Motion Capture
Specialized Motion Capture

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Outline

Introduction: what is Motion Capture?

History and Motion Capture technologies.

Passive Markers Motion Capture.

Specialized motion capture: hand, gaze and face.

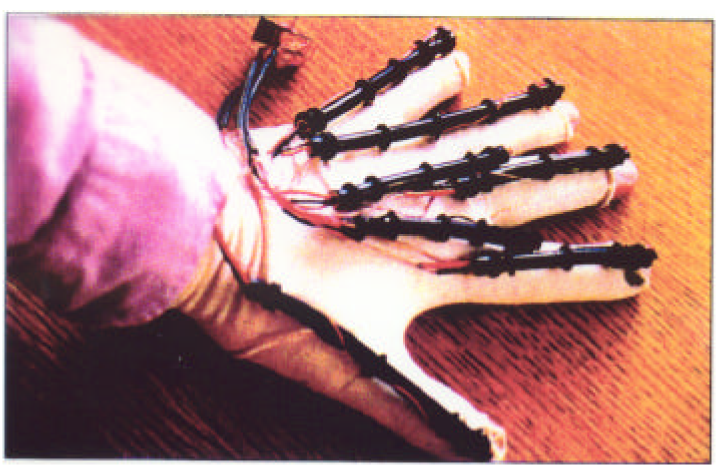
From Motion Capture to Animation (post-processing)

Gloves

Monitor fingers position and force.

Problems with the motion of the fingers:
• overlap.
• fine movements.
• fast movements.
• rich repertoire.

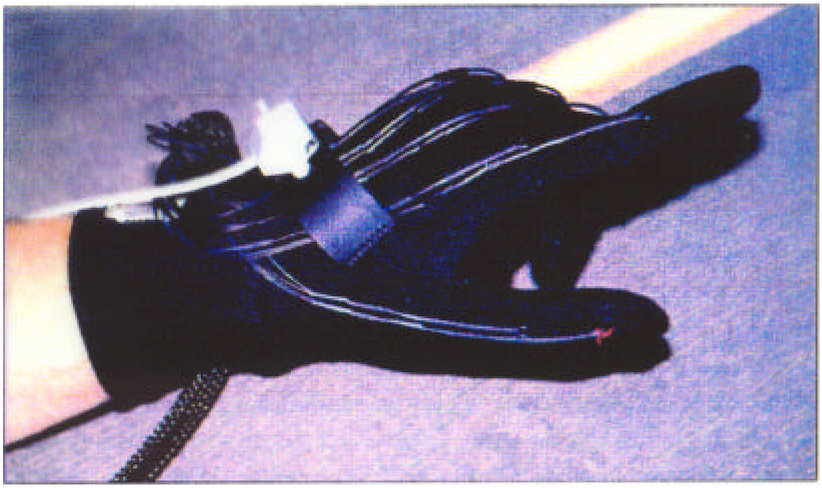
Sayre glove (1976)



MIT glove (1977)

Digital Data Entry Glove (1983)

Data Glove (1987)



Power Glove (1990)

Cyber Glove (1995)

Calibration

Estimate of the geometrical parameters in the transformation operated by the sensors (e.g. the perspective transformation operated by a video-camera).

Estimate of the parameters, which describe distortions introduced by the measurement system.

Measurement of a known pattern. From its distortion, the parameters can be computed.

Algorithms adopted: polynomial, local correction (neural networks, fuzzy).

Haptic displays

Convey to the subject the sensorial information generated in the interaction with the virtual objects: force, material texture…

Measure the force exerted by the subject on the virtual environment.

Aptic displays provide a mechanical interface for Virtual Reality applications.

Most important developments have been made in the robotics field.

Requirements of haptic displays

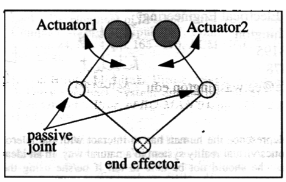
- Large bandwidth.
- Low intertial and viscosity.

