Real-Time Individualized Virtual Humans

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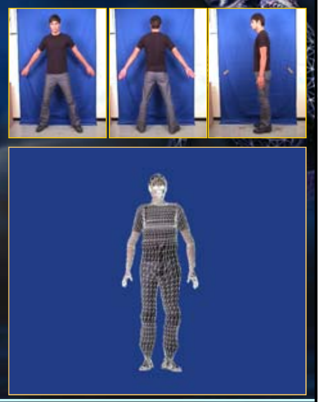
Body Creation: 3D body cloning -

- Structured images input + known topology
- 3D capture techniques
  - from 2D images
  - digitalization

Creating textured cloth body

- Body Cloning & textured cloth:
  - Input:
    - Three photographs.
    - H-Anim 1.1 generic body
  - Feature:
    - Edge based.
  - Output:
    - Animatable virtual human.



Textured cloth body animation

- Motion capture:
  - Optical motion capturing system (Vicon)
  - Anatomical converter > sensor information in model animation parameters.

Motion Capture

Textured cloth body animation

Human body modeling

- One of the most difficult task of animators
  - Realistic body model
    - Accurate geometric surface
    - Appropriate skeleton structure
- Capture of shape and size of real body
  - Range scanner, image-based reconstruction,…
  - Time-consuming to modify
- Interpolation
  - Obtain new models from existing ones
  - Rapid generation, high-level manipulation

Articulated Body Deformation

Allen et al introduced Articulated body deformation from range scan data

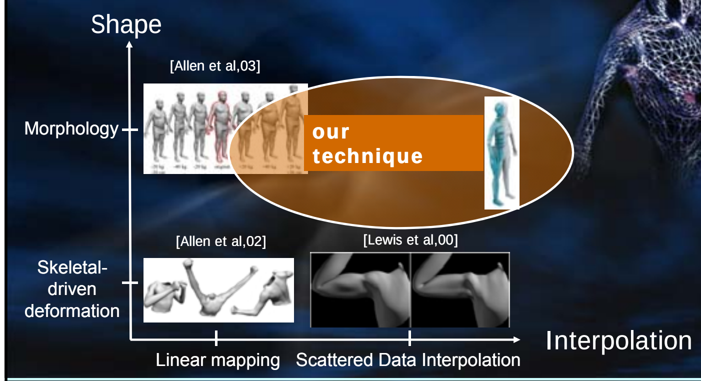
- Example-based, posable model from high definition shape changes.
  - Capture human body scan
  - Estimate Pose and Kinematics
  - Reconstruct subdivision surfaces at each pose

Space of human body shapes

Allen et al extended their work to the reconstruction and parametrization from large range scans

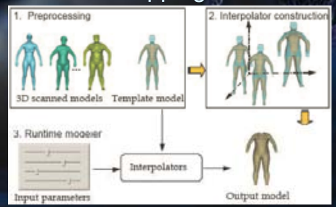
- Fitting high-resolution template meshes (250) to detailed human body range scans with sparse 3D markers
- Able to morph between individuals, and begin to characterize and explore the space of probable body shapes

Seo, Magnenat-Thalmann, "an automatic modeling of Humans Bodies from sizing parameters", ACM Symposium on 3D graphics, 2003



Example-based approach
Seo et al used scanned human data and template model

- Design of template model with appropriate skeleton attachment
- Landmarks placement for parametric deformations
- Database search for scanned data
- Template model mapping on the scanned data
- Skeleton adjustment and displacement mapping.



Seo , Magnenat-Thalmann : an automatic modelling of human bodies from sizing parameters, Proc. I3D 2003

Recent method to create VH in RT

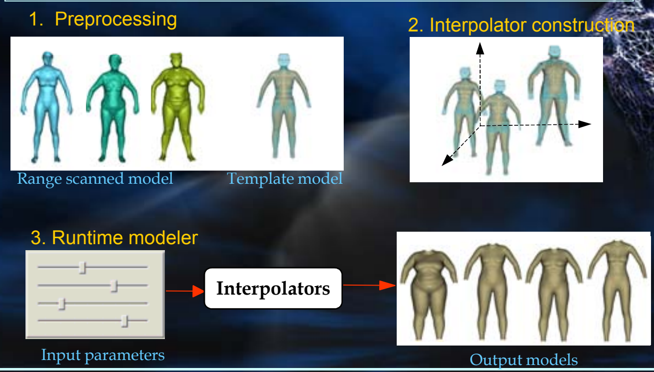
- Scan *examples*
  - Captured geometry of real people provides the best available resource
    - variation, commonality
    - Realistic estimation
- Predetermined topology
  - Vector representation
    - At a desired level
  - Reuse of the skinning data
  - Easily handle scan bodies of different postures
    - joint center estimation
- Interpolation
  - continuous transformation field

3D Scanned Data

- 100 subjects (European adults)
  - Techmath,AG range scanner
  - Erect posture with arms and legs apart, lightly clothed
  - Without faces, no texture
- Additional processing using commercial packages
  - One single mesh with no holes and no open edges
  - Moderate complexity (# of triangles: <=75,000)

Overview of bodysizer

H.Seo, N.Magnenat-Thalmann, An Automatic Modeling of Human Bodies from Sizing Parameters, Proc. ACM SIGGRAPH 2003 Symposium on Interactive 3D Graphics,May 2003, pp.19-26.

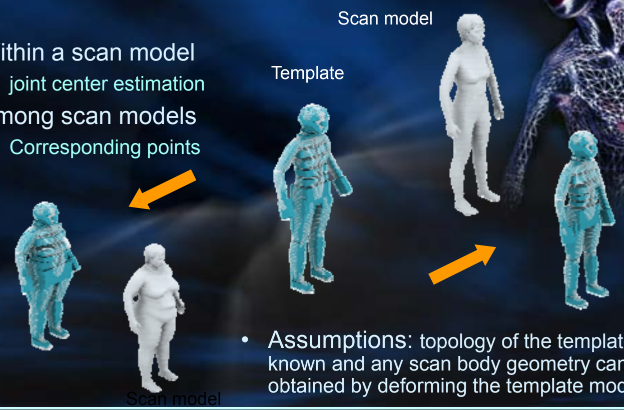


Template Model

- Skeleton
  - H-Anim standard
  - LoA 2, 33 joints excluding hands and feet
- Template mesh
  - Grid structure
    - Bezier patches
  - Two levels of detail
    - 861 and 3401 vertices
- Skinning setup
  - Using 'BonesPro' [www.digimation.com]

Preprocessing : conforming a template model onto each scanned example

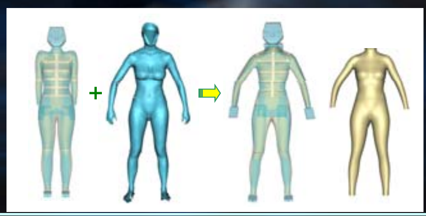
- Within a scan model
  - joint center estimation
- Among scan models
  - Corresponding points



