Computer Animation Curriculum : An Interdisciplinary Approach

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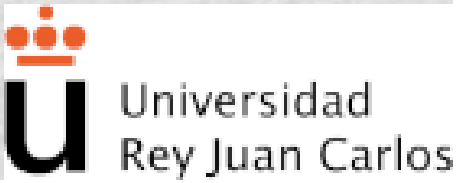

Motivation

- Teaching separated into
  - Computer Science degrees
    - Techniques, programming
    - Math, physics
  - Art degrees
    - Use of animation software
    - Creation of meaningful images / movies

Motivation

- Not always adapted to labor market
  - Researchers need to create models / animations
  - Programmers have to work with artists
  - Artists need to manipulate scripts
  - Technical directors are in-between

Context

- Master in Computer Graphics, Video Games and Virtual Reality
- Intended for Computer Science students
- They pursue career in
  - Movie / 3d animation companies
  - Game industry
  - Research

  We thus also teach software use (Maya)

  Level of involvement is left to the student through the semester project

Interdisciplinarity

- Benefits at several levels
  - Industry : communication between artists and engineers improved
  - Research: researcher independency
  - Personal : satisfaction of creating a finished product (movie)

Outline

1. Bologna & Knowledge Base
2. Course Content
3. Student Evaluation
    1. Homework & Quizzes
    2. Semester Project
4. Lecture Evaluation
5. Conclusion and Perspectives

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Bologna Process

- Requirements for graduate studies
  - Mobility of students and faculty
    - Teaching in English
  - ECTS credit system
    - Lectures should be 5 ECTS
    - Computer Animation is 2.5 ECTS (can be combined with another half lecture like History of Animation)
  - Course content and mobility
    - Sharing of content among European universities

Knowledge Base

- Professional Issues
  - Interdisciplinarity favors communication and improves team work
  - Semester project: team work, ethics and intellectual property
- Course content for Animation
  - Time and motion, modeling, rendering, dynamics and procedural animation
  - Character specifics are not covered

About our Lecture

- 2.5 ECTS
- Corresponds to Animation I
- English language
- Interdisciplinarity
  - Computer science
  - Software use
- Free specialization (semester project)

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Course Content

- Introduction

Course Content

- Introduction
- 5 topics that introduce basic notions
  - Representation of surfaces
  - Modeling
  - Geometry based deformation techniques
  - Physics based techniques
  - Collision detection

Course Content

- Introduction
- 5 topics that introduce basic notions
- 2 topics that show the use of the basic techniques in different contexts
  - Introduction to character animation (MDP - Character Animation lecture)
  - Introduction to plant modeling and animation

Course Content

- Introduction
- 5 topics that introduce basic notions
- 2 topics that show the use of the basic techniques in different contexts
- Does not cover
  - Fluid animation & advanced physically based animation (AA)
  - But, if more time available … introduction to natural phenomena or fluid animation

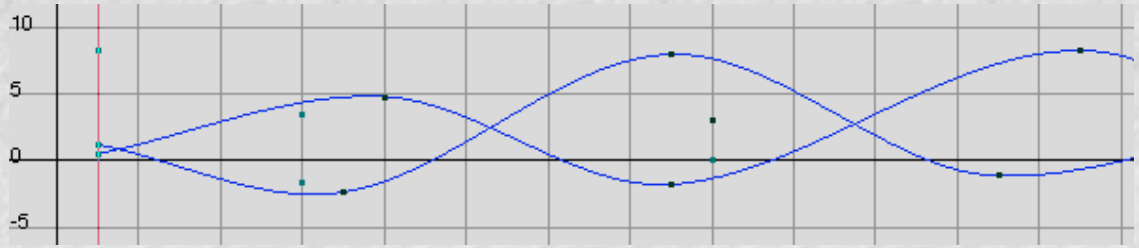
1. Introduction

- Theory
  - Animation pipeline (modeling, animation, rendering)
  - Loops frequency
  - Notion of real-time

```
class Particle
{
public :
  Particle();

  void init();
  void draw();
  void animate();

private :
  qglviewer::Vec speed_, pos_;
  int age_, ageMax_;
};


class Viewer : public QGLViewer
{
protected :
  virtual void draw();
  virtual void init();
  virtual void animate();
  virtual QString helpString() const;

private:
  int nbPart_;
  Particle* particle_;
};
```