Technological solutions:

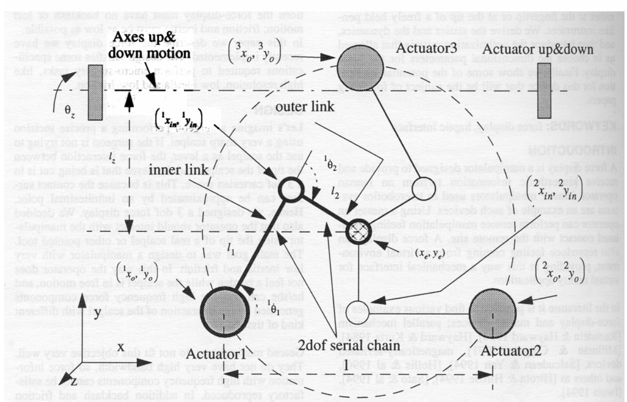
- Direct drive manipulandum (Yoshikawa, 1990), Phantom (2000).
- Parallel manipulandum (Millman and Colgate, 1991; Buttolo and Hannaford, 1995).
- Magnetic levitation devices (Salcudean and Yan, 1994; Gomi and Kawato, 1996).
- Gloves (Bergamasco, 1993).

Direct drive manipulandum (phantom)

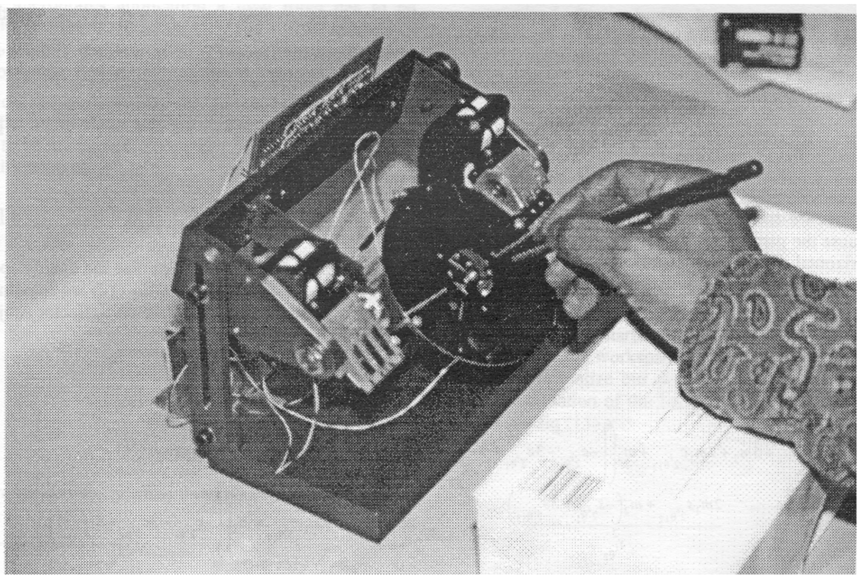
Parallel manipulandum (schema)



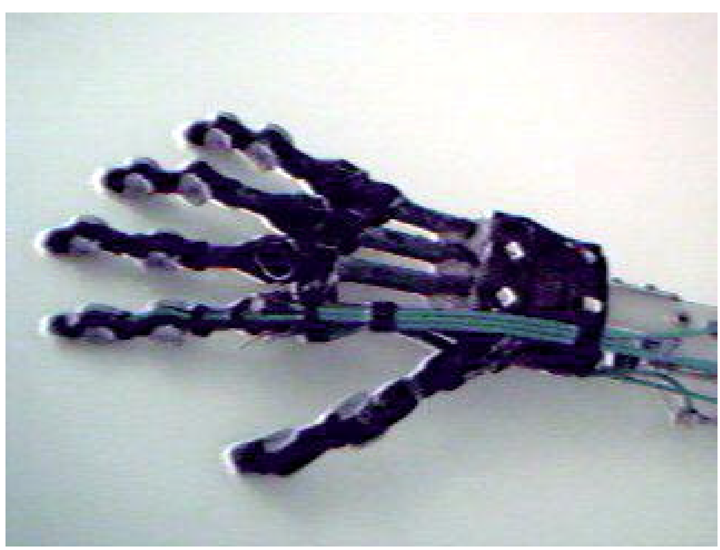
Hannaford et al.



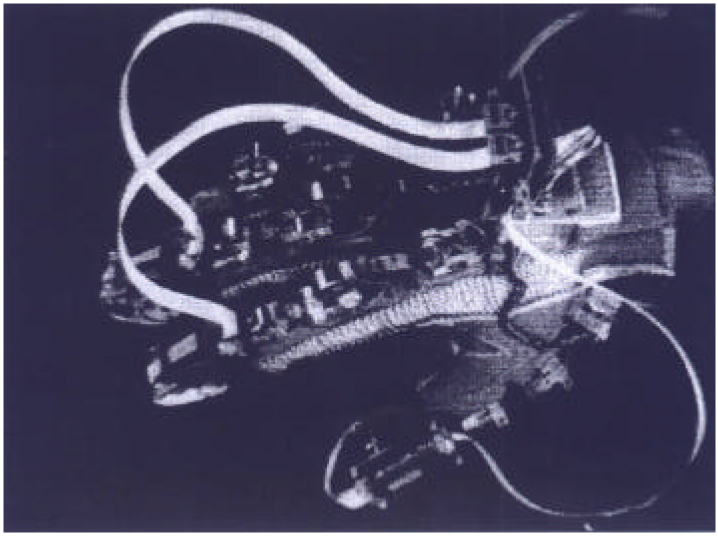
Pen haptic display



Gloves (Gini et al., Blackfinger, 2000)