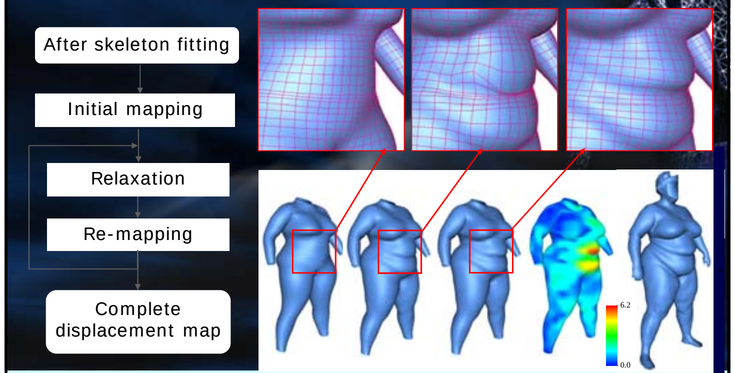
- Assumptions: topology of the template is known and any scan body geometry can be obtained by deforming the template model

Skeleton Fitting

- Find posture and proportion of the scanned model by using position, scale and rotation of each bone of the template
- When applying different joint parameters during fitting, skeleton-driven deformation is used to calculate new positions of skin surface according to the transformation of the underlying skeleton.



Fine skin refinement: deforms the template mesh by computing the displacement vector for each vertex.



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Synthesizer construction

- Modeling synthesizers (mapping functions):
  - Allow runtime evaluation of the body geometry from the input parameters . The goal is to produce a new deformation of the template model derived through the interpolation of the example shapes.
  - *Joint* and *displacement* synthesizers
- As we have high dimensional geometry data and relatively small number of examples, it falls into a scattered data interpolation problem.
  - Consider each example as an interpolant
  - We adopted GRBF (Gaussian Radial Basis Function) which is reputed to behave well in a mild condition

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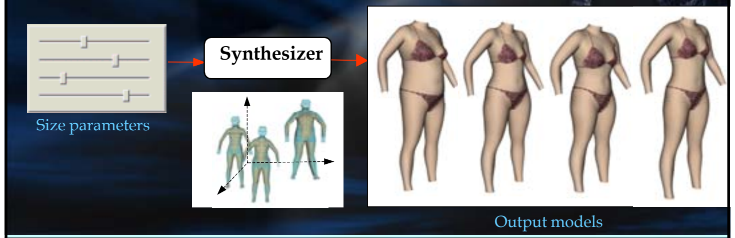
Runtime modeler

- Once the interpolators are built, the model generation at run-time is essentially function evaluation
  - Less than 0.5 sec, including the skin attachment recalculation



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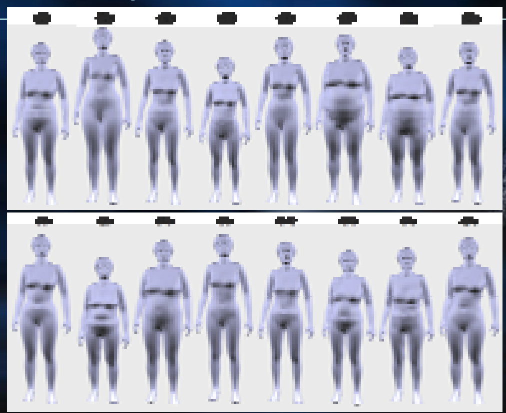
Some examples



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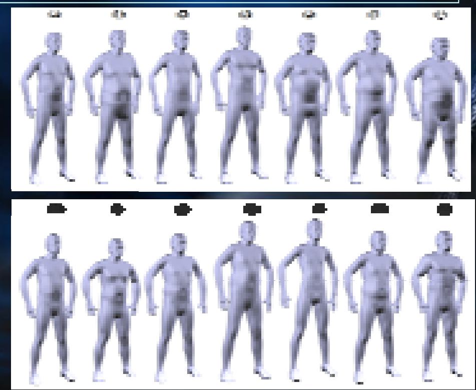
More examples



Demo1 : User interaction

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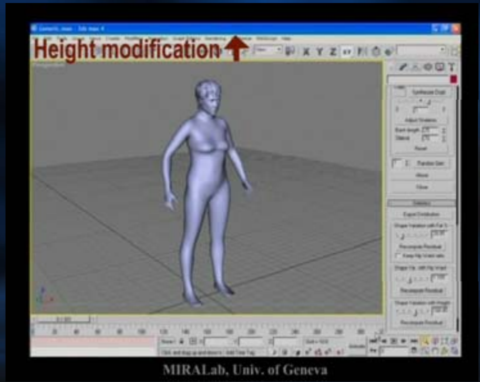

DEMO2

Making them move

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Example based approach
Anguelov et al introduced a pose space deformation of the body model by using body scanner

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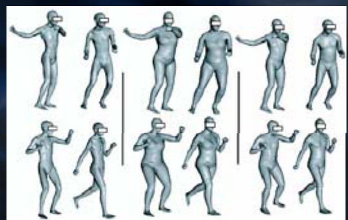
- 3D scans of a single person in multiple poses
- Capture details in different poses
- Transfer the deformations between other models.



Example based approach
Park at al (2006) developed a novel approach for skin deformation with visually realistic results.

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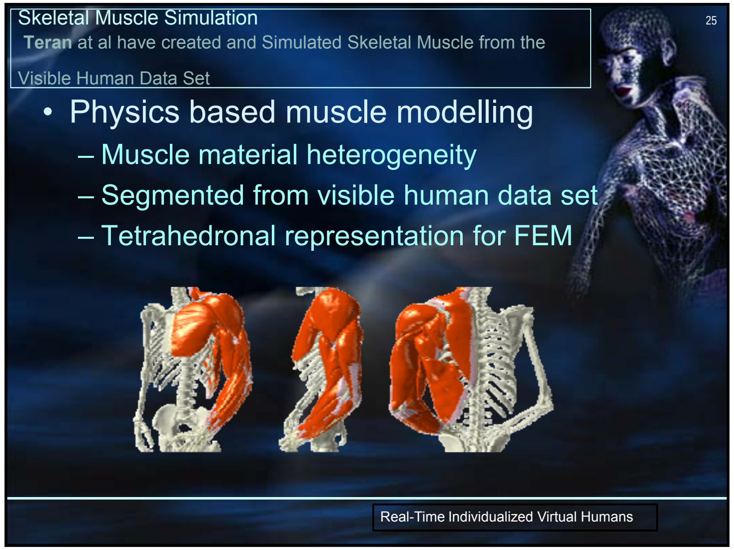
- Very large set of markers (approximately 350) placed on the subject
- Using motion capture data, muscles and fleshy part of the virtual model deformed and applied to other models that must have similar properties