1. Introduction

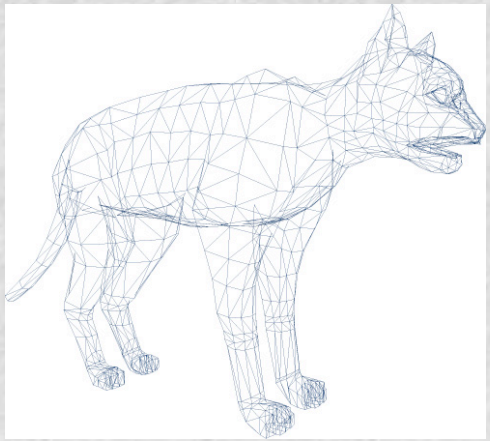
- Practice
  - How to create an animation in Maya
    - Timeline
    - Keyframes
    - Animation framerate
    - Animation curves editing (Graph Editor)



2. Surface Models

- Theory: how is a surface mathematically represented ?
  - Polygonal surfaces

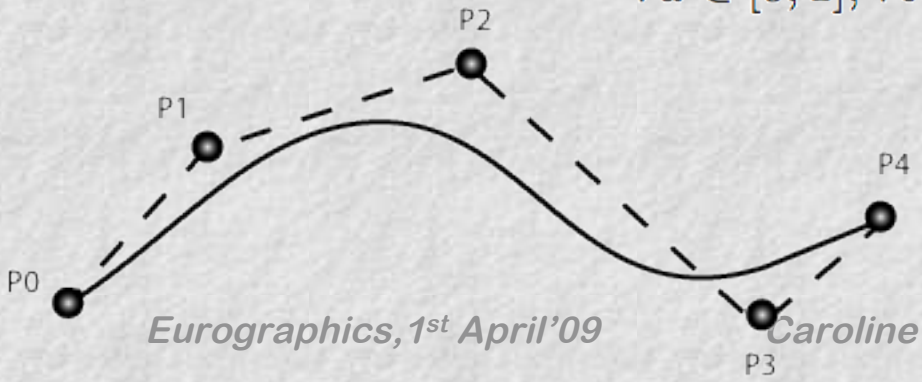
$$ax + by + cz + d = 0$$



2. Surface Models

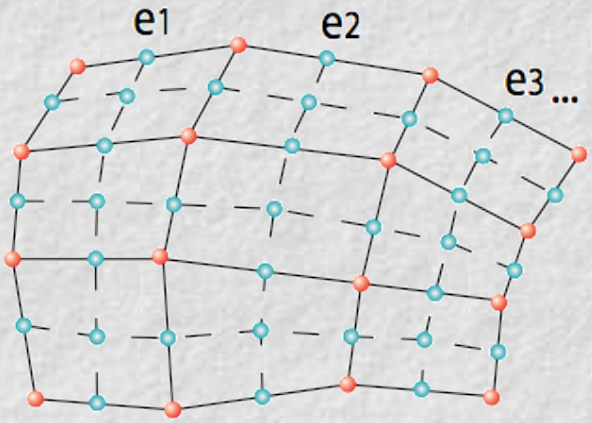
- Theory: how is a surface mathematically represented ?
  - Parametric curves & surfaces
    - Properties (locality, continuity …)
    - Patch stitching, hierarchical splines

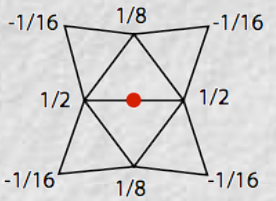
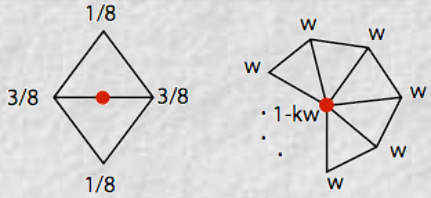
$$\forall u \in [0,1], \forall v \in [0,1], S(u,v) = \sum_{i=1}^{k} \sum_{j=1}^{l} F_i(u) F_j(v) P_{ij}$$