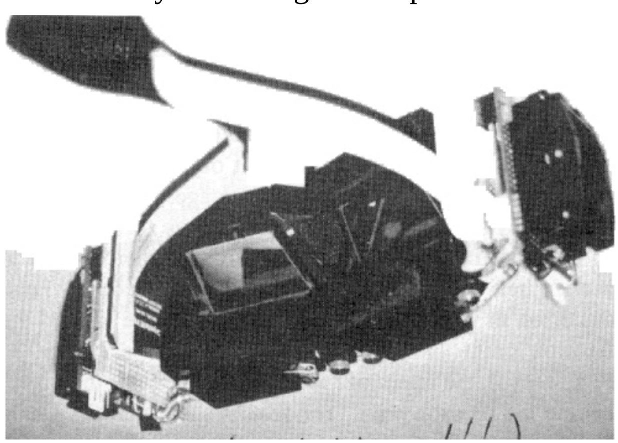


Percro gloves (Begamasco, 1993)



Gaze input

•Contact lenses carrying magnetic coils.
•Tvcameras aligned with an IR LED source.
•Stereoscopic eye-wear.
• The direction of gaze is decided by measuring the shape of the spot reflected by the frontal portion of the cornea (Ohshima et al., 1996).



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Maria Callas: Virtual Tosca

Performance-driven

Animation based on the motion capture (in some cases, in real-time) of an actor.

Types of performance-driven:
•Expression mapping
•Model-based persona transmission

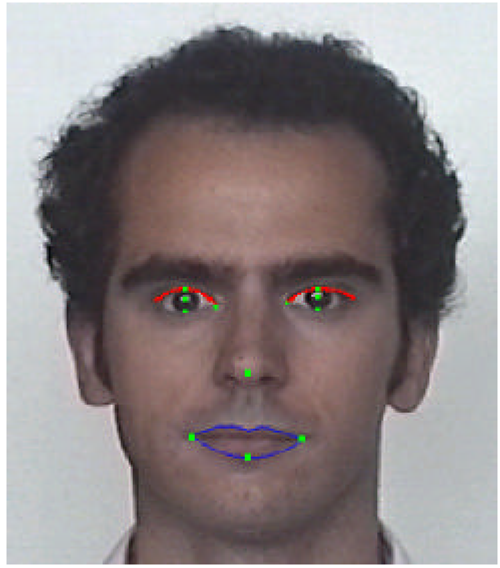
Expression mapping

•Images of 20 expressions.
•Identify the correspondance between the image and the character in neutral position.
•Computation of the deformation field for the character.
•Application of the deformation field to the character (possibility of exaggerating the expression).

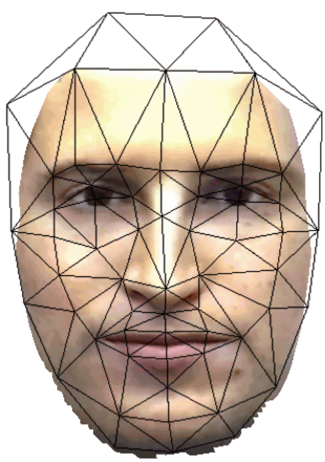
•Tony de Peltrie, 1985.

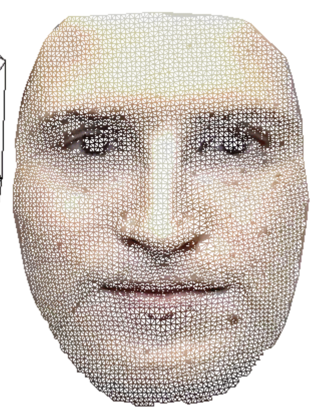
Model-based Persona Transmission, feature based

Identifying the features to map the model to the character.



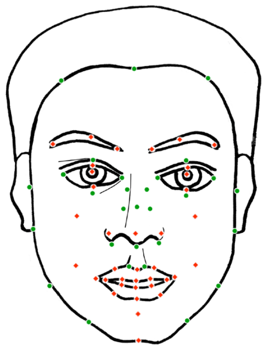
Model-based Persona Transmission, mesh based





•Deformation of a topological mesh induced by a control mesh.
•The control mesh connects the marker points.