Skeletal Muscle Simulation
Teran at al have created and Simulated Skeletal Muscle from the Visible Human Data Set
25
• Physics based muscle modelling
– Muscle material heterogeneity
– Segmented from visible human data set
– Tetrahedronal representation for FEM
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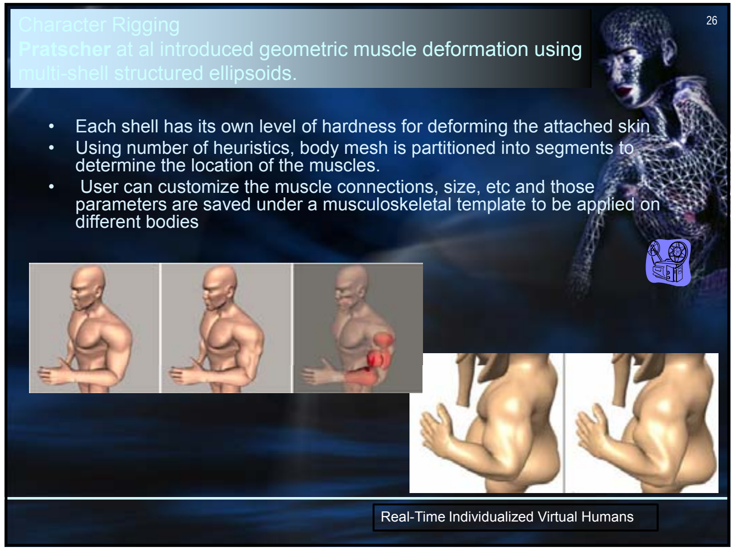
Character Rigging
Pratscher at al introduced geometric muscle deformation using multi-shell structured ellipsoids.
26
• Each shell has its own level of hardness for deforming the attached skin
• Using number of heuristics, body mesh is partitioned into segments to determine the location of the muscles.
• User can customize the muscle connections, size, etc and those parameters are saved under a musculoskeletal template to be applied on different bodies
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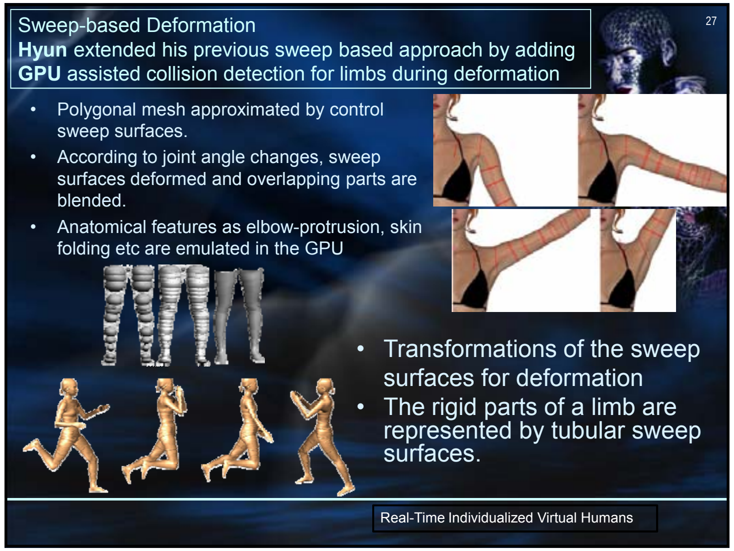
Sweep-based Deformation
Hyun extended his previous sweep based approach by adding **GPU** assisted collision detection for limbs during deformation
27
• Polygonal mesh approximated by control sweep surfaces.
• According to joint angle changes, sweep surfaces deformed and overlapping parts are blended.
• Anatomical features as elbow-protrusion, skin folding etc are emulated in the GPU
• Transformations of the sweep surfaces for deformation
• The rigid parts of a limb are represented by tubular sweep surfaces.
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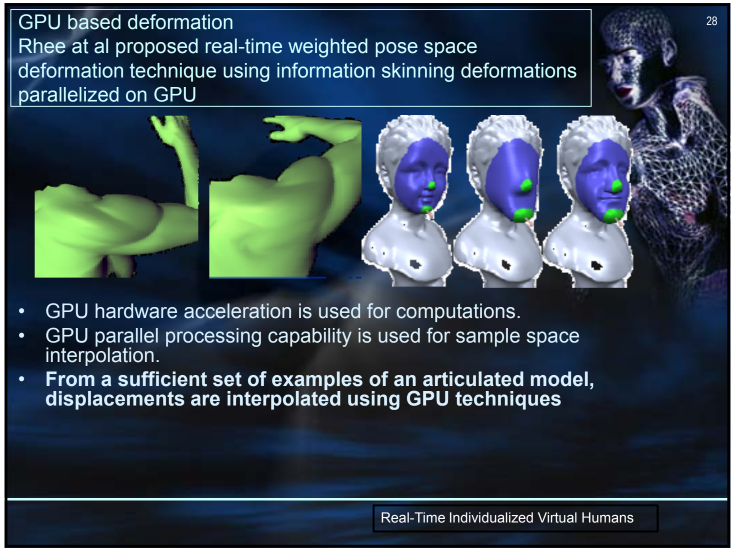
GPU based deformation
Rhee at al proposed real-time weighted pose space deformation technique using information skinning deformations parallelized on GPU
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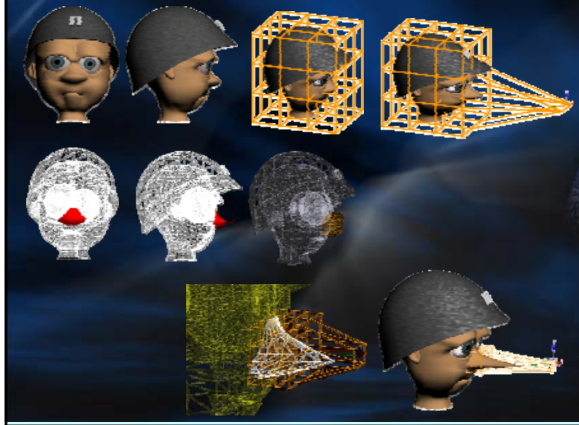
• GPU hardware acceleration is used for computations.
• GPU parallel processing capability is used for sample space interpolation.
• **From a sufficient set of examples of an articulated model, displacements are interpolated using GPU techniques**
Real-Time Individualized Virtual Humans

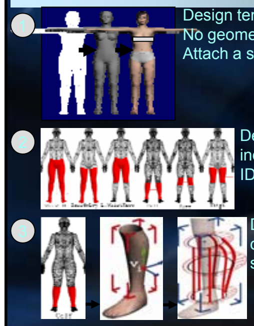
MIRALab recent work Modelling any body size

- Based on **SCODEF et al** method.
- Looks similar to FFD but **have much more deformation control for complex models.**
- Spatial model deformation is possible. This feature is exactly fitting for anthropometric segmentation of the body model.
- **No need to modify all the control points for deformation. Single parameter deforms single segment**.
- Deformed ovelapping segments are smoothly blendable. No visual side-effects between segments.
- No need to update surface normals. Displacement is occured through the existing normal vector direction.

Basic deformation technique (in our case, no linear deformation, each vertex can have a different deformation table)



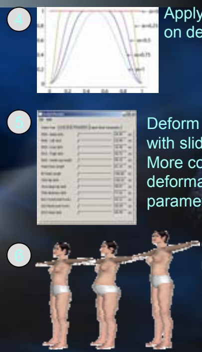
Recent work – Overview – MIRALab research



Design template model. No geometry constraint. Attach a skeleton.

Define group of indices by unique ID.

Define deformation schema



Apply smoothing on deformation.

