

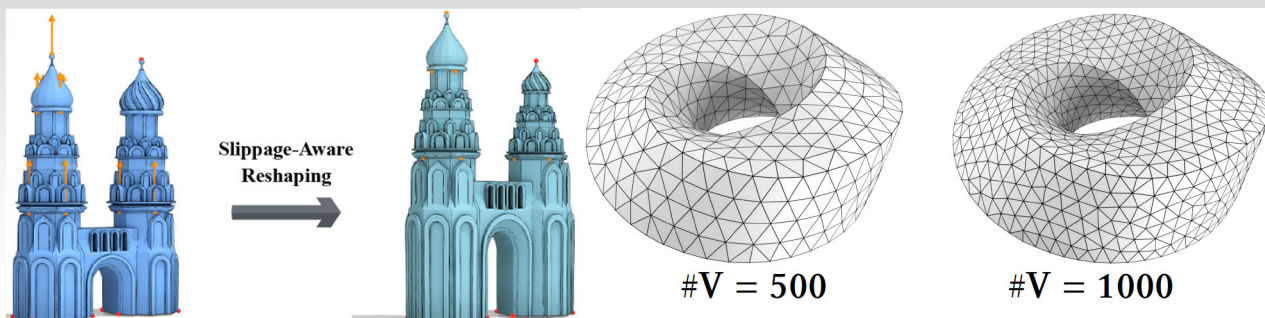
CPSC 424 Geometric Modeling



Alla Sheffer

My research areas: Computer Graphics/
Visual Computing/Geometry Processing/Geometry Modeling

<https://www.cs.ubc.ca/~sheffa>



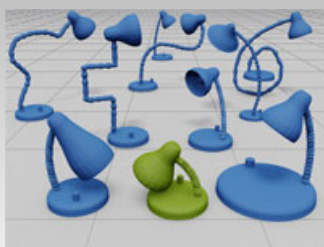
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What is Geometric Modeling?

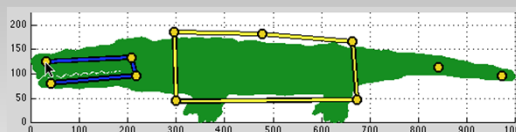


- Representation, Creation, Manipulation & Editing of Virtual 3D & 2D Shapes

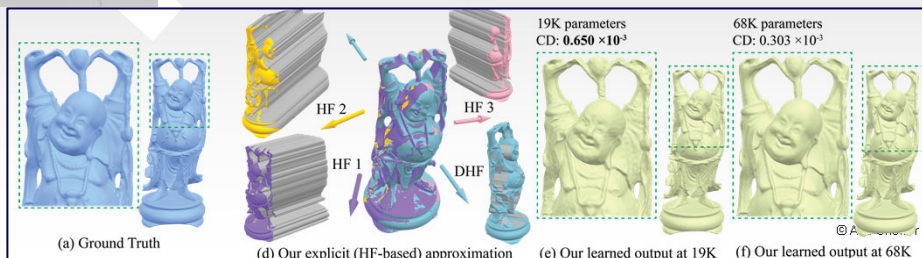
Creation



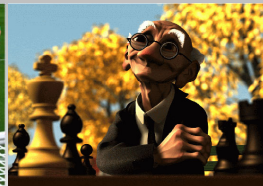
Editing



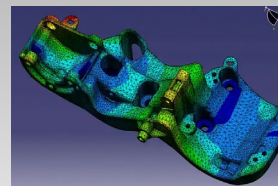
Representation



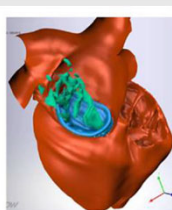
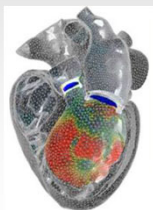
What is it used for?