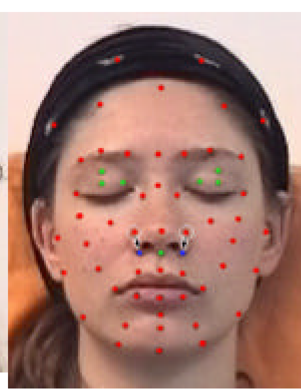
Markers disposition

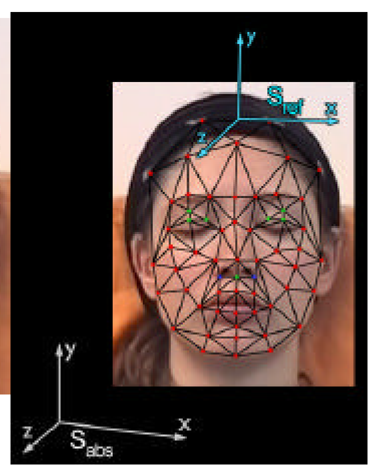


Position of the feature points
according to MPEG-4 standard:
- ◆ principali
- ● secondari

Problems with:
Eyes and tongue.
Nose basis (visibility).

Construction of the Control Mesh





47 markers on the skin:
- *Problems with:*
Eyes and tongue.
Nose basis (visibility).

4 markers on an elastic band:
To identify a local Reference Frame (LRF).

- 51 Markers acquired (cf. MPEG-4 specifications).
- 7 virtual markers defined through the LRF (green).
- 2 Virtual markers defined through Real Markers (blue).
- 56 control points for the mesh + 4 for LRF.

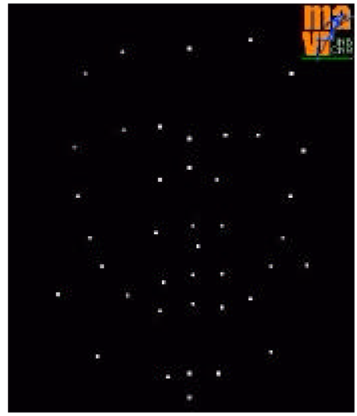
A possible implementation of mesh deformation

Model constituted of a 3D mesh, inspired to the anatomy.
Goal: duplicate facial appearence with few parameters.

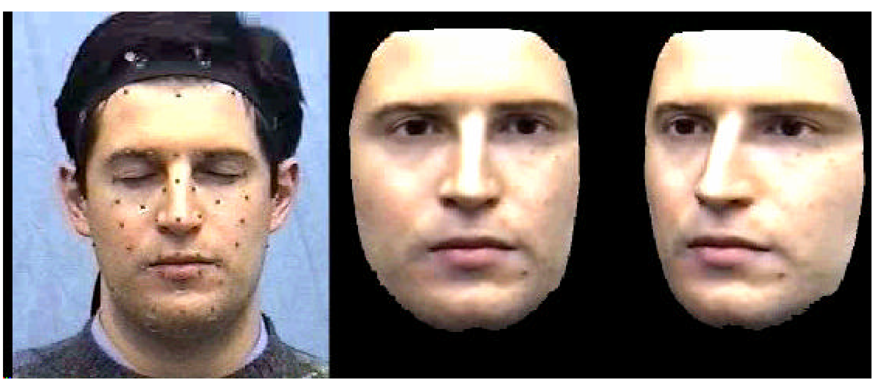
Mesh warping is induced by the modification (of the position of) few features.

The modification consists in the change in 3D position of the features.

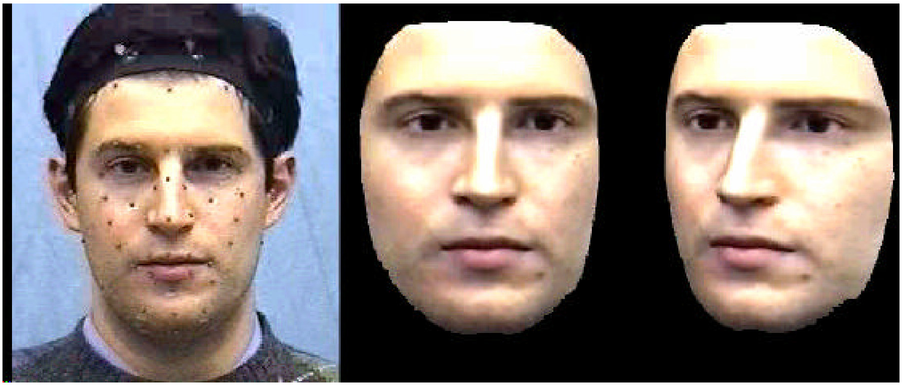
The modified mesh is then rendered.



