CS 348C

Topics in Computer Graphics

Modeling

http://graphics.stanford.edu/courses/cs348c-95-fall/

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Please don't send email!

You can find all course material, even these overheads, on-line. Now, just write down the WWW site and stop taking notes.

My accent is Greek, in case you are curious. My name is weird I know... check the WWW for more on this issue and others...

I am a third year grad student, been at Stanford since 1989, Marc Levoy is my advisor, I have no research project yet (medical visualization seems promising), and I like teaching (I have TA'd three classes so far).

I have RSI, so call me (at work or at home) instead of using email. Well, it's OK to use email for questions with no or short replies.

Today

- Course administration.
- Overview half of course.

You are not expected to know what I'll cover. My goal is to demystify annoying buzzwords.

Admin: Birth of *This* CS 348C

This CS 348C =
Part CS 348A (geometric modeling) +
Part old CS 348C (natural phenomena)

1 unit = Presentation

3 units += Assignments + Project

How class came about: once upon a time there was a grad student who liked teaching... CS 348A was not offered that fall and so new students wouldn't get essential background on geometric modeling... too many lectures needed to teach CS 348A... CS 348C had not covered natural phenomena recently... mix them!

CS 348A has two parts: geometric modeling (easy), algorithms (hard). We will cover first part only. And we'll add a lecture on wavelets in geometric modeling, a hot topic, even though CS 348A does not do this.

The CS 348C part of the class will cover *recent work* on natural phenomena. Circulate SIGGRAPH proceedings with examples; SIGGRAPH is the most prestigious annual conference on computer graphics.

I apologize to new students for using unfamiliar course abbreviations.

I do geometric modeling lectures on Tuesdays. You do presentations on natural phenomena in groups of 2 or 3 students on Thursdays (and the last Tuesday). Working in groups is easier for people who had not had CS 348B. Also, presentations had better be good! Given that I have allocated time for 9 student presentations, with 3 student (at most) each, class size will be 27 students and no more; auditors are welcome though.

Units: 1, means you just do a presentation and take the class CR/NC (*CR/NC is not automatic; you still have to sign up for the CR/NC when you submit your study list*). 3 units means you also do 3 assignments, and a programming project, and you can take the class either CR/NC or for a grade.

Admin: 1-Unit Option

See WWW also!

Presentation:

- Use good overheads.
- Explain intuition; don't repeat formulas.
- Use visual aids: contact authors!
- Time is limited!

Attend other talks and participate.

Do not use “micro-fonts” in your overheads.

On the WWW listing of the readings, I have hyperlinks to most authors with their contact info. Use them!

A short discussion follows each presentation, during which ideas for projects are born.

Admin: 3-Unit Option

See WWW also! As 1 unit plus...

Project:

- Work in pairs.
- Implement algorithm from recent paper.
- Need to keep me posted.

Three short assignments:

- Two have each a programming and a written part.
- Last one is hands-on with `SoftImage`.

No more than two people are allowed per project; less than two is fine.

Improve and customize an algorithm from recent paper. To motivate you, Andrew Beers, Maneesh Agrawala, and myself have gotten our projects from past years published! Also, you can use advanced hardware for your projects, such as our RealityEngine.

We'll have student–coordinator meetings to discuss progress in the projects. The relevant dates and deadlines are posted on the WWW.

`SoftImage` is a computer graphics software package, distributed by Microsoft corporation. It contains a large collection of executables, from a production quality modeling and animation system, to a ray tracer, a particle system simulator, and standalone utilities for image compositing, format conversions, and much more.

One assignment every two (or more) weeks. You must work alone on the assignments. Remember: honor code violations tick me off!

Admin: Details...

- Office hours: see WWW.
- Meeting time/place: *really* see WWW.
- Course reader.
- Prerequisite: CS 248 or equivalent.
- Auditors: welcome, but yield.

Present hours are MW 1–2:30p

Meeting place changes on a few occasions. Also, we'll go on a field trip to PDI sometime during class time.

Course reader would be too expensive to make now, since we don't know which topics we will cover — we wouldn't want to include papers which we will not read, since copyrights are expensive.

Some course material is already on reserve at the MCS library: reference books, and a folder with (i) all the papers I propose to study for all the topics on natural phenomena, and (ii) papers on geometric modeling. The pictures look real bad, though... Keep in mind that the list of papers might change slightly on the basis of your suggestions, or as notable recent work is published; such new items will be handed out for free. *Do not get scared by the material in the reader* — we won't go into too much depth in class.

See WWW for a description of CS 248 and its syllabus. The geometric modeling material we'll cover is almost self-contained; the CS 248 intuition will be useful for programming assignments. CS 248 is a must for reading and understanding research papers which is what the reading on natural phenomena consists of.