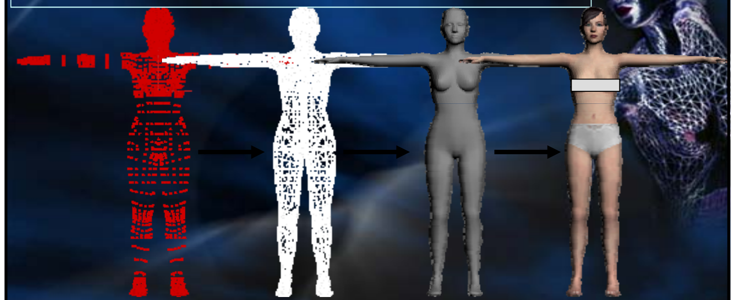
Deform the model with sliders. More control, 24 deformation parameters.

Get immediate result.

Requirements:
•Template model without geometric constraint.
•Skeleton with any standards.

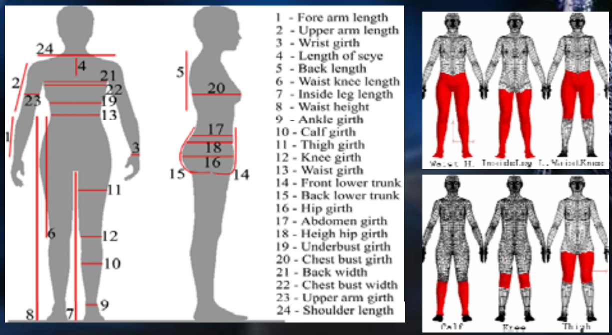
Steps 1,2,3 are one time process in design stage.

Recent work – Design



- Design template model(s) with generic body size(s).
  - Geometry of the mesh is not important.
  - Generate high number of triangulation on the joints.
- Export the model as COLLADA file.

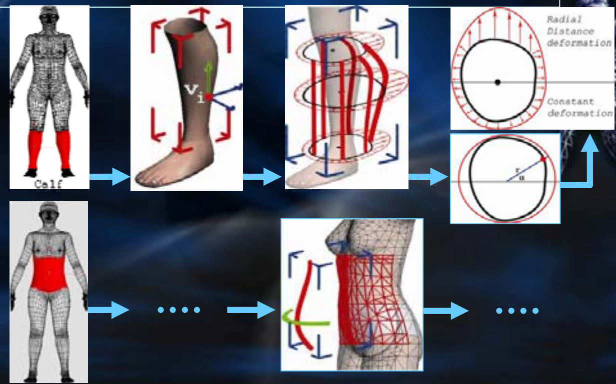
Anthropometric measurement standards



- Regarding to ISO-7250 and ISO-8559 anthropometric measurement landmarks, template body model segmented during the design stage.. Totally 24 parameters.

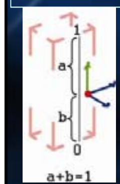
Kasap, M. & Magnenat-Thalmann, N. Parameterized Human Body Model for Real-Time Applications *Cyberworlds, 2007. CW '07. International Conference on Cyberworlds,* **2007**, 160-167

Recent work – Each region with its own deformation schema

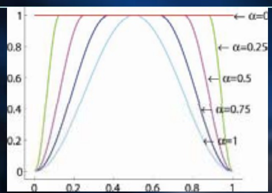


Deformations on belly and calf regions.

Recent work – Smoothing



Each region is represented as a bounding box. Each vertice in this box has its local coordinate within [0, 1] domain.

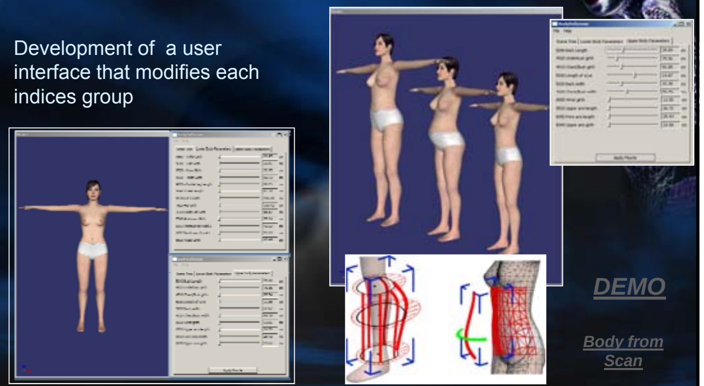


Tukey window[37] with different parameters as a smoothing function. Domain of this function is [0, 1] which is the same as the local bounding box frame of the corresponding region. Applying this window function will make the deformations to become zero on the boundary parts of the region.

Deformation on the boundary parts of the regions must be zero. Figure shows with and without smoothing the deformations on the boundary parts.

Our Deformable Body Model

- Development of a user interface that modifies each indices group



DEMO

Body from Scan

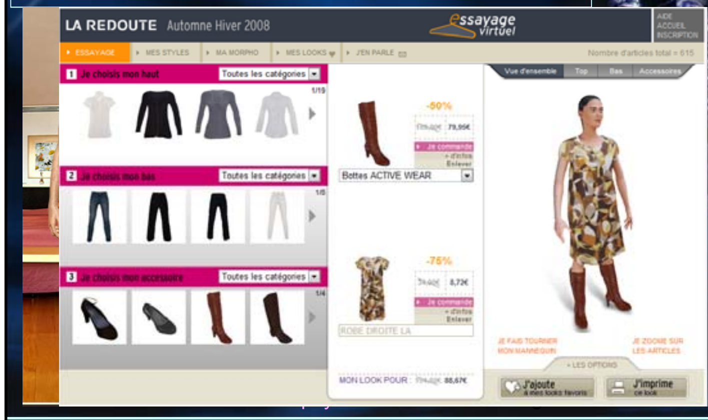
Parameterized human body model

- **Real-time** deformation of **animated** model.
- Simple anthropometric size range generation.

What is a "Virtual TryOn"?

- An (online) application, allowing you to try on virtual garments
  - For consumers
    - Online shopping: "I like this garment, but how does it look on my body and will it fit?"
  - For designers
    - Rapid prototyping/evaluation of a design in various sizes and with various fabrics

Existing Virtual TryOn-s



Beyond existing VTOs

- With our VTO we want to provide
  - Realistically deformable models to accurately match the user's morphology
    - Based on anthropometric data
  - Real time animation of the virtual body
    - Influenced by user's morphology
  - Accurate simulation of garments
    - Based on measured physical parameters of fabrics

Body Sizing

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- An accurate body is essential
  - To "try on" clothing, you need a virtual body that represents your own
- Start from a template body
  - Generate a body with your sizes based on anthropometric data

[KMT07] Parameterized Human Body Model for Real-time Application. M. Kasap and N. Magnenat-Thalmann. *Cyberworlds 2007, International Conference, IEEE, pp. 160-167, October 2007*