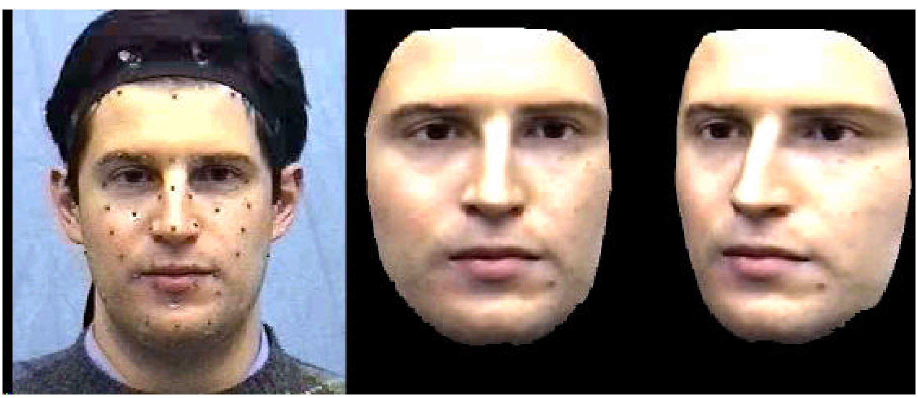
Disgust



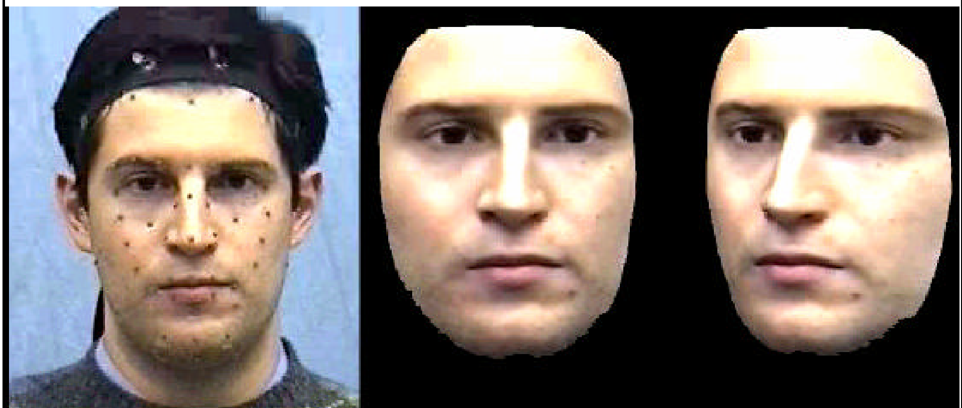
Fear



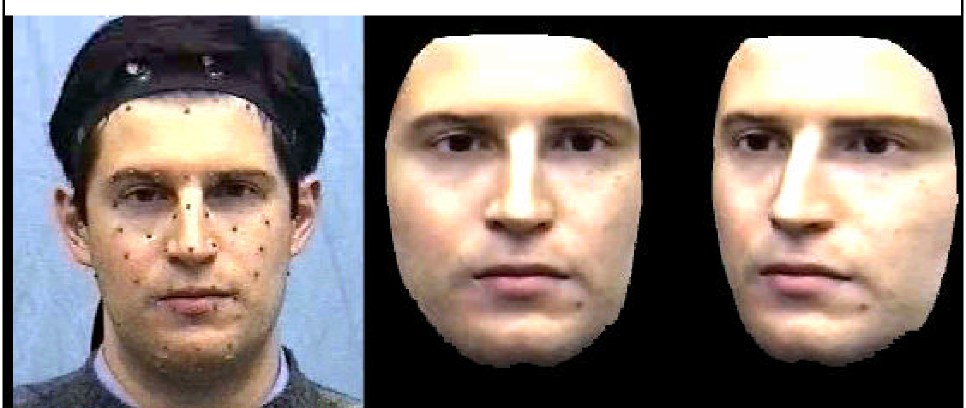
Anger



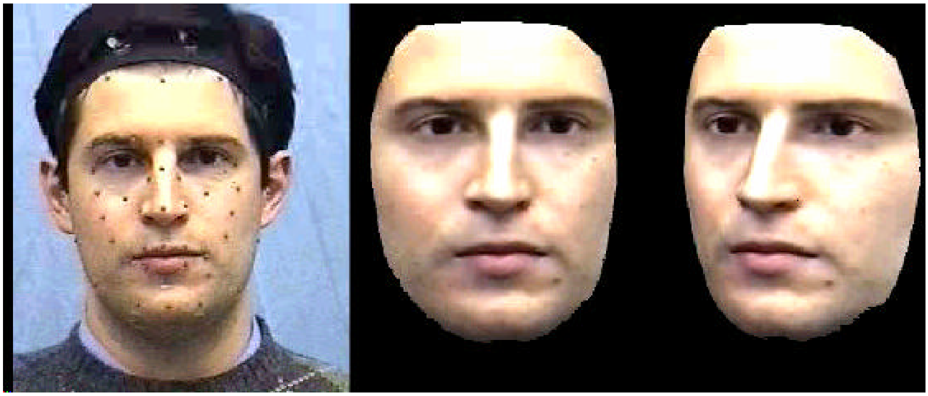
Surprise



Sadness



Happiness

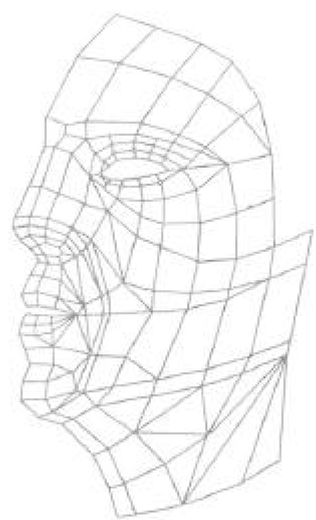


Direct parameterization