2. Surface Models

- Theory: how is a surface mathematically represented ?
  - Subdivision surfaces & masks

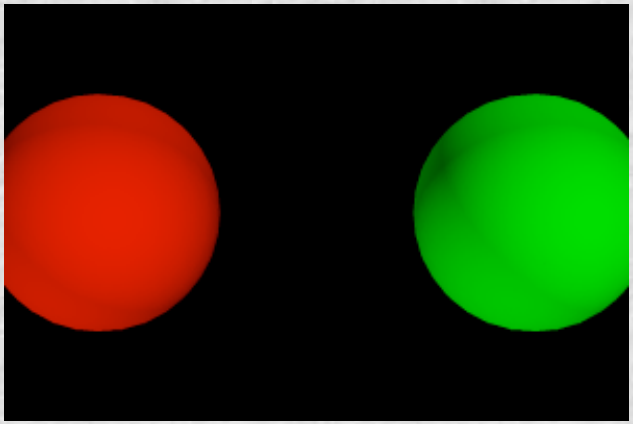


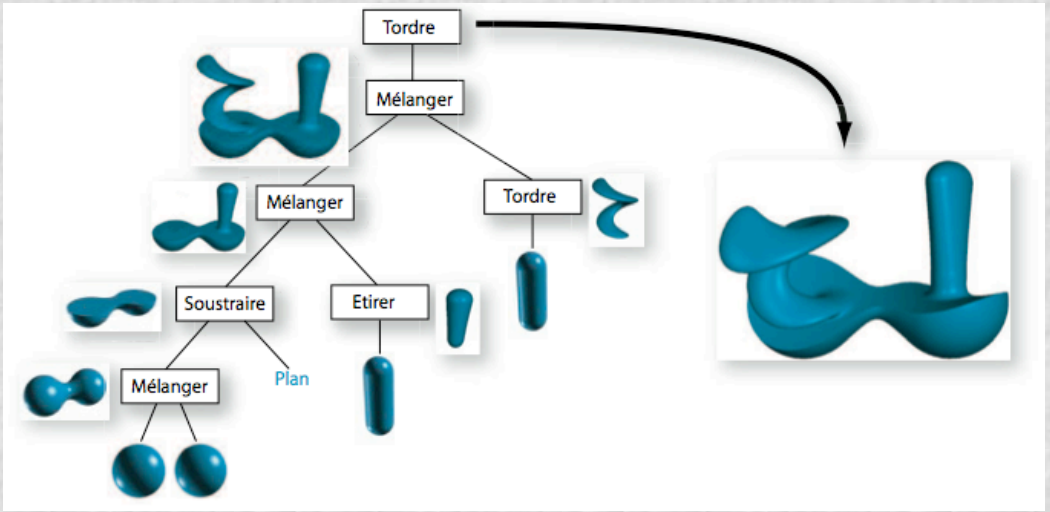
	Maillages triangulaires
Interpolation	 Butterfly modifié [DLG90, ZSS96] (C^1)
Approximation	 Loop [Loo87] (C^2)

2. Surface Models

- Theory: how is a surface mathematically represented ?
  - Implicit surfaces
  - Blob tree, volume conservation