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Animation adaptation

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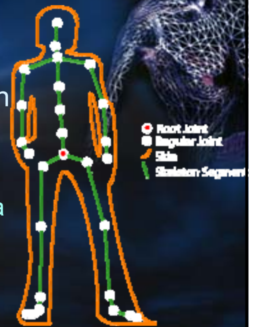
- Animation is usually pre-recorded
  - Through the use of motion capture equipment
- Any changes to the body's morphology influence its animation e.g.
  - A heavier set person has a different gait than a lighter person
  - Someone with longer legs will have a longer stride
- The recorded animation needs to be adapted to account for these changes



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Motion Adaptation Based on Character Shape

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Motion Adaptation

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- Take an existing clip and modify it according to higher level requirements
  - Step here
  - Grasp this object
  - Change the character's size
  - …
- A widely investigated topic

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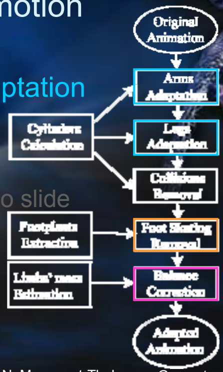
Animation adaptation

- We have developed a motion retargeting system
  - Allows for on-the-fly adaptation of motion
  - Removal of foot skating
    - When the body appears to slide
  - Balance correction
    - Weight distribution



Motion Adaptation Based on Character Shape. E. Lyard and N. Magnenat-Thalmann. *Computer Animation and Virtual Worlds, John Wiley and Sons Ltd, Vol. 19, No. 3-4, pp. 189-198*, September 2008

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Motion Adaptation for VTO

- Virtual Try On Application
  - Deformed avatars
  - Provide Animation
    - Motion adaptation
      - Self penetration removal
      - Balance correction
    - Foot skating removal
- Requirements
  - Skin based (instead of skeleton only) thus real shape of the character
  - Motion mostly preserved
  - No user interaction (automatic)
  - Use of spacetime optimization

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Foot skating removal for VTO

- Skin Based
  - To account for the shape modifications
- Does not modify the motion
  - Change the root translation instead
- Horizontal drift
- Vertical minimization of the ground penetrations

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Change the girth of the limbs ?

- Enables to create:
  - Virtual Try On application
  - Crowds with more variety
- Introduces *Shape penetrations*

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Skeleton Design

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- Approximate the body shape with cylinders
  - Provides one radius per limb
  - Rough estimate of the mass distribution

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Motion Adaptation

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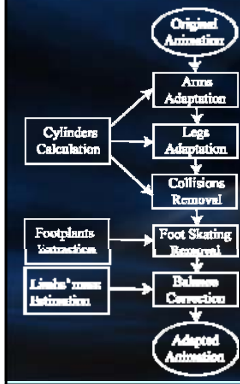

- Requirement: no more self-penetration
  - Minimal changes
  - Balance enforcement
- Multi-steps process
- Uses Spacetime optimization
  - Ensures smoothness

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Example

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White foot prints : foot skating
Yellow foot prints: no more foot skating

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Example (1) balance Adaptation

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(if the motion has changed much, the balance of the character is no longer maintained and the character is allowed to lean)

Left: modified, badly balanced model. Middle is the corrected one. Right: both models are superimposed

Etienne Lyard and Nadia Magnenat-Thalmann, Motion Adaptation Based On Characters Shape, CASA 2008, CAVW Journal , Wiley

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Example (2) penetration removal

On the left, the hand self penetrates the body and the right arm self penetrates itself. On the right, both penetrations were removed

MOVIE

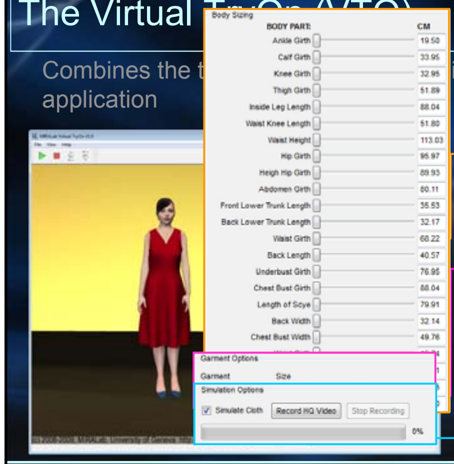
Garment Simulation

- Physical simulation of garments
  - Simulation based on measured physical parameters of used fabrics
  - Includes grading information
    - Selection of various different garment sizes
    - No need to change to different meshes
  - 2 Simulation modes:
    - Real-time (preview) simulation
    - High-Quality simulation

[MTH08] N. Magnenat-Thalmann, E. Lyard, M. Kasap and P. Volino. Adaptive body, motion and cloth. *Proceedings of Motion in Games 2008, Lecture Notes in Computer Science (to appear)*

The Virtual TryOn (VTO)

Combines the t ... into a single coherent application



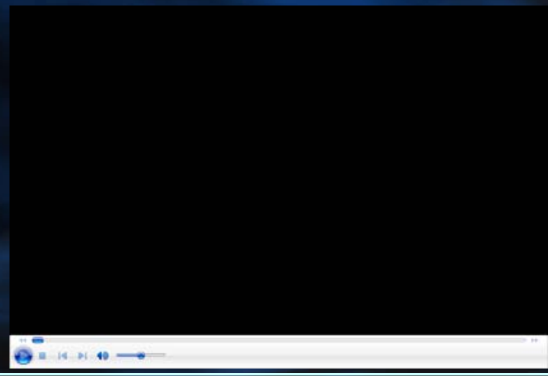
Body sizing
- 23 Parameters
- Animation automatically retargeted to new sizes

Garment sizing
- On-the-fly switching between different sizes
- No new files needed

High quality simulation
- Highly accurate simulation
- Generates video output

The Virtual TryOn: Body Sizing

- Resizing and retargeting a body (Real-time capture)



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The Virtual TryOn: Grading

SIZE 36

SIZE 40

SIZE 44

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The Virtual TryOn: HQ Simulation

- High Quality Simulation

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Ongoing developments

- Optimization of the simulation
  - New approaches to simulation
    - “Drive” high resolution garments through simulation of lower resolution garments
  - Utilization of modern hardware
    - Multi-Core CPUs
    - Graphics Processors (GPGPU)
- Customization through multi-grading
  - Localized deformation of garments
    - Editing without changing topology

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Ongoing developments

- Server based VTO
  - The VTO as a web service
    - Remote Computation: Allowing the VTO to run on virtually any device with a decent network connection
- …

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Modelling and animating faces

Anthropometry-Based Deformation

Douglas developed a system based on anthropometric human face measurements to model the face

From anthropometric measurements to variational face deformation (Douglas et al).

- **Statistical anthropometric measurements are used as geometric constraints on the specific part of the parametric surface**.
- Corresponding measurement landmarks detected on template model.
- Because of its parametric property, variational modelling technique (wavelets) is used to deform the surface which satisfies the underlying contraints.

Animation

- Why facial animation needs specific attention ?
  - Main interest centre
  - Face movement difficult to capture
  - Very complex (~30 facial muscles)
  - Hard to design (feeling, emotions)
  - Synchronization problem

Requires TIME, PRECISION and OBSERVATION

Pioneer’s work

- Parke – 1972
- A mesh is painted on a real model
- Animation and modeling references created by photographing frozen expressions

Facial animation pipeline

1. Define a geometric model
2. Define for the model an animation structure and a parameterization set
3. Animation creation (by vision, optical tracking, AI, manual design)
4. Animation of the model according to animation structure and parameters

P. Kalra, A. Mangili, N. Magnenat-Thalmann, and D. Thalmann. Smile : Multi layered facial animation system. In IFIP WG 5.10, Tokyo, pages 189–198, 1991.