Universal model (e.g. Parke's model, 1974) + few parameters to adapt the model and obtain "key poses" or "animation curves".

The time course of the parameters can be given or derived from motion capture.

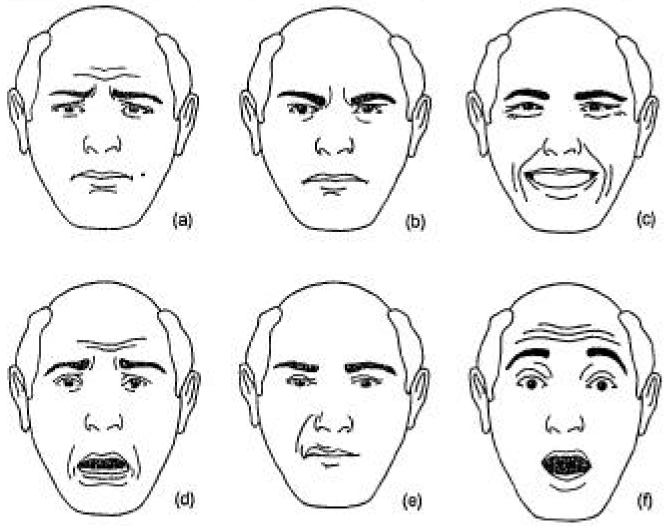
Complexity of the face, from the kinematics / deformation point of view, is captured by the mesh (points + connectivity).