$$f(x,y,z) = \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2}$$





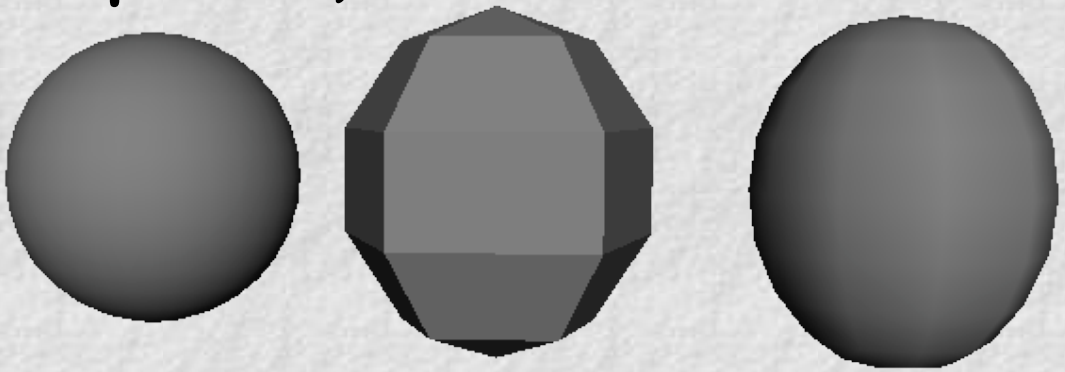
Eurographics, 1st April'09

2. Surface Models

- Theory
  - Discussion about pros and cons
    - How many points to be moved to create/deform the surface ?
    - Efficiency/controllability of deformation
    - Cost/accuracy of collision detection
    - Volume conservation
    - Rendering times
    - …

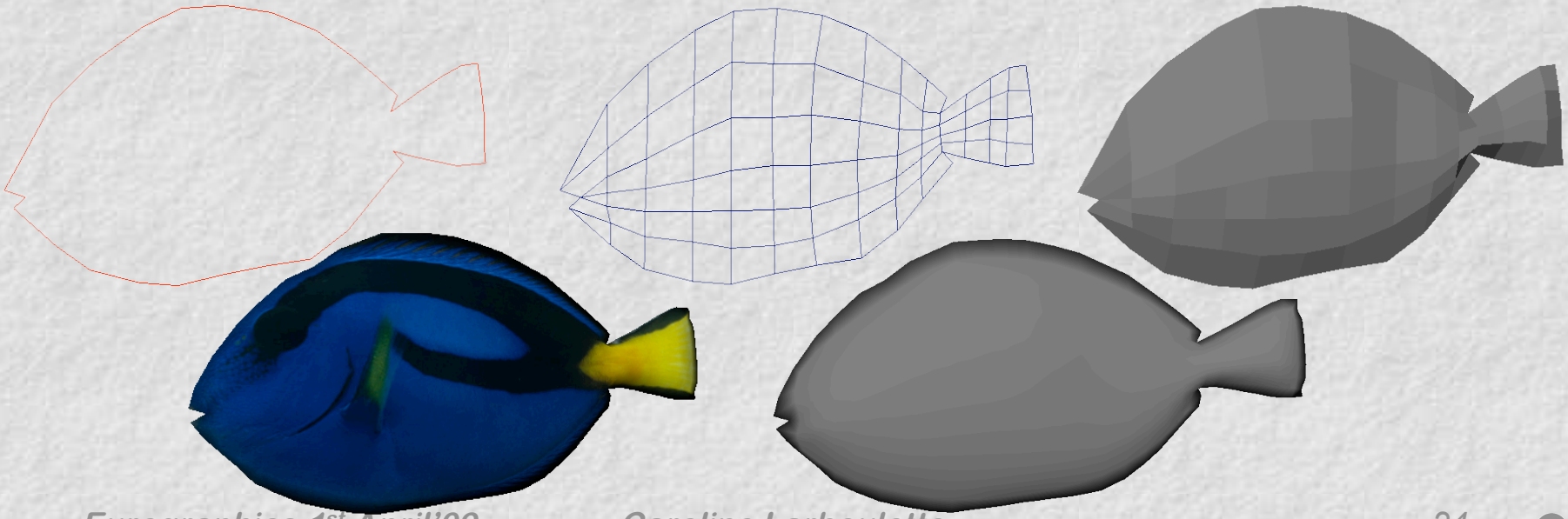
2. Surface Models

- Practice
  - We create objects with the different types of surfaces
  - We show the differences wrt number of control points, smoothness …