Admin: Signing Up

1. Consult reserve material at library.
2. Choose number of units, grading option.
3. Choose 5 favorite topics for presentation.
4. Fill out on-line registration form by 5p tomorrow!

By Sat 5p you will be told

- If you are one of the chosen 27, and if so,
- when and which topic you are presenting.

Overview: Curves

Parametric curve: $x(t)$, $y(t)$ — not $y(x)$. t is *the parameter*.

Cubic parametric curve: $x(t)$, $y(t)$ cubic polynomials, e.g.

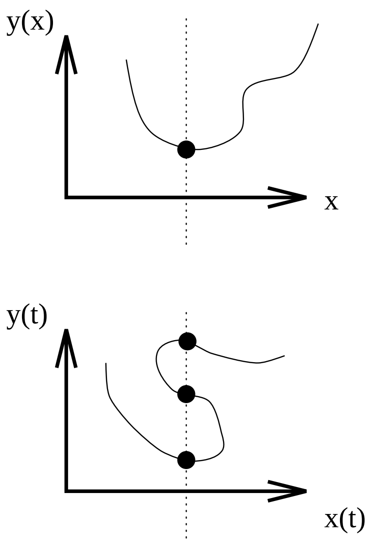
$$x(t) = 3t^2 + 4t + 1 \quad \text{and} \quad y(t) = t^3 + 5.$$

Piecewise curves: $x(t)$, $y(t)$ *different* cubic polynomials (*segments*) depending on t, e.g.

$$\begin{aligned} t \in [0,1] &: x_1(t) = 3t^2 + 1, y_1(t) = t^3 + 5 \\ t \in (1,2] &: x_2(t) = t^3 + t, y_2(t) = 3t^3 + t. \end{aligned}$$

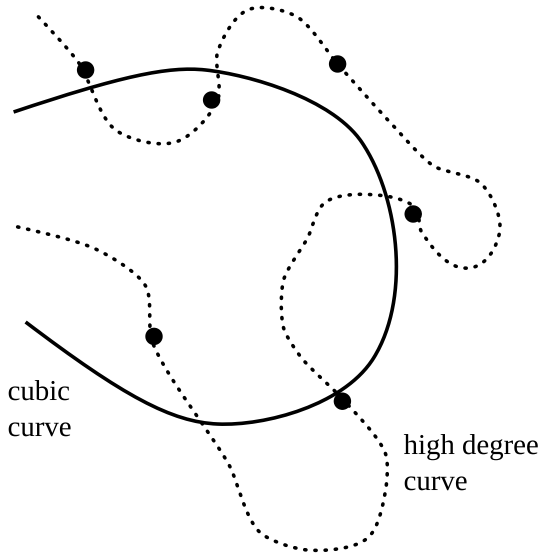
$t = 1$ is *knot*. $(x(1), y(1))$ is *joint*.

Overview: Parametric Curves



$y(x)$ drawback: only one y per x.

Overview: Interpolating Curves

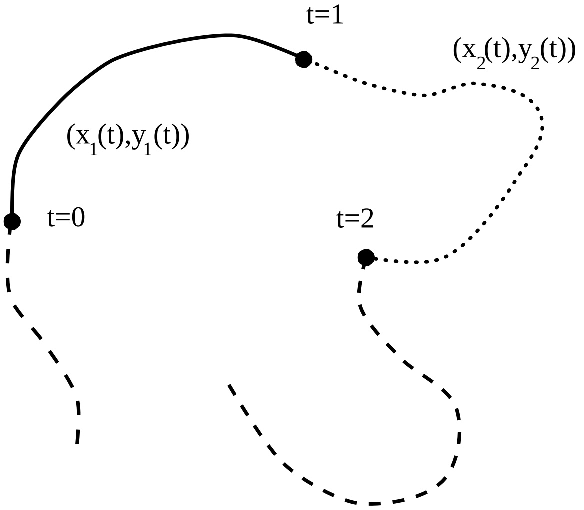


The high degree curve is exact but wiggly.

The cubic is inexact but it doesn't wiggle.

With 8 coefficients (4 for x, 4 for y) we don't have enough degrees of freedom to do modeling, e.g. a cubic cannot pass through all of 6 random points on the plane. Solution: use higher degree curves? Nope, they get too wiggly. Instead,...

