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Virtual fashion design

European Supply Chain Linking Conference
23.10.2007

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Prof. Nadia Magnenat-Thalmann

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MIRALab - Geneva University

- founded by Prof. Nadia Magnenat-Thalmann
- 15+ years of **3D cloth simulation** R&D
- 30+ researchers and developers
- 50+ commercial shows, installations, productions

1989

- novel type of **3D fashion**
- **state-of-the-art clothing** simulation
- 3D visualization, animation, and validation
- bringing existing **digital workflow** to the next level

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A bit of MIRALab history…

- Flashback (1990)

Flashback – MIRALab / University of Geneva – 1990

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Fashion Museum, Geneva "Mode, Passion & Collection"

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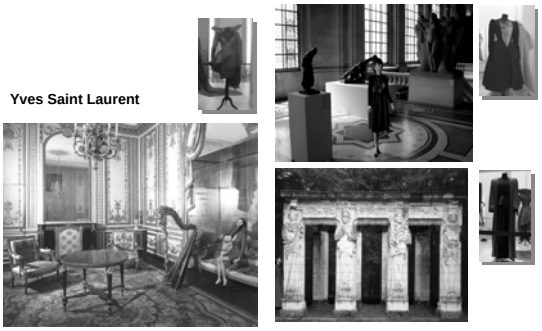
Yves Saint Laurent



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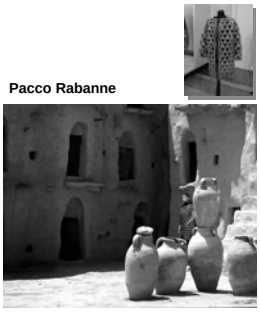
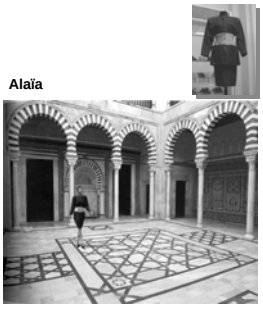
Pacco Rabanne



Alaïa



Research projects

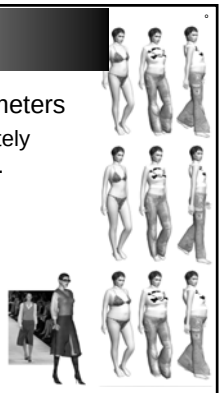
1989 → 2007

- Industrial driven projects:
  Clothing/apparel/textile industry
  EU projects:
  - **E-Tailor**
  - Tex-map
  - Fashion online
  - E-merit
  - **Leapfrog IP**
    (current research project)

Applications:
Virtual garment prototyping
&
Virtual Try-On

Objective:
Comfort and fit

Garment Prototyping



- Accurate Simulation of Parameters
  - Draping and animating accurately garments on virtual characters.
  - Taking into account:
    - Precise patterns
    - High-accuracy garment surface representation
    - Accurate simulation of mechanical properties
    - Precise body measurements

Garment Simulation

- Highly challenging topic:
  - Large garments
  - Intricate shapes
  - Highly deformable materials
  - Nonlinear anisotropic mechanics
  - Collisions on complex shapes
  - Millimeter simulation accuracy

Garment Simulation

- Mechanical Properties of Cloth
  - How to describe the mechanical behavior of cloth.
- Mechanical Cloth Modeling
  - How to simulate these properties on virtual cloth.
- Numerical Integration
  - How to solve the differential equations resulting from the mechanical model.
- Collision Detection and Response
  - How to detect efficiently contacts between cloth and other objects and take them in account in the simulation.
- Garment Design and Prototyping
  - Interactive tools using state-of-the-art techniques for creating high-quality virtual garments.

Ongoing Research

- Accurate Mechanical Models
  - New accurate formulations
- Efficient Numerical Integration
  - Adding performance and robustness

Ongoing Research

- Collision Methods
  - Efficient collision resolution and repair.
- Haptic Simulation
  - Real-time interaction with cloth.
- Garment Design and Prototyping
  - Interactive prototyping tools
  - Real-Time visualization

Mechanical Properties

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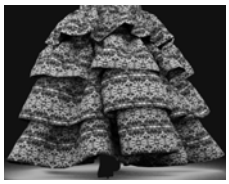
- Simulation of Cloth or other Thin Shells
  - Decomposition of elastic forces into:
    - Tensile Elasticity
      - In-plane forces.
    - Bending Elasticity
      - Out-of-plane forces.
  - Simulated independently