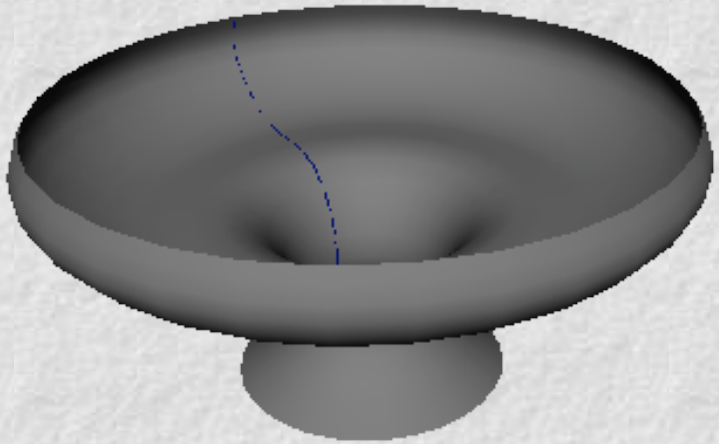
2. Surface Models

- Practice
  - We show how to create a simple polygonal object (fish)



3. Modeling Techniques

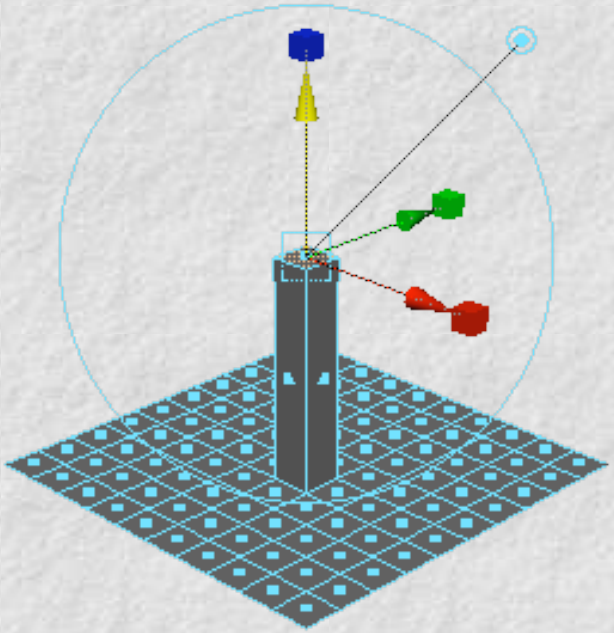
- Theory & Pratice
  - Revolve



$$x(\theta, t) = r(t)\cos\theta$$
$$y(\theta, t) = r(t)\sin\theta$$
$$z(\theta, t) = C(t)$$

3. Modeling Techniques

- Theory & Pratice
  - Revolve, Extrude



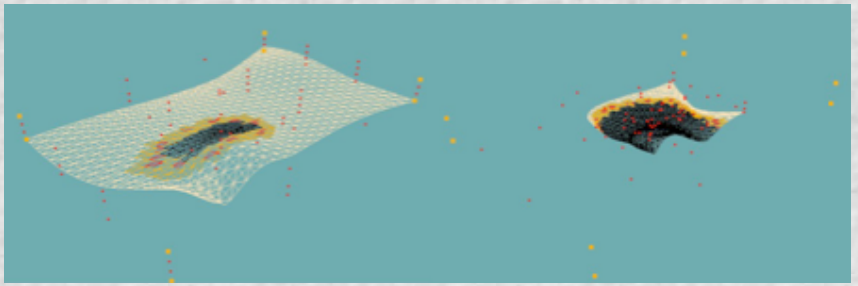
$$P_{new} = P + \vec{n} * l$$

3. Modeling Techniques

- Theory & Pratice
  - Revolve, Extrude, Loft, Sweep

4. Geometrically Based Deformation Techniques

- Theory
  - Keyshape interpolation
  - Warping
  - Global Deformations
    - Scaling, tapering, bending, twisting
  - Free Form Deformations



4. Geometrically Based Deformation Techniques

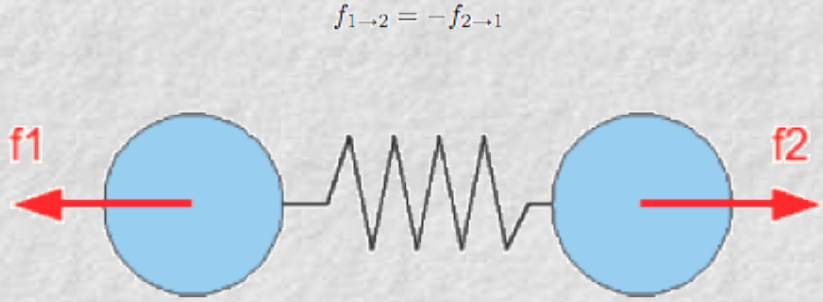
- Practice
  - Assignment: create a short animation using any of the techniques on an object