Overview: Piecewise Curves



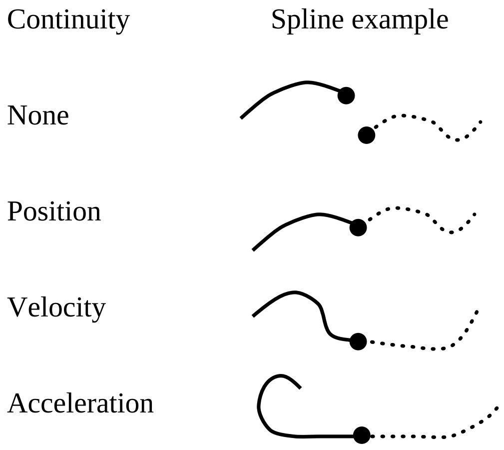
Overview: Spline Curves

Piecewise curves where adjacent segments meet smoothly at joints. Enforce smoothness by requiring same derivatives at knots, e.g.

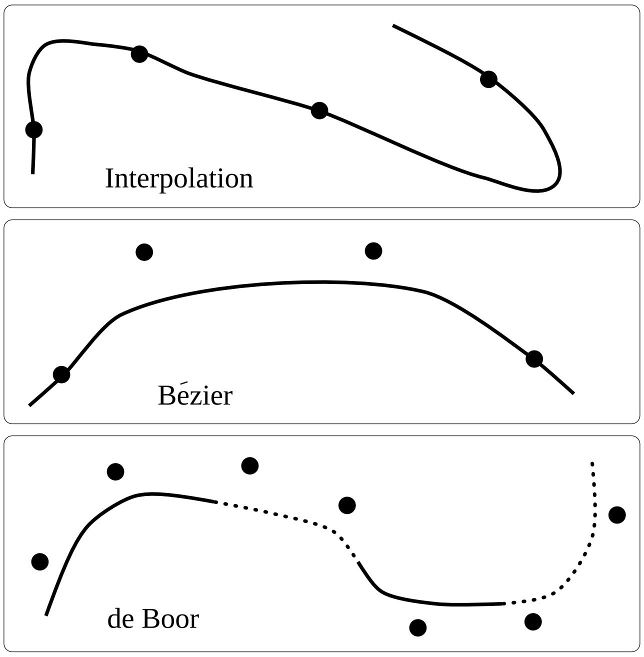
$$x_1(1) = x_2(1) \quad , \quad y_1(1) = y_2(1),$$
$$x'_1(1) = x'_2(1) \quad , \quad y'_1(1) = y'_2(1).$$

Equality of derivatives is *parametric continuity*. Number of identical derivatives is *degree of continuity*.

Overview: Continuity



Overview: Specifying Curves



As we said earlier, a problem with using high-degree curves to interpolate a given set of points is that the resulting high-degree curve wiggles too much. Specifying a curve by setting the points through which it must pass is problematic in a another way, too: moving one point changes the overall shape of the curve, even far away from the point we moved. To avoid this, people have designed different input techniques for curves (the Bézier points) and splines (the de Boor points)...

Overview: Specifying Curves

Bézier points: friendly user input to defining shape of a single cubic.

de Casteljau algorithm: how to find curve points from Bézier points.

Bernstein basis: closed-form representation of de Casteljau algorithm.

Blossoms or *polar forms* are alternate representation of polynomials, helpful in analyzing properties of curves.

Lyle Ramshaw, a co-inventor of polar forms, will come and give a guest lecture on the topic!

Overview: Specifying Splines

de Boor points: friendly user input to defining shape of a B-spline.

de Boor algorithm: how to find spline points from de Boor points.

de Boor basis: closed-form representation of de Boor algorithm.

For *Non-Uniform Rational B-Splines* (NURBS), replace cubics with ratios of cubics, space knots varying distances apart.

Overview: Tensor-Product Surfaces

Move a spline curve along a path defined by another spline curve.

Surfaces are defined by mathematicians as the trace left behind a moving curve.

Overview: Quaternions

A concise, intuitive representation of orientation with 4 numbers.

What is orientation? When I talk about my head, it is the direction I am looking at, which can be described by two numbers (angles in spherical coordinates, or azimuth and elevation), and how much my head is turned, which can be described by an angle. This is a total of 3 degrees of freedom. Quaternions represent rotation with 4, instead of 3, numbers — the extra number is added to make *composition*, i.e. combination of successive rotations (changes of orientation), easy.

Overview: Projective Geometry

Site notation: represent points on the plane with three numbers $(1; x, y)$, and vectors with $(0; x, y)$, instead of two (x, y).

Homogeneous coordinates: represent points and vectors on the plane with three numbers $(w; x, y)$; w is arbitrary now.

Projective geometry: interpreting, visualizing, and manipulating triples $(w; x, y)$.

Overview: Natural Phenomena

Excerpts from SIGGRAPH videos.

Register by 5p tomorrow!

I will now play some SIGGRAPH videos illustrating the kind of modeling techniques we will be discussing in the class:

- Issue 96, no. 17, fast forward 4 minutes,...
- Issue 96, no. 19,
- Issue 114, nos. 1–3.