Games/Movies



Engineering/Fabrication



Medicine/Biology



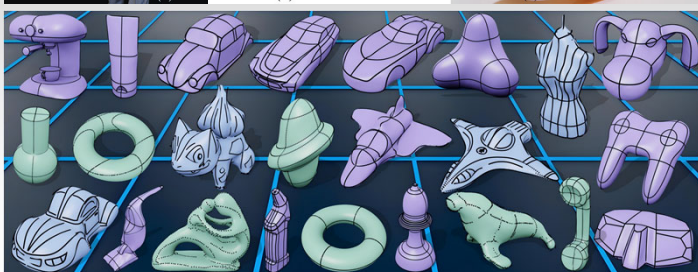
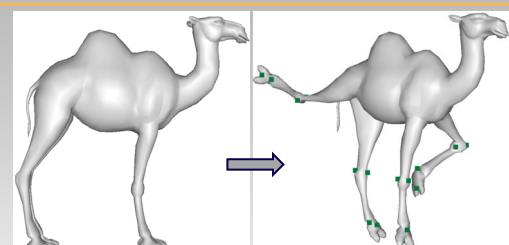
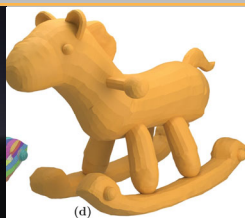
Computer Vision/Robotics



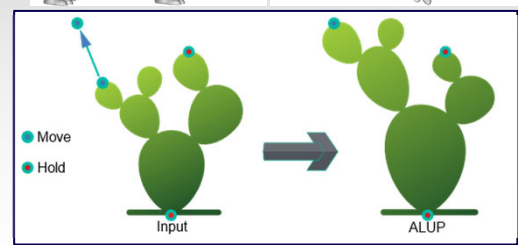
Architecture

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State of the Art (very partial)



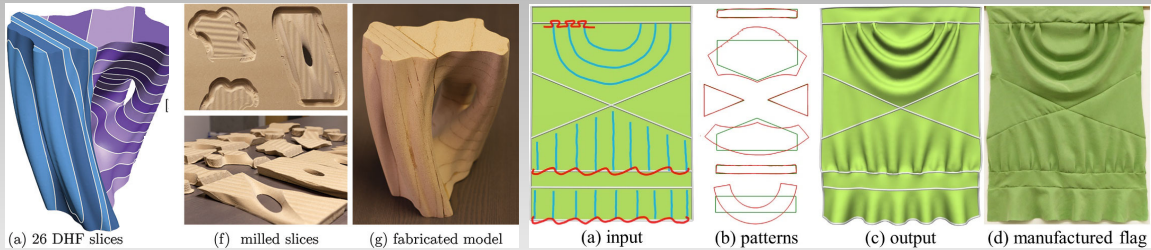
Modeling Interfaces



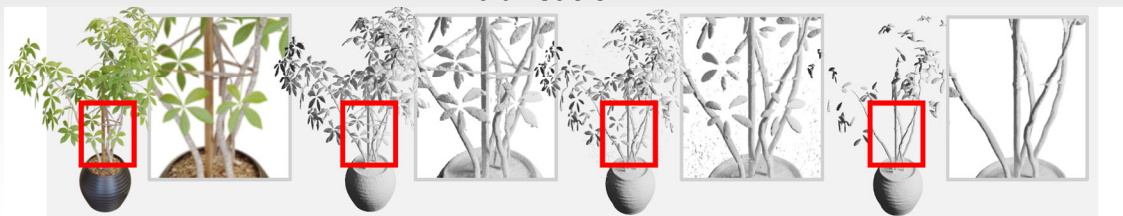
Editing

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State of the Art (very partial)



Fabrication



Shape Reconstruction

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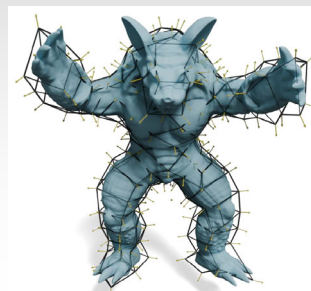
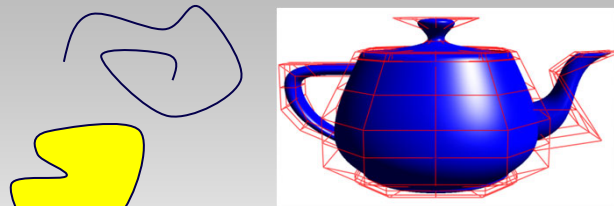
Topics Covered:

Curves and Surfaces

- Geometry representations
- Mathematical foundations
- Algorithms
- Data structures

Emphasis:

- Parametric curves & surfaces
- Subdivision curves & surfaces
- Polygon meshes
- 2D and 3D Implicits
- Neural representations



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Topics NOT Covered:

Interesting but no time:

- Fractals, iterated function systems, etc.
- Procedural geometry

Fine Arts topics:

- Artistic issues
- How to use a geometric modeling package

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Course Format

Lectures:

- Tue, Thu 11AM-12:30PM, CHEM 124

Tutorials:

- TAs: Oliver Oxford, Daniel Cui
- Thu 4PM-5PM, **ORCH 3074** (& ORCH 3018)
 - *Ideally merge into one*
 - *First tutorial: next week (week 2)*

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Prerequisites

Formal:

- one of MATH 152, MATH 221, MATH 223
- one of MATH 200, MATH 217, MATH 226, MATH 253.

Informal:

- Ability to program with JavaScript/WebGL
- Solid math foundation

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Resources

Web:

- <https://www.students.cs.ubc.ca/~cs-424/>
- Piazza discussion forum (link from course page)
 - **Note: !!!! Contact me ASAP if you have privacy concerns re direct use of PIAZZA !!!!**
- Canvas: quizzes + grade reporting

Textbooks:

- None

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Grading System

30% Final

- **Must pass** to pass course

30% (15% + 15%): Midterms

- (Probably) October 6 and November 3, in class
- **Must have passing average** to pass the course

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Grading System

30%: 7 Assignments

- Mix of theoretical & WebGL/JavaScript
 - https://www.students.cs.ubc.ca/~cs-424/assn_index.html
 - Heavier weight for two larger (coding) assignments **(12%)**
 - JavaScript/WebGL
 - Theory assignments **(18%)**

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Grading System

30%: 7 Assignments

- Details will be posted at
https://www.students.cs.ubc.ca/~cs-424/assn_index.html
- Due online (handin) **Friday 11:59PM**
- Grace day policy
 - Have 3 (workday) grace days across **all** assignments
- Solutions discussed in subsequent tutorials
 - **Can't submit once solution discussed**
- **Crucial for midterms & final!!**

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Grading System

10% Participation++

- Weekly quizzes (3%) + Review questions (3%) + In class participation (4%)

Weekly Quizzes (3%)

- Do-at-home multiple choice quiz
- Starting from week three
- Typically selected from the questions posted by students as part of the weekly review (next slide)
- Posted on **Canvas** Tue due Fri noon (same week)
- **Some of these questions will be on midterms/final**

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Grading System

Review Questions (3%)

- Submit one question per week
 - via **private** Piazza message
 - Due **Monday noon**
- Based on material covered *the week before*
- Each submission needs to include:
 - question
 - four+ multiple choice answers
 - **explanation of correct answer**
- If your question is selected for a quiz your grade for the quiz containing it will **double**

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Grading System

Class Participation (4%)

- Q & A
 - Points for asking/answering questions in class
- Clicker questions
 - On average 1 per class (often in first 5min...)
 - Credit for participation not correctness
- **Written notes**
 - Points for uploading (good) class notes to Piazza

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LLMs

Short Summary:

- Can use (I don't think it is a good idea to use them but I can't prevent you from doing it)
- Must:
 - *Disclose*
- Work done with LLM that does not match specifications will get zero grade + scrutiny (in person questioning) for all submitted work
- Need to be able to explain in person every submitted assignment/quiz questions, etc...
 - *Students will be randomly selected to explain work in person*
 - *Failure to explain = grade of zero*