    http://gmrv.escet.urjc.es/~zabador/APOspring08/APO08_videos.html

5. Physically Based Deformation Techniques

- Theory
  - Some physics (elasticity, newton laws …)
  - Mass-Spring model
  - Numerical Integration (Euler, Runge-Kutta)

$$v(t+dt) = v(t) + a(t) * dt$$
$$p(t+dt) = p(t) + v(t) * dt$$



5. Physically Based Deformation Techniques

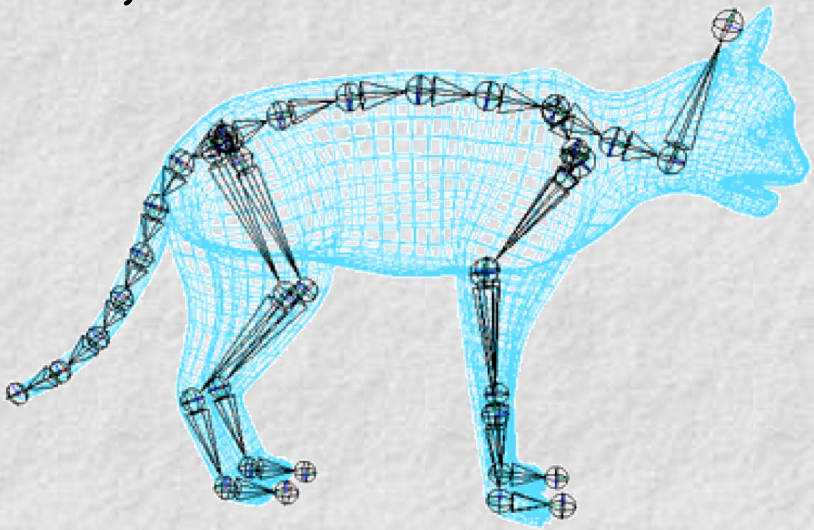
- Practice
  - Implementation of a mass-spring model (C++ openGL / Maya)
  - Maya mass-spring system
  - Maya nCloth

6. Collision Detection

- Theory
  - Distance computations
  - BVH
  - Penalty method
- Practice
  - Maya nCloth with *Passive* objects

7. Skinning

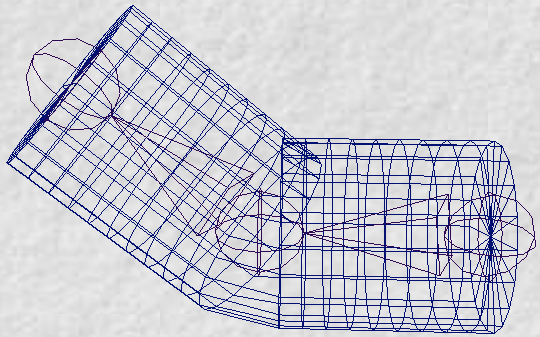
- Theory
  - Structure of an articulated character
    - Skeleton, skin

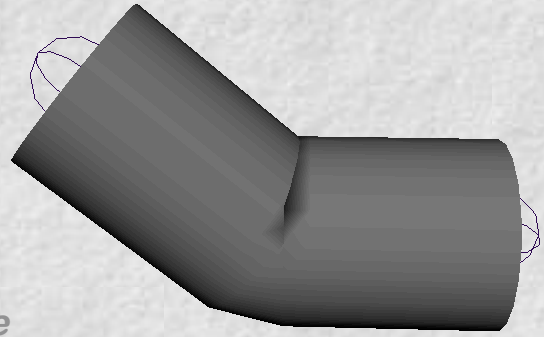


7. Skinning

- Theory
  - Structure of an articulated character
    - Skeleton, skin
  - Rigging
    - Rigid Skinning