Tensile Properties

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- Viscoelasticity laws of cloth surfaces:
  - Relating deformation strain $\boldsymbol{\sigma}$ to stress $\boldsymbol{\varepsilon}$ and stress velocity $\boldsymbol{\varepsilon'}$ along weft and warp directions.
  - Orthotropic material and null Poisson Coefficient: Independent strain-stress laws weft, warp, shear.

$$\sigma_{uu}(\varepsilon_{uu},\varepsilon_{vv},\varepsilon_{uv},\varepsilon_{uu}',\varepsilon_{vv}',\varepsilon_{uv}')$$
$$\sigma_{vv}(\varepsilon_{uu},\varepsilon_{vv},\varepsilon_{uv},\varepsilon_{uu}',\varepsilon_{vv}',\varepsilon_{uv}')$$
$$\sigma_{uv}(\varepsilon_{uu},\varepsilon_{vv},\varepsilon_{uv},\varepsilon_{uu}',\varepsilon_{vv}',\varepsilon_{uv}')$$

$$\sigma_{uu}(\varepsilon_{uu},\varepsilon_{uu}')$$
$$\sigma_{vv}(\varepsilon_{vv},\varepsilon_{vv}')$$
$$\sigma_{uv}(\varepsilon_{uv},\varepsilon_{uv}')$$

Tensile Properties

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- Linear Elasticity (Orthorhombic material)
  - Relating deformation strain $\boldsymbol{\sigma}$ to stress $\boldsymbol{\varepsilon}$ along weft and warp directions $\boldsymbol{u}$ and $\boldsymbol{v}$:

$$\begin{bmatrix}\sigma_{uu}\\ \sigma_{vv}\\ \sigma_{uv}\end{bmatrix} = \begin{bmatrix} E_u & \nu_v E_u & 0 \\ \nu_u E_v & E_v & 0 \\ 0 & 0 & G(1-\nu_u \nu_v)\end{bmatrix}\begin{bmatrix}\varepsilon_{uu}\\ \varepsilon_{vv}\\ \varepsilon_{uv}\end{bmatrix} \qquad \nu_v E_u = \nu_u E_v$$

  - Isotropic material:
    - Orientation-independent behaviour:

$$E = E_u = E_v$$
$$\nu = \nu_u = \nu_v$$
$$G = \frac{E}{2(1-\nu)}$$

Bending Properties

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- Bending Elasticity (Orthorhombic material)
  - Relating curvature strain $\boldsymbol{\tau}$ to stress $\boldsymbol{\gamma}$ along weft and warp directions $\boldsymbol{u}$ and $\boldsymbol{v}$:

$$\begin{bmatrix}\tau_{uu}\\ \tau_{vv}\\ \tau_{uv}\end{bmatrix} = \begin{bmatrix} B_u & 0 & 0 \\ 0 & B_v & 0 \\ 0 & 0 & K\end{bmatrix}\begin{bmatrix}\gamma_{uu}\\ \gamma_{vv}\\ \gamma_{uv}\end{bmatrix}$$

  - Usually:

$$K = 0$$

Bending Properties

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- Typical Parameters of Cloth Materials
  - Elasticity: $\boldsymbol{E}$ between 10 and 10 000 N/m.
    - Nonlinear
  - Shear: $\boldsymbol{G}$ usually lower than $\boldsymbol{E}/2$.
  - Poisson: $\boldsymbol{\nu}$ between 0.1 and 0.2.
    - Often ignored in usual standards.
  - Bending: $\boldsymbol{B}$ between 1 and 100 μ N.m.
  - Viscosity parameters: Unmeasured.
  - Density: $\boldsymbol{\rho}$ between 10 and 500 g/m^2

Cloth Simulation

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- Simulation Schemes
  - Particle Systems (spring-mass systems)
    - Interactions defined between punctual masses which discretize the surface geometry.
    - Fast, but inaccurate computation.
  - Continuum Mechanics
    - Numerical discretization of the mechanical laws over the continuous surface.
    - Accurate, but slow computation.