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TODO

Webpage

- Read
- Comply with policies

Piazza

- Register

iClicker

- Register/install: <https://join.iclicker.com/THQV>

A1:

- Read

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Decorum (respect your classmates)



Please seat at the front of the class

- Ensures you can see & hear

Please come on time & stay till end of class

- Coming/leaving disrupts everyone *even if done quietly*
- Hint: we will have clicker questions near start/end

Please no open screens with non class stuff

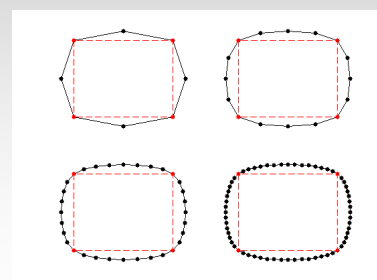
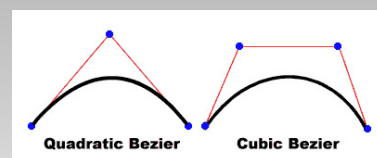
- Very disruptive for folks sitting behind you

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Syllabus (I): Curves in 2D and 3D



- Implicit vs. explicit vs. parametric curves
- Basis functions and Splines
- Hermite and Bezier curves
- Elementary differential geometry
- Other bases
- Subdivision Curves
- 2D Implicits: Analytical and Neural

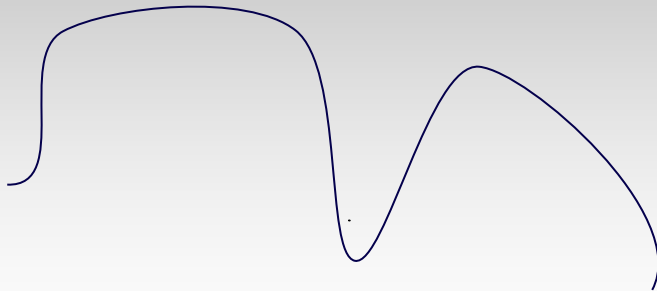


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Syllabus (I): Curves in 2D and 3D

Curves in 2D and 3D

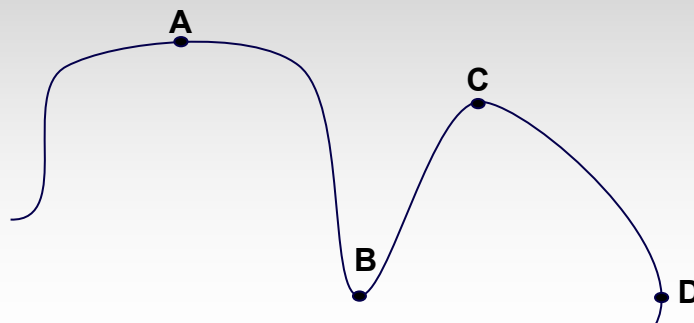
- Example: Curves in PowerPoint (Bezier/Hermite)



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Syllabus (I): Curves in 2D and 3D

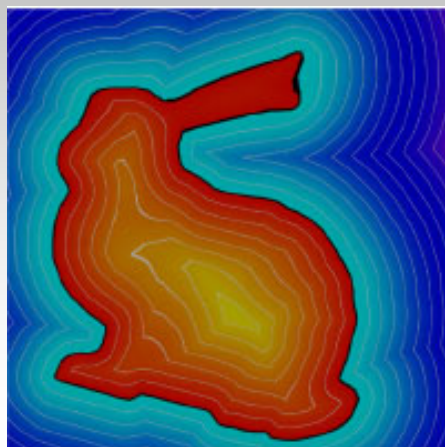
- Example: Elementary differential geometry – curve properties



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Syllabus (I): Curves in 2D and 3D