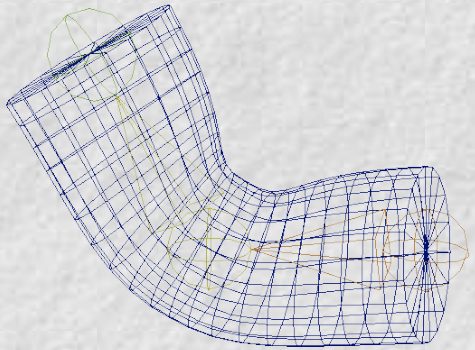
$$p_{v_i} = T_f \cdot p_{0v_i}$$

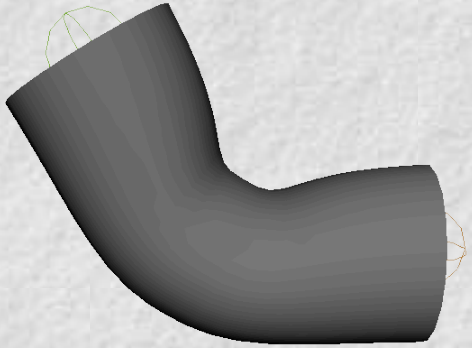




7. Skinning

- Theory
  - Structure of an articulated character
    - Skeleton, skin
  - Rigging
    - Rigid Skinning
    - Smooth Skinning





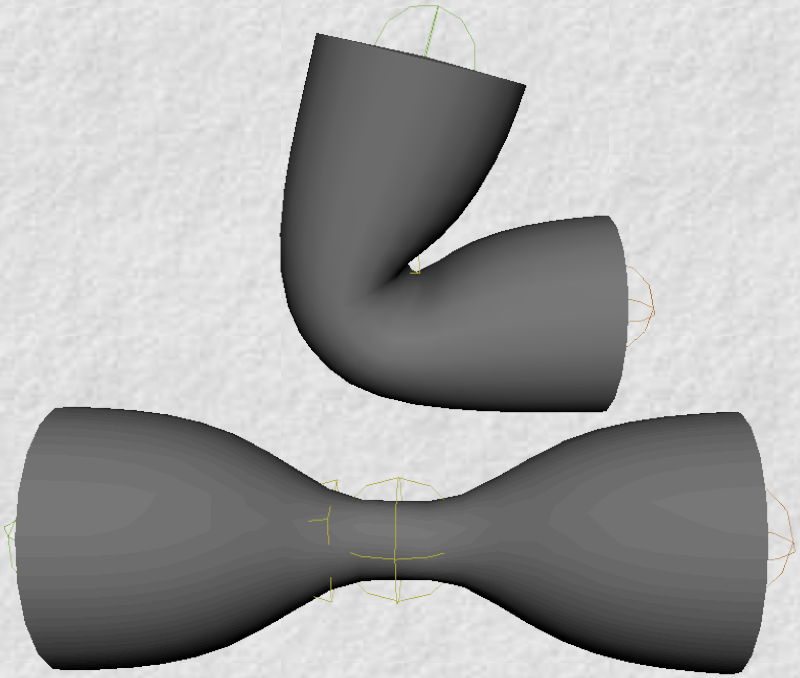
$$p_{v_i} = (\sum_{f=0}^{n} w_{if} . T_f) . p_{0v_i}$$

7. Skinning

- Theory
  - Structure of an articulated character
    - Skeleton, skin
  - Rigging
    - Rigid Skinning
    - Smooth Skinning
    - Comparison

7. Skinning

- Theory
  - Structure of an articulated character
    - Skeleton, skin
  - Rigging
    - Rigid Skinning
    - Smooth Skinning
    - Comparison
    - Problems