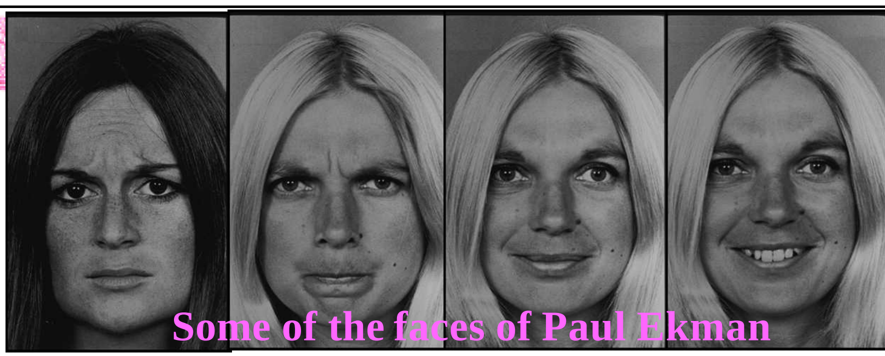


Expressive structure of the face

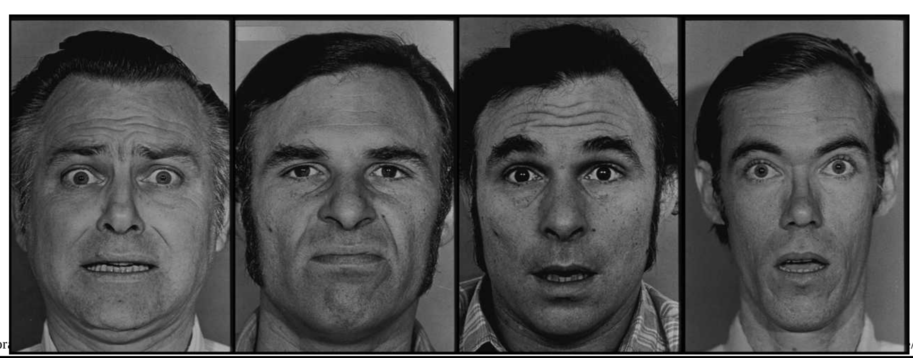
•Emotion expression. Mainly in the eyes, eye-brows and mouth.

•Somatic expressions: pain, sleepness, hungry, attention, shock…





Some of the faces of Paul Ekman



How FACS was developed

•The main idea was to determine which muscles can be activated **indipendently** and determine how these muscles modify the appearance of the face.
•Goal is to identify elementary motion associated to each elementary action (**Action Unit**): many muscles contribute to the single elementary action.
•The corrispondence between muscles and Action Units is many to many.
•The identified Action Units are 46. ***They are activated in different percentage in each expression ➔ They are added to produce a given facial expression.***

•Problems are in the description of jaw and lips motion.

The Action Units (AU)

AU	FACS Name	Muscular Basis
1	Inner Brow Raiser	Frontalis, Pars Medialis
2	Outer Brow Raiser	Frontalis, Pars Lateralis
4	Brow Raiser	Depressor Glabellae, Depressor Supercilli, Corrugator
5	Upper-Lid Raiser	Lavator Palpebrae Superioris
6	Cheek Raiser	Orbicularis Oculi, Pars Orbitalis
7	Lid Tightener	Orbicularis Oculi, Pars Palebralis
8	Lips Together	Orbicularis Oris
9	Nose Wrinkler	Levator Labii Superioris, Alaeque Nasi
10	Upper-Lip Raiser	Levator Labii Superioris, Caput Infraorbitalis
11	Nasolabial Furrow Deepener	Zygomatic Minor
12	Lip Corner Puller	Zygomatic Major
13	Cheek Puffer	Caninus
14	Dimpler	Buccinnator
15	Lip Corner Depressor	Triangularis
16	Lower-Lip Depressor	Depressor Labii
17	Chin Raiser	Mentalis
18	Lip Puckerer	Incisivii Labii Superioris, Incisivii Labii Inferiouis
20	Lip Stretcher	Risorius
22	Lip Funneler	Orbicularis Oris
23	Lip Tightener	Orbicularis Oris
24	Lip Pressor	Orbicularis Oris
25	Parting of Lips	Depressor Labii, or relaxation of Mentalis or Orbicularis Oris
26	Jaw Drop	Masetter; relaxed Temporal and Internal Pterygoid
27	Mouth Stretch	Pterygoids; Digastric
28	Lip Suck	Orbicularis Oris
38	Nostril Dilator	Nasalis, Pars Alaris
39	Nostril Compressor	Nasalis, Pars Transversa and Depressor Septi Nasi
41	Lid Droop	Relaxation of Levator Palpebrae Superioris
42	Eyelid Slit	Orbicularis Oculi
43	Eyes Closed	Relaxation of Levator Palpebrae Superioris
44	Squint	Orbicularis Oculi, Pars Palpebralis
45	Blink	Relax Levator Palpebrae and then contract Orbicularis Oculi, Pars Palpebralis
46	Wink	Orbicularis Oculi

AU	FACS Name
19	Tongue Out
21	Neck Tightener
29	Jaw Thrust
30	Jaw Sideways
31	Jaw Clencher
32	Lip Bite
33	Cheek Blow
34	Cheek Puff
35	Cheek Suck
36	Tongue Bulge
37	Lip Wipe

Avenues of research

Detailed biomechanical models (FEM). Not compatible with real-time for non-linear elements.

Streaming of images over the 3D mesh.

Blending 3D models of "critical" parts (tongue, teeth..) and pre-defined texture for grooves (bump mapping) with the 3D mesh.

Map feature or marker motion into FACS => Animate a "physical" mesh.

Intersting problems:

- Impossible interviews.
- Virtual speakers for low-band transmission.
- Rehabilitation.