Facial Animation

- A set of techniques in order to deform a model to reproduce natural facial expressions
- A face is important for
  - Lip animation according to the speech
  - Emotion
- The face is not a body: a face does not have a skeletal structure (except for the jaw)

Parameterization

Why do we need a parameterization system ?

- What do we have ?
  - Complex mesh topology
  - Different mesh for each character
- What do we want ?
  - Quick and easy facial animation design
  - **Animation working on any character**
  - Suitable for real time applications
  - Reduce amount of data necessary (for animation, storage and network applications)
- One solution
  - Create a topology independent of parameterization
  - Standardization

Parameterizations

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- 3 main parameterization systems
  - 1978 : Facial Action Coding System (FACS)
  - 1993 : Minimal Perception Action(not shown)
  - 1999: MPEG4 parameterization for facial animation

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FACS : description of the movement of facial muscles

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- Mainly developed for facial analysis
- Based on visual facial anatomical movements
  - Used in psychology to classify face movements and expressions
  - Designed to describe facial expression / visual motion, then exclude
    - Muscle contraction without motion
    - Face morphology
  - Requires a knowledge of muscular face anatomy
- Using FACS for animation synthesis is an extension of the initial goal

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FACS Action Unit

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- Study of face anatomy
- Definition of all muscle actions separately
- Sometimes, more than 1 muscle is responsible for a facial deformation, in this case an AU (Action Unit) includes 2 or 3 muscles
- 1 muscle could create more than 1 AU
- → Action Unit (AU) definition
  - 35 basics AU
  - 11 extended AU (deformations not implying the action of a face muscle, i.e. “tongue out”)

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FACS Example

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AU No.	FACS Name	Muscular Basis
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 Inferioris
20	Lip Stretcher	Risorius
22	Lip Funneler	Orbicularis Oris
23	Lip Tightner	Orbicularis Oris

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MPEG-4 for face (1998)

- MPEG-4 allows for independent encoding of different audio-visual objects (AVO).
- The AVO could be video, audio, 2D or 3D objects
- Specifies a compressed binary representation of the AVO.
- IMPORTANT : MPEG4 only specifies the encoder, the “terminal” has the choice to generate an MPEG4 compliant bit stream
- **A special AVO is the Face and Body Animation (FBA)**
- MPEG4 is a parameterization for network applications
- The FBA object encompasses both 2D and 3D models, which can look realistic as well as cartoon-like.

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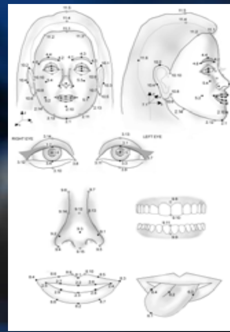
MPEG-4 for face

- FBA defines two sets of parameters
  - Definition Parameters (FDP)
    - Specifies the geometrical shape definition of the face model
    - Transmitted only once
    - 88 parameters
  - Animation Parameters (FAP)
    - 68 parameters
    - Transmitted for each frame



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MPEG-4 for face

- Each FAP corresponding to a particular facial action deforms the face from its neutral state
- The value of a particular FAP indicates the magnitude of the deformation
- A “terminal” could use its own animation rules in order to animate the face
- **FAP values are defined in facial animation parameter units (FAPU) to be model independent**
- FAPU are computed using spatial distances between major features on the model

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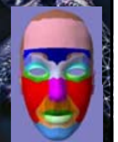
MPEG-4 for face

- 2 of 68 FAPs can be used as two high level parameters:
  - Visemes
  - Expressions
- High level parameters allow the transmission of fewer parameters
- **FAPs are categorized into 10 groups and represent a complete set of basic facial actions including head, tongue and eye movement**



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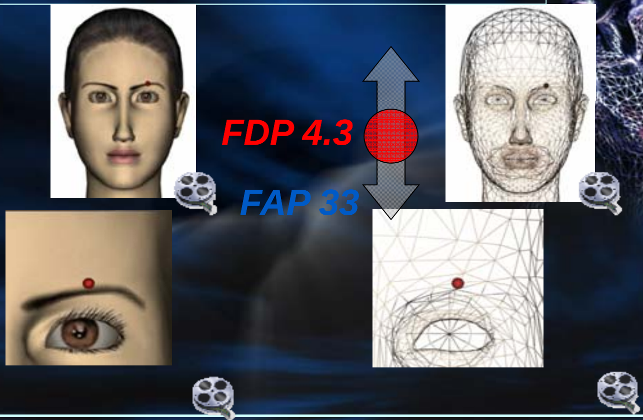
Example of FDP and FAP



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Concepts of face animation

Different approaches to animate a face

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Keyframing (1)

- Animation made by interpolating between keyframes or expressions
  - Can be based on mesh deformation or on a parameter set

Advantages	Can provide very realistic animation
Disadvantages	Time consuming process to build animation

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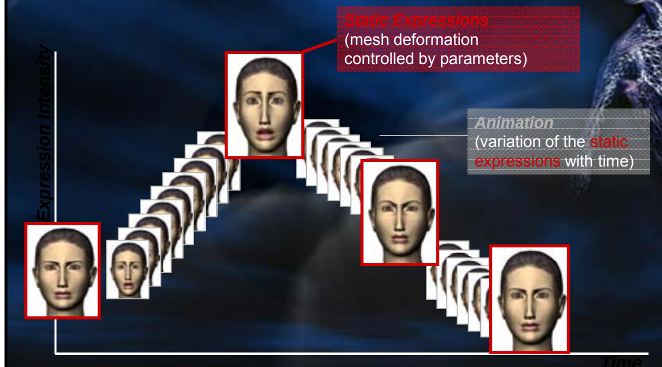
Keyframing (2)



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Automatic Methods

- Text-to-Speech (Visual)
  - Animation and sound are built automatically using phonemes and visemes
    - Text → phoneme → viseme → animation parameters

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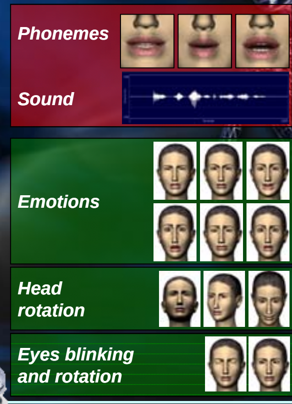
Automatic Methods

- Expressive speech
  - Different animation layers can be used in order to create an expressive speech animation such as emotions, head rotation and eyes blinking/gaze
  - Requires realistic blending of different animation layers
  - Requires a high-level control mechanism to define the timing of each expression