Cloth Simulation

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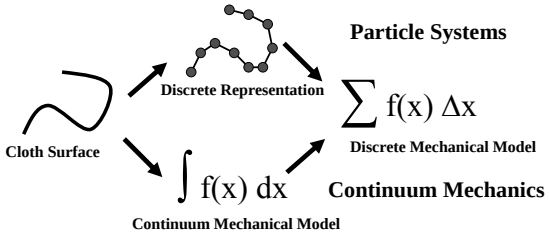
- Simulation Schemes



Cloth Simulation

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- Particle Systems offer a good compromise between accuracy, computational speed and versatility for the simulation of complex garments.

Fabric Input Parameter

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Measuring Properties

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- Mechanical Properties of Cloth:
  - Strain-Stress curves measured experimentally.
- Standards for Properties of Fabrics
  - Kawabata Evaluation System (KES)
    - Numerical values extracted from strain-stress curves and other measurements.
    - Measures stiffness and hysteresis of curves.
    - Most popular standard in the industry.
  - Other simpler alternatives
    - SiroFAST: Simple measurements of stiffness.

Measuring Properties

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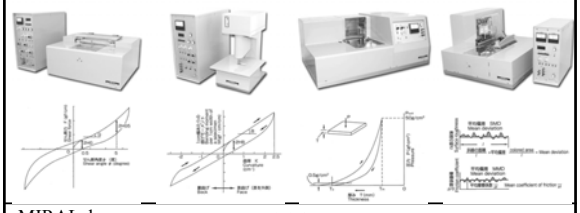
- Kawabata Evaluation System (KES)
  - Tensile, Shear, Bending, Compression, Surface properties.



Simulating Accurate Properties

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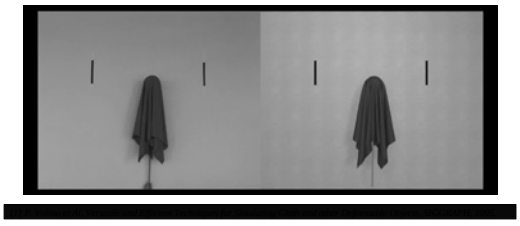
	Elasticity: N/m			Bending: μ N.m		Weight g/m²	Friction
	Weft	Warp	Shear	Weft	Warp		
Weft knitted plain single-jersey	17 $40 * 10^{-3} / 50$ $800 * 10^{-3} / 450$	70 $100 * 10^{-3} / 200$ $400 * 10^{-3} / 3.5 * 10^{3}$	22	0.9	1	172	0.22



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Virtual bodies

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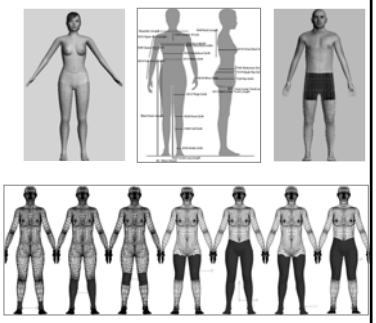
Our Deformable Body Model

Approach:

- Start from a template model
- Defining contours according to chart table measurement
- Define distinct indice groups corresponding to each contour
- Define separate non-linear deformation curves on each indice group



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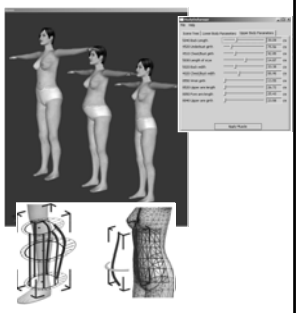
Our Deformable Body Model

- Development of a user interface that modifies each indices group



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2D Patterns

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Garment prototyping and animation

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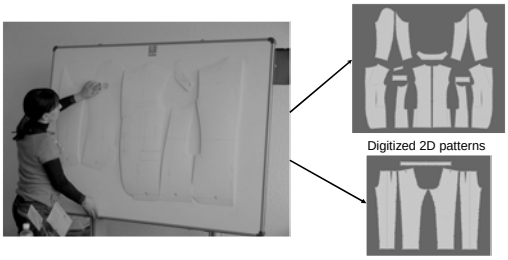
2D Patterns

To be able to process traditional 2D patterns in CAD-applications, digitalisation methods have to be applied



Digitized 2D patterns

2D Pattern

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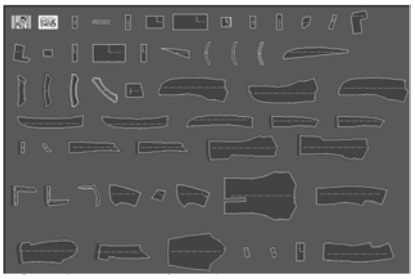
Jacket pattern pieces with interlining and facing



