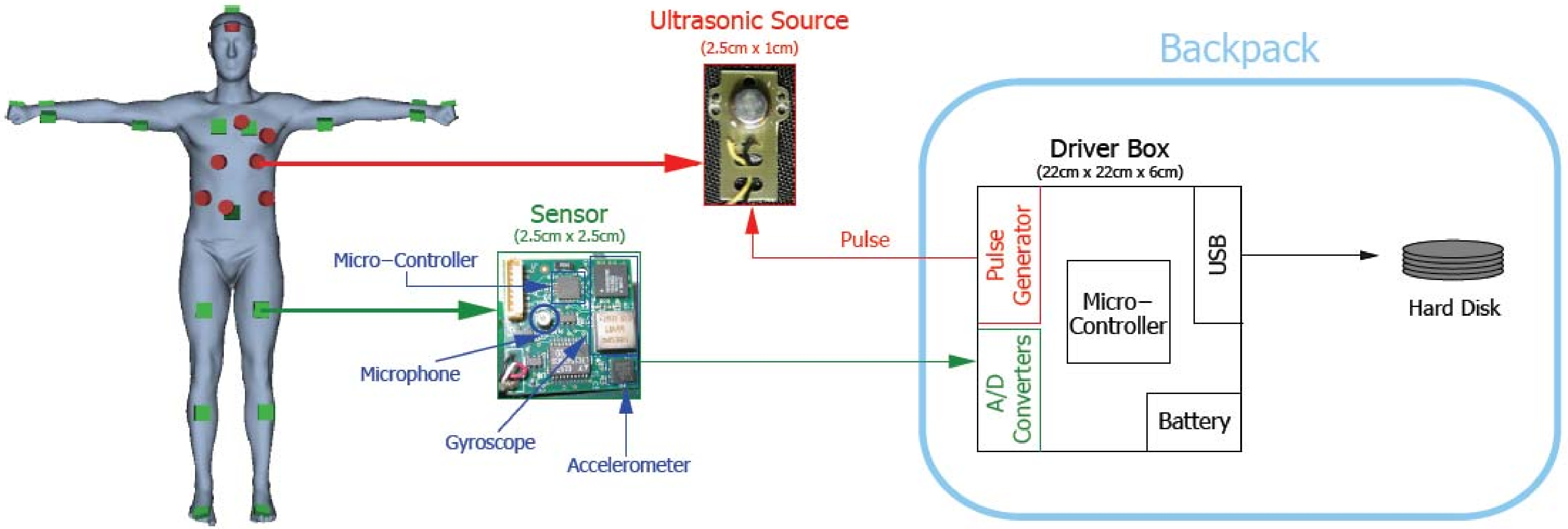
Daniel Vlasic, Rolf Adelsberger, Giovanni Vannucci, John Barnwell,
Markus Gross, Wojciech Matusik, Jovan Popović

Motivation:

Design a wearable self-contained system that is capable of recording and reconstructing everyday activities such as walking, biking, and exercising.

Sketch of method:

(1) System component:



Result discussion:

http://people.csail.mit.edu/jovan/

(1) Various motion capture examples
- the system is portable, and can be used for outdoor environment

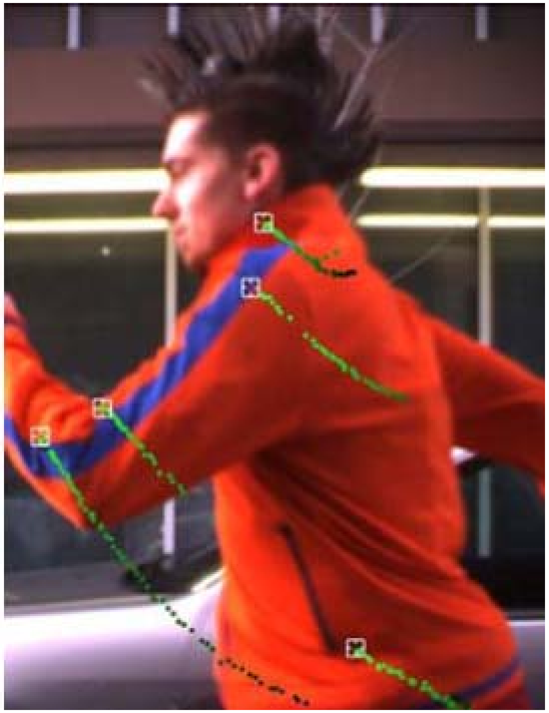
(2) Motion tracking accuracy is lower than vicon