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Facial Animation Languages

- Assure the synchronization between different facial movements
- Provide higher level controls of the animation
- Integrated with an animation player
- Mostly XML based
  - VHML: Virtual Human Markup Language
  - AMPL: Affective Presentation Markup Language
  - FML: Face Modeling Language
  - AML: Avatar Mark-up Language

```
<vhml>
  <person disposition="angry">
    First I speak with an angry voice and look very angry,
    <surprised intensity="50">
      but suddenly I change to look more surprised.
    </surprised>
  </person>
</vhml>
```


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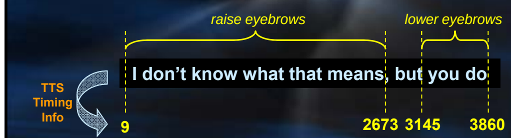
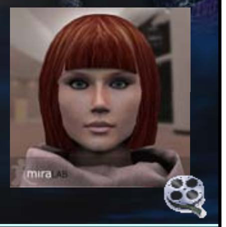
Facial Animation Control

- Creating facial animation from

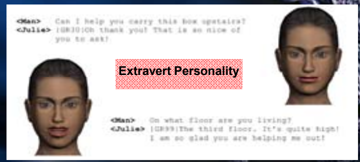
<begin_gesture id="raise_eyebrows"/>I don't know what that means,<end_gesture id="raise_eyebrows"/> but <begin_gesture id="lower_eyebrows"/> you do.<end_gesture id="lower_eyebrows"/>

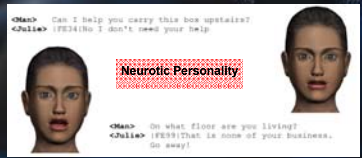




Personality and emotion simulation for conversational agents

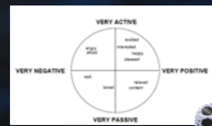
- Ekman's six basic expressions are used for the visual front-end
  - Joy, anger, fear, sadness, disgust and surprise
- OCEAN model is used for personality
  - Openness
  - Consciousness
  - Extraversion
  - Agreeableness
  - Neuroticism





Emotions with varying intensity

- People normally exhibit a mixture of emotions
  - Not only Ekman's six facial expressions
- Modeling intermediate emotions is not easy
  - One solution: Interpolate between different emotional states considering activation and intensity parameters

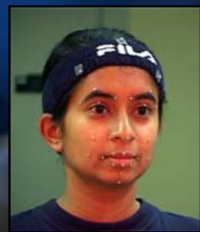


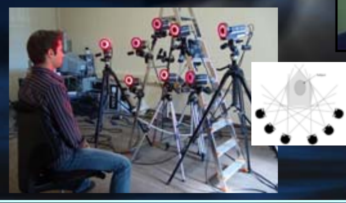
Motion Capture

- Capturing real people's performances to animate a virtual character
  - performance-driven animation
- Problems such as calibration, occlusion
- Captured data can be used directly or a statistical analysis can be applied (e.g. Principal Component Analysis)

Camera and marker set-up

- Camera position
  - 8 Infra-Red High-Resolution Cameras
- Marker placement
  - 30 facial markers



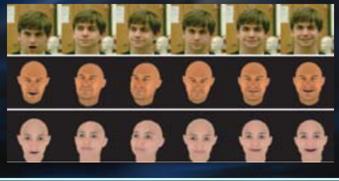


Active Scanners & Video Cameras

- Active scanners (Laser, structured light)
  - High resolution face capture
  - Capturing subtle changes on face such as wrinkles
- Video cameras (passive scanning)
  - Less expensive and easy capture
  - 2D data needs to be converted to 3D

Vision-based Control of 3D Facial Animation

- Interactive expression Control
- Video input is used in order to control the animation of virtual faces in RT. Similar to motion capture since animation control signals from a real performer are **mapped onto a 3D facial model**
  - *a user can control 3D facial expressions of an avatar interactively employing a video input*



New challenges in RT Virtual Humans

Communicating with Virtual Characters and Robots: Why and How?

- Why to communicate?
  - A universal interface for communication between human and computer
- How to communicate?*
  - Express and perceive emotions
  - Communicate with high-level dialogue
  - Establish/maintain social relationships
  - Exhibit distinctive personality
  - Learn/recognize models of others
  - Use natural ways of communication (speech, facial expressions, gesture and gaze)

T. Fong and I. Nourbakhsh and K. Dautenhahn, A survey of socially interactive robots, Robotics and Autonomous Systems, 42, 2002

Examples of Interactive Virtual Characters

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Examples of Social Robots

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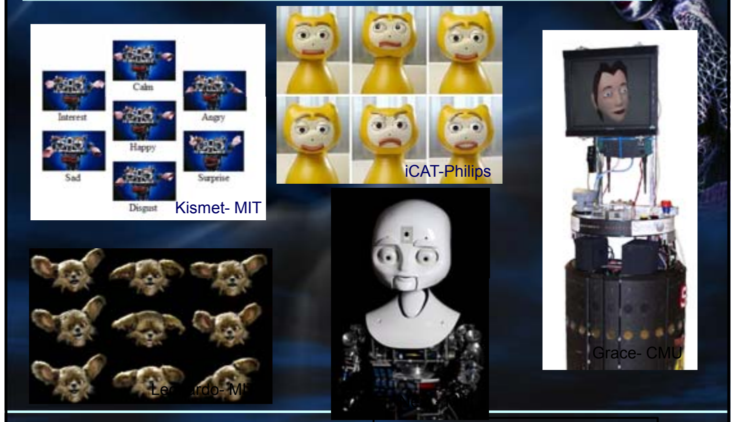

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Limitations

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- Far from being **intelligent** and **expressive** enough to **engage** user to a **believable interaction**
- Behaviors not linked very well with content, **repetitive** and **unnatural**

Real-Time Individualized Virtual Humans

Our Research at MIRALab

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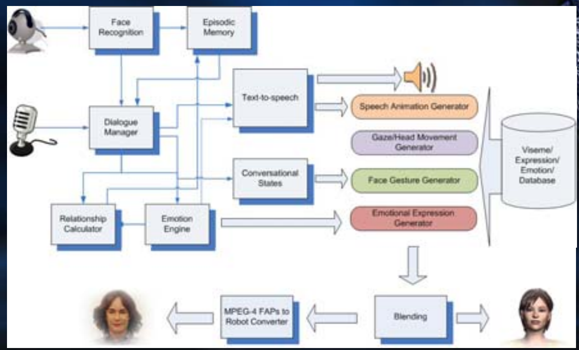
- Interaction with a virtual character and a robot that can
  - speak with us (audio and expressive gestures)
  - understand what we are talking about (content and emotional appraisal)
  - behave emotionally according to predefined personality types
  - establish long-term emotional relationships
  - recognize faces of different people and remember past interactions

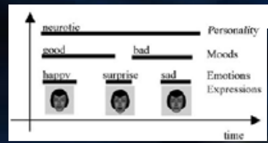
Real-Time Individualized Virtual Humans

Common Interaction Architecture for VH and Robot



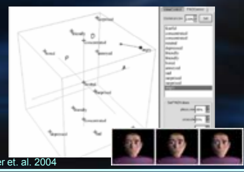
Emotional Interaction

- Examples of some existing emotional models

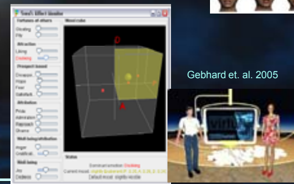


Kshirsagar et. al. 2002

Egges et. al. 2004



Becker et. al. 2004



Gebhard et. al. 2005

Discussion on Emotion Models

- Most of the systems model personality, mood and emotions
- What is missing?
  - User modeling
    - Long-term component
    - Relationship with user