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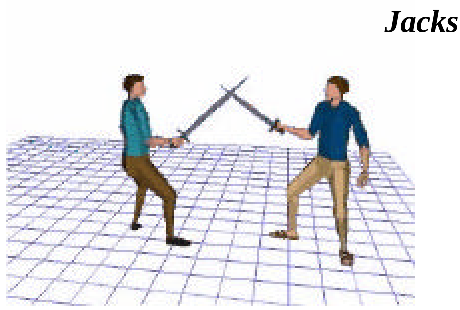
Avatars and Motion Capture



Avatars are goods from the heaven (from Induism, usually Visnù)

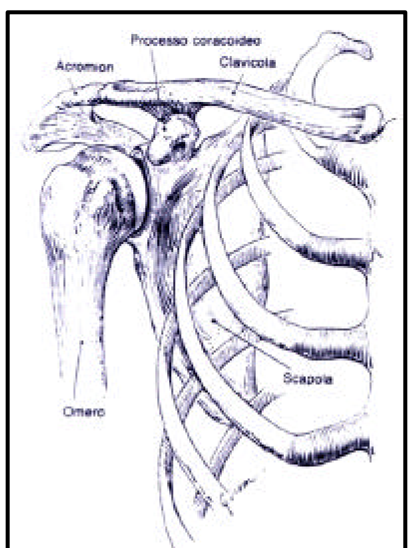
http://www.plmsolutions-eds.com/products/efactory/jack/moviesandimages.shtml

The human skeleton has complex articulations

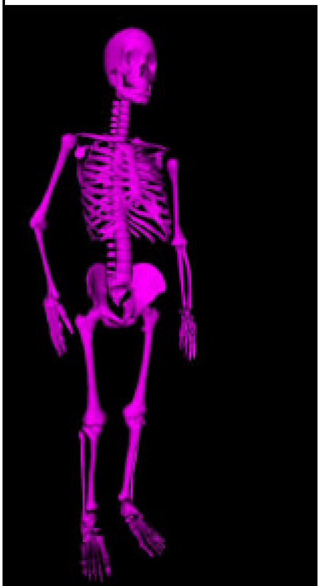
"Rigid" bones connected. Tendons keep the bones in place.

Motion allowed can be very complex (e.g. shoulder, spine).

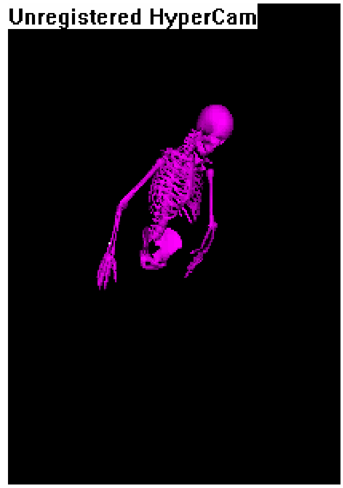
The reconstruction of the finest details of the motion are beyond reach, simplifying assumptions are made => ***Level of detail*** in motion analysis



Retargetting



From Motion Capture to Virtual Motion:
3D positions $\rightarrow$ Angles
Model fitting
Motion correction



Motion correction & retargetting

What happens if the arm of the digital character enter inside the shoulder of his girl-friend?

The problem is reframes as an optimal control problem.

Zero error in the final frame.

Minimal deviation of the control actions (the angle sequence).

$$\underset{\{\mathbf{u}(t_k)\}}{a\sum_k}\left(\mathbf{u}_k(t)\right)^2 + b(\mathbf{x}_d(t_N) - \mathbf{x}(\mathbf{t}_N))^2$$

Hard and Soft constraints

Motion retargetting: an example

Data captured have to be adapted to a smaller female.

Motion retargetting: an example

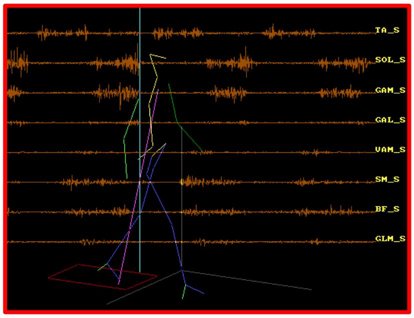
Clinical Motion Analysis

MOTION ANALYSER

FORCE TRANSDUCER

MATHEMATICAL MODELS

EMG



JOINT KINEMATICS

JOINT KINETICS

EXTERNAL FORCES

PLANTAR PRESSION

MUSCLE ACTIVATION AND FORCE

The future

Digital and Reality in real-time (virtual theater).

Color-coded markers.

Mixed vision/marker techniques.

Integration of gloves, gaze trackers and marker trackers.

Detailed biomechanical models.

More biology into digital characters (motion retargetting, with "biological rules").

Is there any future for motion capture?

Motion capture