2D Pattern

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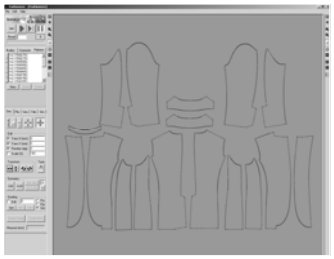
Extraction of the jackets outer shell pattern pieces and importation into the simulation software:



Garment Prototyping

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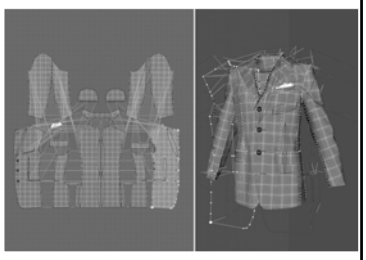
Interactive 2D-3D corrections:

- Simultaneous synchronized views of pattern shape and garment drape
- Corrections can be interactively done in 2D or 3D



Garment Prototyping

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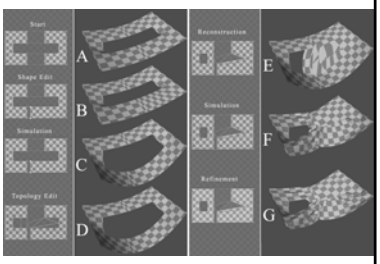
- Interactive 2D-3D design tool:
  - Tools for pattern editing:
    - Topology
    - Shape
    - Measurements
    - Seams
    - Materials
    - Texture



Garment Prototyping

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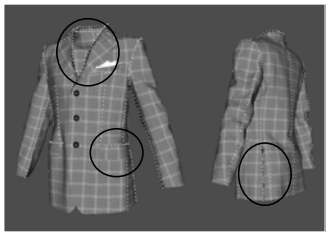
Simulation of typical garment features:

- Folds
- Collars
- Pockets



Virtual Garment Fitting

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Interactive prototyping:

- Visualization of mechanical properties on interactively edited patterns (Comfortability)

Comfort feedback

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Example Zegna

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Example La Redoute

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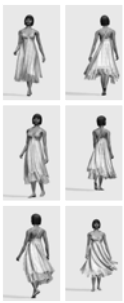

Example La Redoute

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Real time simulation

Real Time Garment Animation

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- Methods for Real-Time Garments
  - Layered Models
    - Use assumptions on the cloth motion on local areas of the garment for simulation them with specific algorithms.
      - Cloth sticking to the skin.
      - Cloth moving close to the skin.
      - Cloth moving freely without collisions.

Real Time Garment Animation

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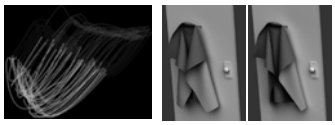
- Methods for Real-Time Garments
  - Learn-By-Example Methods
    - Based on interpolation schemes using precomputed example simulations.
      - Geometric interpolation methods.
      - Learning process with neural networks.



Real Time Garment Animation

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Preparation of the static 3D cloth with typical garment features:

- Seaming
- Folds
- Collars
- Pockets

Real Time Garment Animation

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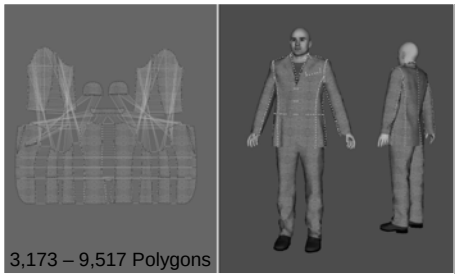
Data optimization for real time animation:



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Robot supported sewing

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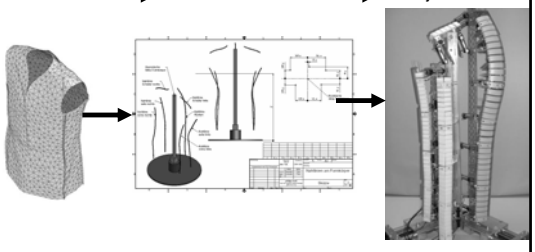
LEAP FROG IP

T 3.4 - Adjustable mould

STRATEGY / CONCEPT:

Input from Miralab → **Extracted seam paths** → **Adjusted mould**



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Thank you