(3) Their reconstructions exhibit drift in both global translation and rotation

Prakash: Lighting Aware Motion Capture using Photosensing Markers and Multiplexed Illuminators SIGGRAPH07,

R Raskar, H Nii, B de Decker, Y Hashimoto, J Summet, D Moore, Y Zhao, J Westhues, P Dietz, M Inami, S Nayar, J Barnwell, M Noland, P Bekaert, V Branzoi, E Bruns

Motivation:



They present a high speed optical motion capture method that can measure three dimensional motion, orientation, and incident illumination at tagged points in a scene

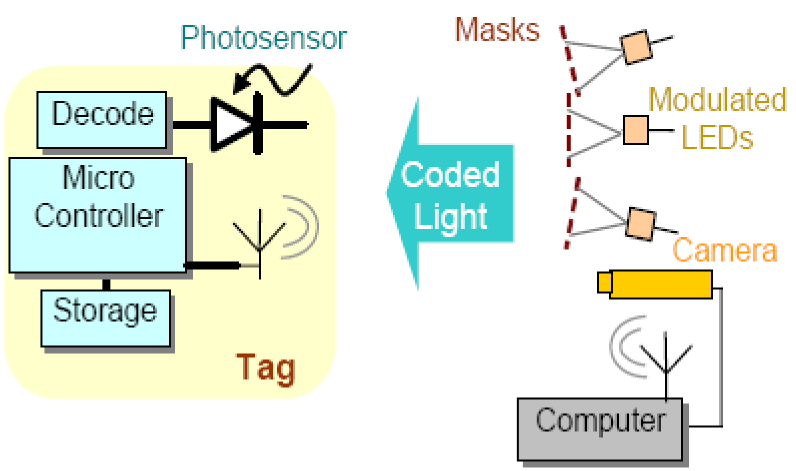
Sketch of method:

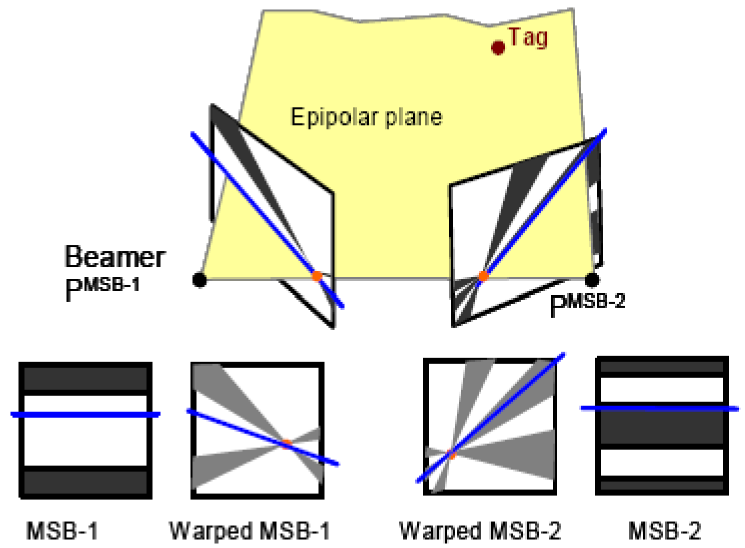
(1) Instead of high speed cameras, they use high speed projectors to optically encode the space

(2) Instead of retro-reflective or active light emitting diode (LED) markers, they use photosensitive tags to decode the optical signals to determine their location that exploits the epipolar geometry of a cluster of transmitters

(3) They measure the strength of the signal received from four or more LED *beacons*, which are used to compute tag orientations.

(4) The markers can be imperceptibly integrated with a performer's costume and shot under natural or theatrical lighting conditions

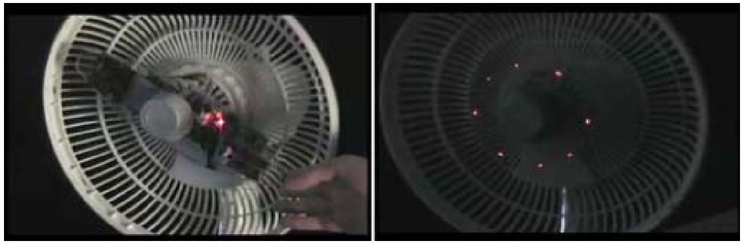




Result discussion:

http://www.merl.com/people/raskar/LumiNetra/

(1) Tracking high speed motion



(2) Tracking outdoor activity

(2) Video enhancement: synthetic object and motion blur

Motion capture for performance control

(1) Marker based motion control

(2) Markerless motion control

Performance Animation from Low-dimensional Control Signals
SIGGRAPH05,

Jinxiang Chai,Jessica K. Hodgins

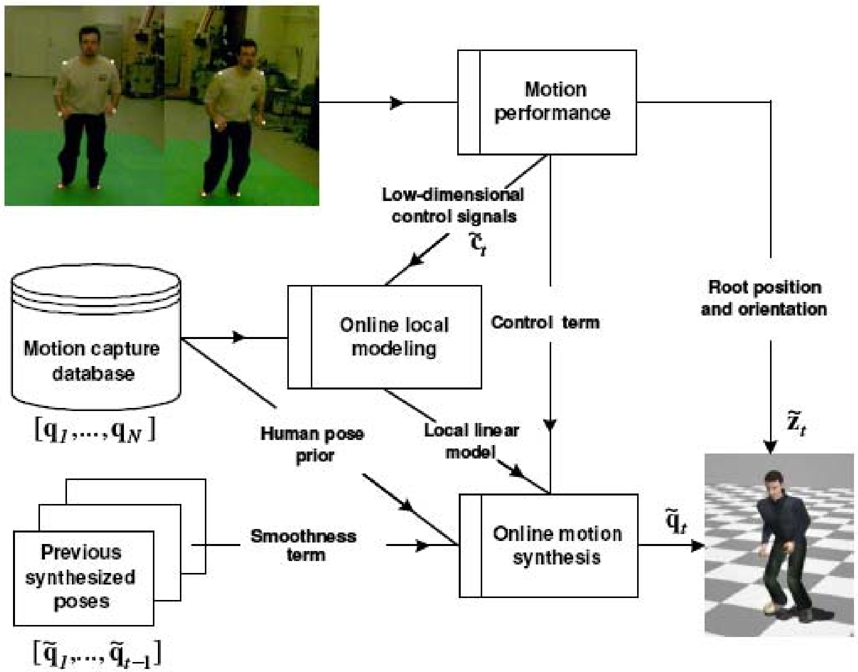
Motivation:

To capture motion/animation using:

(1) a small set of markers

(2) and motion database

Sketch of method:



(1) Two 640x480 camera at frame rate of 60 fps to capture the 3D marker positions

(2) Motion database is built as neighbor graph to speed up the neighbor searching

(3) Use the current marker positions and latest estimated poses to retrieve the similar poses from database

(4) Local linear model is obtained by PCA analysis on the similar poses

(5) Pose is further reconstructed as an optimization problem that including three factors:

- the closeness to reconstructed marker position
- the closeness to the local linear model
- the smoothness of the motion

Result discussion:

http://graphics.cs.cmu.edu/projects/performance-animation/pa_projectpage.html

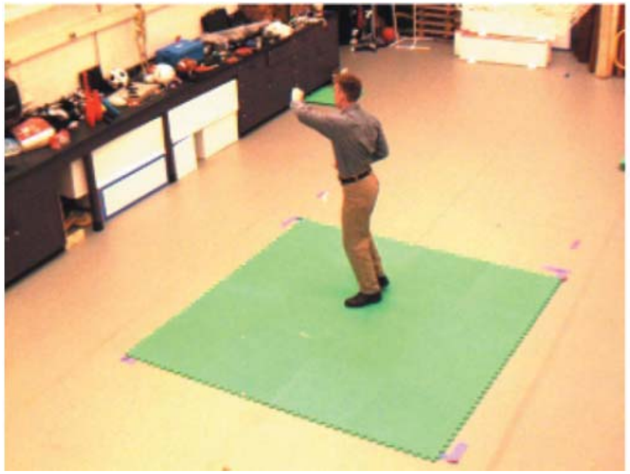
(1) The users' performance is used to control

- boxing,
- Kendo,
- walking,
- running,
- jumping
- and hopping

Learning Silhouette Features for Control of Human Motion
Transactions on Graphics05,

Liu Ren,Gregory Shakhnarovich,Jessic k. Hodgins,Hanspeter Pfister,Paul Viola

Motivation:

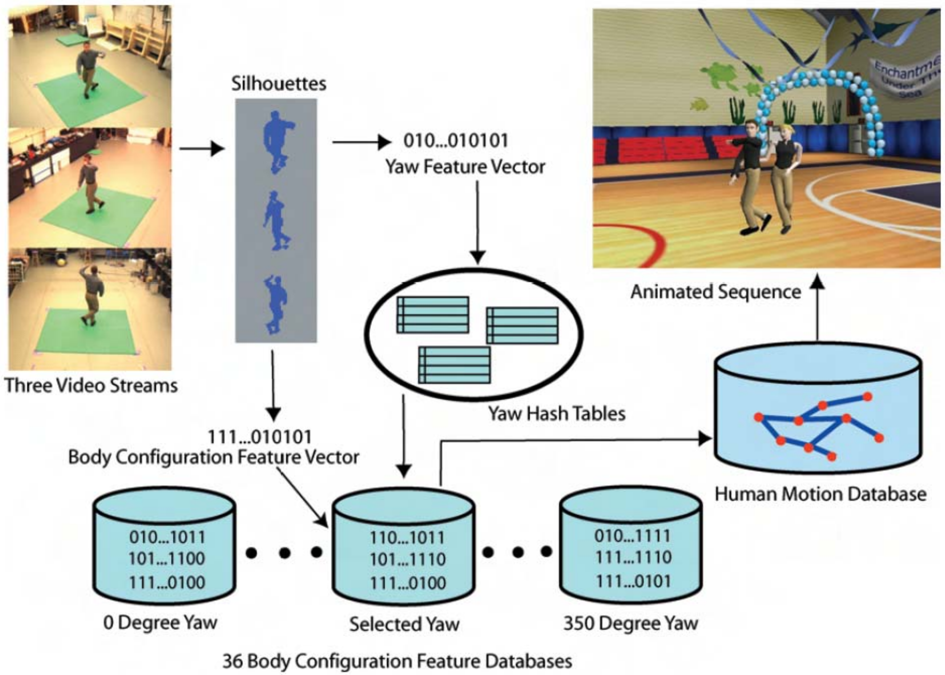


To capture motion/animation using:

(1) a set of silhouette features

(2) and motion database

Sketch of method:



(1) Three 640x480 camera at frame rate of 15 fps to capture the images
(2) Motion database is built as mograph with extra node to speed up the nearest neighbor searching
(3) Query the database includes two steps:

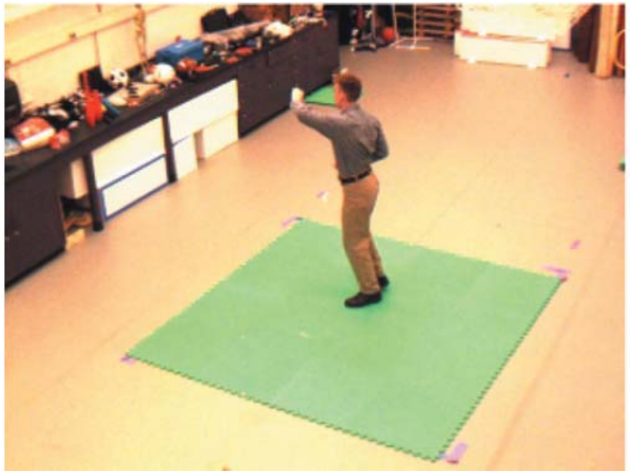
- Learning and query yaw angles
- Learning and query the body configuration

Result discussion:

http://graphics.cs.cmu.edu/projects/performance-animation/pa_projectpage.html

(1) Demo video of swing dancing

• No interpolation is performed, only query the nearest neighbor



Markerless motion capture

(1) Back-projection based approach

(2) Visual-hull based approach

(3) Commercial systems

- ***OrganicMotion***
- ***CaptiveMotion***

Free-Viewpoint Video of Human Actors
SIGGRAPH03,

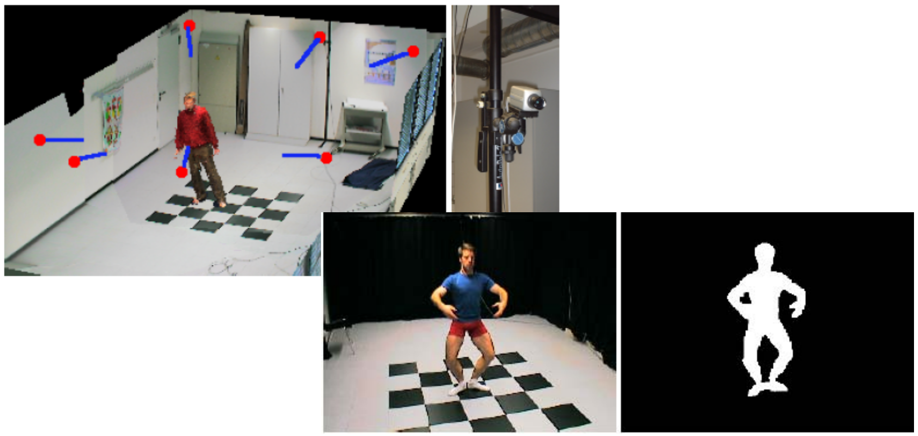
Joel Carranza, Christian Theobalt, Marcus A. Magnor, Hans-Peter Seidel