Relational Agents and Long-term Interaction

- Recognize and remember faces of people interacted and information about them
- Establish and maintain long-term relationships
  - Like, dislike, trust, affection
- Complex social behaviour

MIT

CMU

Our Emotional Model

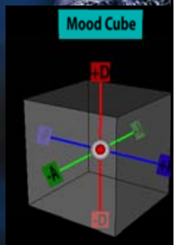
- We model 4 components and their interaction in our emotional model:
  - Personality
  - Emotions
  - Mood
  - Relationships

Personality - OCEAN

Openness	open to experience new things, being imaginative, intelligent and creative
Conscientiousness :	indicates responsibility, reliability and tidiness.
Extravertion:	Outgoing, sociable, assertive and energetic to achieve his/hergoals.
Agreeableness:	trustable, kind and cooperative considering other people's goals and is ready to surrender his own goals.
Neuroticism:	anxious, nervous, prone to depression and lack of emotional stability.

Emotion Engine

- OCEAN personality (McCrae & Costa, 1996)
  - Openness, Conscientiousness, Extroversion, Agreeableness, Neuroticism
- OCC emotions (**Collins, Ortony & Clore, 1988**)
  - Positive: Joy, hope, relief, pride, gratitude, love
  - Negative: Distress, fear, disappointment, remorse, anger, hate
- Mehrabian Mood (**Mehrabian 1996**)
  - 3 dimensional: pleasure, arousal, dominance
  - Positive: Exuberant, dependant, relaxed, docile,
  - Negative: Bored, disdainful, anxious, hostile



OCC Emotions

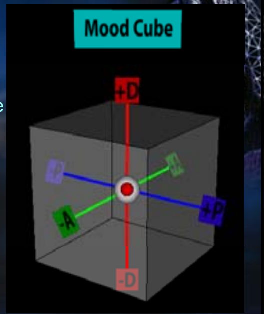
Positive Emotions	Negative Emotions
- because something good happened (joy)	- because something bad happened (distress)
- about the possibility of something good happening (hope)	- about the possibility of something bad happening (fear)
- because a feared bad thing didn't happen (relief)	- because a hoped-for good thing didn't happen (disappointment)
- about a self-initiated praiseworthy act (pride)	- about a self-initiated blameworthy act (remorse)
- about an other-initiated praiseworthy act (gratitude)	- about an other-initiated blameworthy act (anger)
- because one finds someone/something appealing or attractive (love)	- because one finds someone/something unappealing or unattractive (hate)
- because something good happened to a liked person (happy-for)	- because something bad happened to aliked person (sorry-for)
liked person (happy-for) unliked person (gloating)	- because something good happened to an unliked person (resentment)

Mood (PAD)

Mehrabian (1996)

- Arousal: level of physical activity
- Dominance: feeling of control
- Pleasure: positivity or negativity of emotional state

+P+A+D	Exuberant	-P-A-D	Bored
+P+A-D	Dependent	-P-A+D	Disdainful
+P-A+D	Relaxed	-P+A-D	Anxious
+P-A-D	Docile	-P+A+D	Hostile



Relationship

- (Argyle, 1998)

Two dimensions

- Friendliness
- Dominance

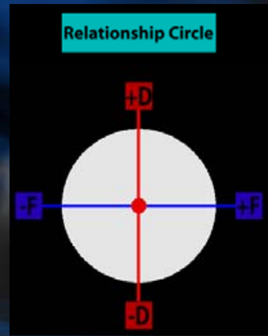
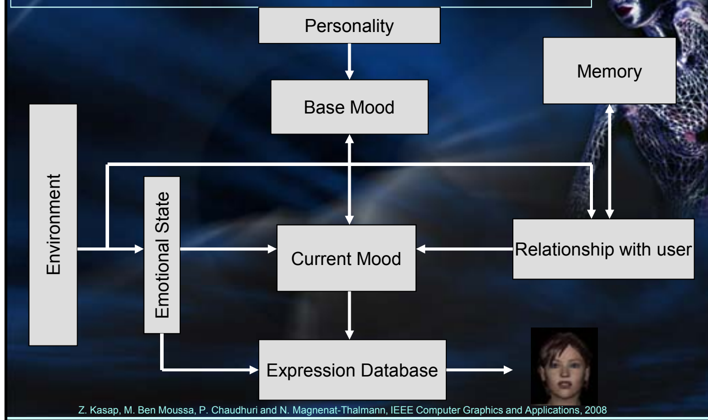


Diagram of Emotional Model



Z. Kasap, M. Ben Moussa, P. Chaudhuri and N. Magnenat-Thalmann, IEEE Computer Graphics and Applications, 2008

Mood Update

- Mood update is done in four cases:
  - Case 1: Initialization of base mood with personality
  - Case 2: At the beginning of each interaction session when a person is recognized
  - Case 3: At the end of each interaction session when a person leaves
  - Case 4: At each emotional impulse during dialogue

Relationship Level

- How do we decide on the relationship level?
  - Based on past interaction sessions

We employ long-term memory modeling to remember past interactions

What is Long-term Memory?

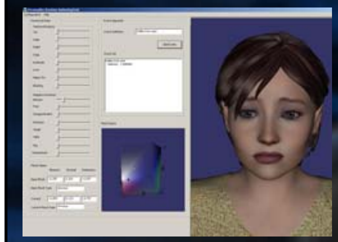
- Two types:
  - Procedural Memory (related with learning skills like riding a bicycle)
  - Declarative Memory (important for natural communication)
    - Episodic memory
      - represents our exprериences as points on a timeline
    - Semantic memory
      - Derived from episodic memory and it is a structured representation of learned facts and concepts

Episodic Memory Structure

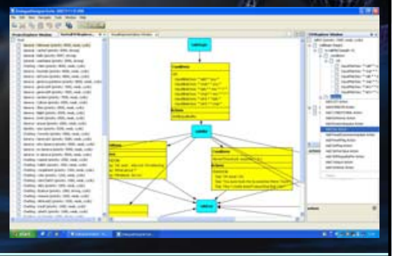
- Currently, we focus on episodic memory and store the following pieces of information at each interaction session:
  - Name of person interacted p_i
  - Time passed since the session started t_i
  - Starting relationship at the beginning of session R_i^e
  - Ending relationship at the end of session R_i
  - Relationship change during the session R_i^s
  - Recall probability P_i

Quantification Phase

Emotional model and all the parameters can be tested and changed using the Personality/Emotion Authoring Tool



Dialogue Authoring Tool is used to design dialogue scripts with emotional appraisals



Scenario

- Eva teaching Geography
- Interaction with two types of students
  - A good and a difficult student
- Eva recognizes them automatically and stores information about them (name, relationship level)
- Eva remembers the level of relationship and answers accordingly