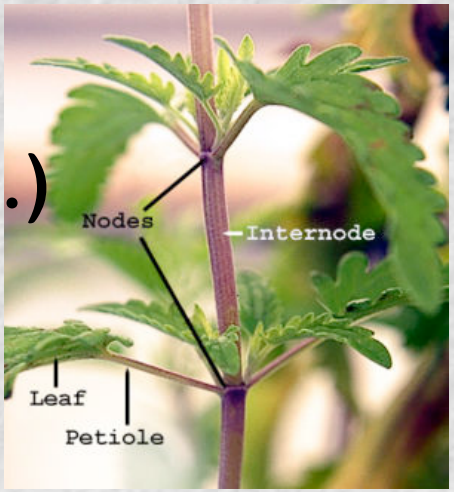
7. Skinning

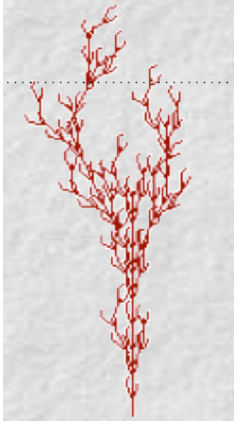
- Practice
  - Rigid & smooth skinning in Maya
  - Paint Skin Weights Tool
- Assignment
  - Create a simple character, a smooth skinning and paint the weights

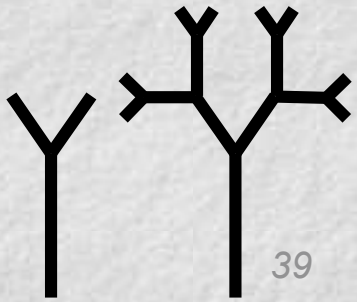
  http://gmrv.escet.urjc.es/~zabador/APOspring08/APO08_videos.html

8. Plants

- Theory
  - Some vocabulary (stem, bud …)
  - L-systems
    - Non-deterministic, Stochastic Parametric, Timed
  - Plants representations / animations
    - Polygonal models with skinning
    - Physics based techniques …







8. Plants

- Practice
  - How to use L-system to create actual plants
  - Maya fur

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Homework & Quizzes

- Quizzes
  - Aim : make the students read the course notes before each class
  - 10% of the grade
- Homework
  - Aim : make the students experiment with Maya or work on some problems
  - 10% of the grade
- Another 30% for the final exam and 50% for the semester project

Homework 1

- Relates to the different types of surfaces
- Project a point on a mesh
- Recognize spline basis functions
- Subdivide a surface patch using a mask
- Create an algorithm to deform a bouncing ball using constant volume

Homework 2

- Relates to the use of the different geometric deformation techniques
- Makes the students use Maya

Homework 3

- First part deals with numerical integration by hand of a simple function using different schemes
- Second part deals with the use of Maya to create a simple skinned character

Semester Project

- Students need to create teams (2 people if possible)

Semester Project

- Students need to create teams (2 people if possible)
- Team decides on the project (project proposal)
  - Context is animation of deformable objects
  - Can be a programming / scripting project
  - Can be an animation movie (in which case, it needs to tell a story)
  - Proposal includes a timetable and how the work is shared among students

Semester Project

- Students need to create teams (2 people if possible)
- Team decides on the project (project proposal)
- They have about 1.5 months to work

Semester Project

- Students need to create teams (2 people if possible)
- Team decides on the project (project proposal)
- They have about 1.5 months to work
- They submit a project report and video/source code/Maya files … by a deadline

Semester Project

- 22 students
  - 11 chose a programming project
  - 6 worked on a movie
  - 3 used scripting to create a movie
  - 1 developed scripts in Maya
  - 1 devoloped a video game
- 1 project ended up in a research paper [SCCG 09]

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Lecture Evaluation

- Evaluation by the students through an anonymous form
- Homework and quizzes
  - No complain
  - 17% enjoyed it
  - Well-balanced between theory and Maya

Lecture Evaluation

- English language
  - 39% complained (but half of them took the test in English)
  - 1 student was happy
  - All of them agreed it was a good thing
    - Improves students mobility
    - Prepares to read scientific papers
  - Except 2, they liked writing the project report in English
    - One of them is considering to now write his Master's thesis in English

Lecture Evaluation

- Content
  - Interdisciplinarity was a success
  - Videos and Maya examples helped to understand the theory
  - Corresponded to students expectations
- Duration
  - Not enough credits
  - Not enough time wrt the content

Conclusion

- Out of 28 registered students
  - 22 came to class
  - 20 took the character animation class this semester (in English too)
- Homework improved the knowledge acquisition
- Semester projects gave good results

Perspectives

- Develop better course notes -- book
- Continue to share content and share students

Thank you !

And thanks to the students who attended the class and actively participated !

Questions ?