Motivation:

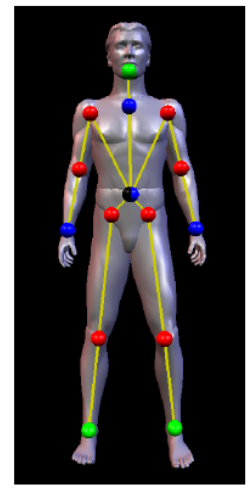
- To capture motion and appearance from multiple cameras (offline)
- To interactively re-render the appearance from any viewpoint

Sketch of method:

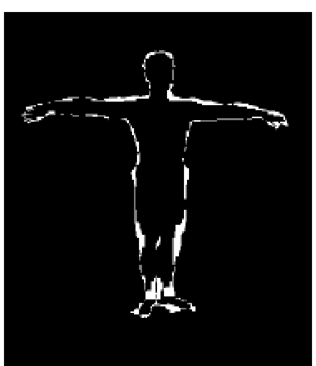
(1) Multiple camera system configuration



(2) Articulated human model



(3) Pose estimation as minimization of energy function formed from the difference between captured silhouette and model back-projected silhouette



(4) Texture generation to avoid the occlusion

Result discussion:

http://www.mpi-inf.mpg.de/~theobalt/FreeViewpointVideo/free_viewpoint_video.html

(1) Video demo on motion capture

Markerless tracking of complex human motions from multiple views
CVIU06,

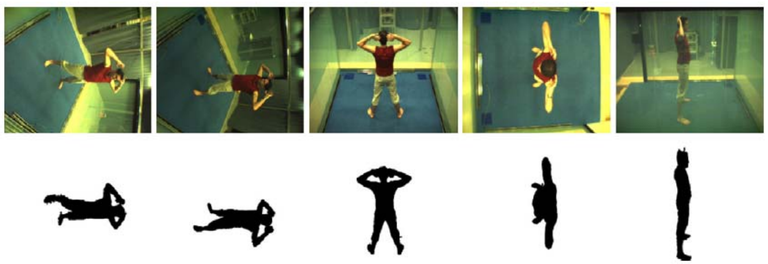
Roland Kehl, Luc Van Gool

Motivation:

- To capture motion and appearance from multiple cameras

Sketch of method:

(1) Multiple camera system configuration



(2) Visual hull reconstruction

(3) Articulated human model

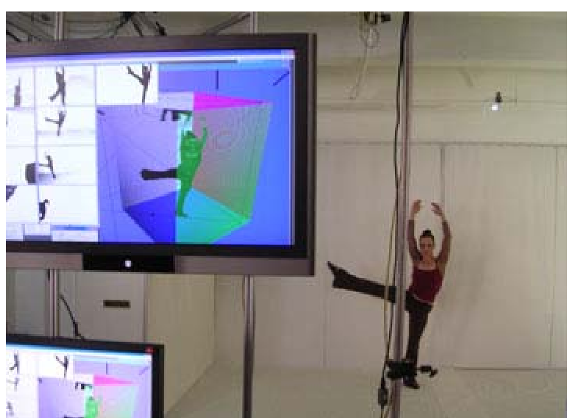
(4) Pose estimation as minimization of energy function formed from:

- the alignment between model and visual hull.
- the alignment between model occlusion contour and image edge

OrganicMotion
http://www.organicmotion.com/

After working for four years, Tschesnok's efforts yielded a now patent-pending code which makes up the heart of the first commercial markerless motion capture system breaking from the pattern comparison approach completely

Tschesnok developed a system using 10 2D cameras that track the subject. The data output from each camera is then fed into a vision processor which maps every pixel of information and triangulates the location of the subject by seeing where the various camera images intersect. The system dynamically makes decisions on what pixels are of higher value than others. In this way it is similar to the way a human looks at a complex scene: Head, hands and rapidly moving body parts hold more of our attention than static elements.



Motion capture: comments and discussion

(1) Robustness of the motion capture algorithm

- For marker based optical motion capture, marker occlusion handling is an challenging problem for fully-automatic motion capture.
- For markerless based optical motion capture, it is difficult to reconstruct pose when body parts are close to each other (such as arm touches the torso). At that moment, tracking might fail, and should be recovered automatically afterward.

(2) Outdoor scene motion capture (from lab to real-world)

(3) Single camera based motion capture (for easy system deployment)

(4) Intelligent application and processing of motion capture data such as:

- Data-driven animation through retargeting
- Etc.