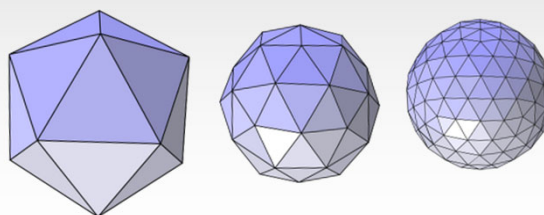
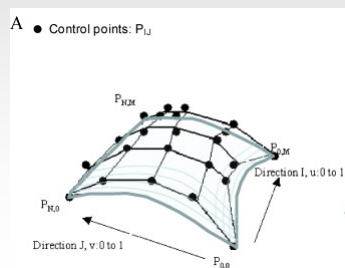
- Example: 2D Implicits



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Syllabus (II): Surfaces and Meshes

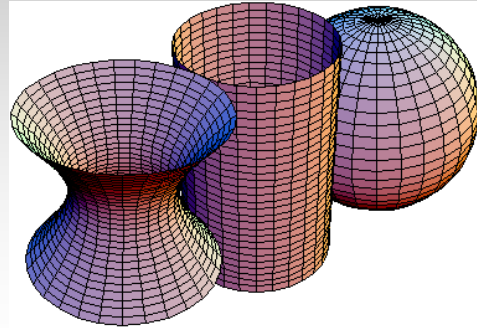
- Tensor product surfaces
- Elementary Differential Geometry of Surfaces
- Polygonal Meshes
- Implicit surfaces
- Neural surface representations



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Syllabus (II): Surfaces and Meshes

- Example: Properties of Curves and Surfaces - Elementary Differential Geometry
 - Frenet Frame
 - Curvature (Gauss, min/max...)
 - Discrete curvature

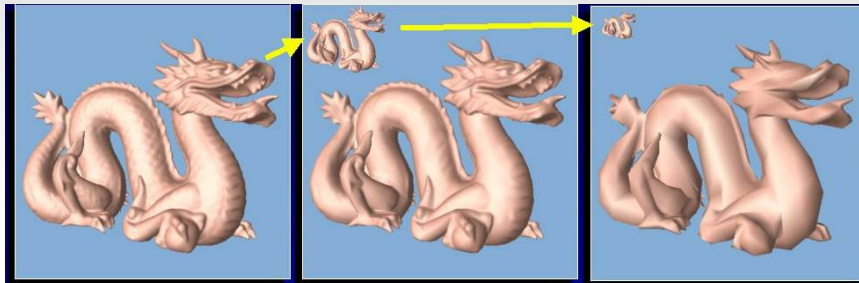
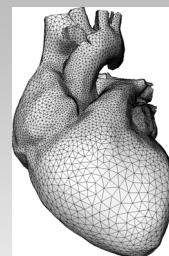


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Syllabus (II): Surfaces and Meshes

Example: Polygonal Meshes

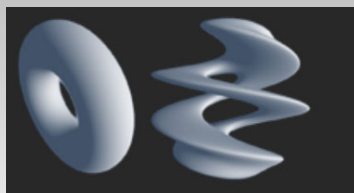
- Data structures
- Processing
 - Simplification
 - Parameterization
 -



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Syllabus (II): Surfaces

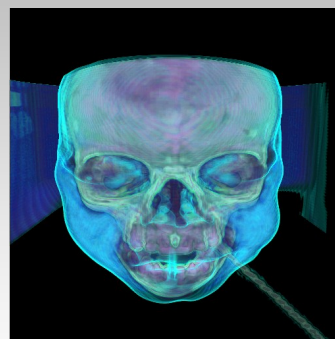
- Example: Implicit surfaces



Torus

```
float sdTorus( vec3 p, vec2 t )
{
    vec2 q = vec2(length(p.xz)-t.x,p.y);
    return length(q)-t.y;
}
```

```
float opTwist( in sdf3d primitive, in vec3 p )
{
    const float k = 10.0; // or some other amount
    float c = cos(k*p.y);
    float s = sin(k*p.y);
    mat2 m = mat2(c,-s,s,c);
    vec3 q = vec3(m*p.xz,p.y);
    return primitive(q);
}
```



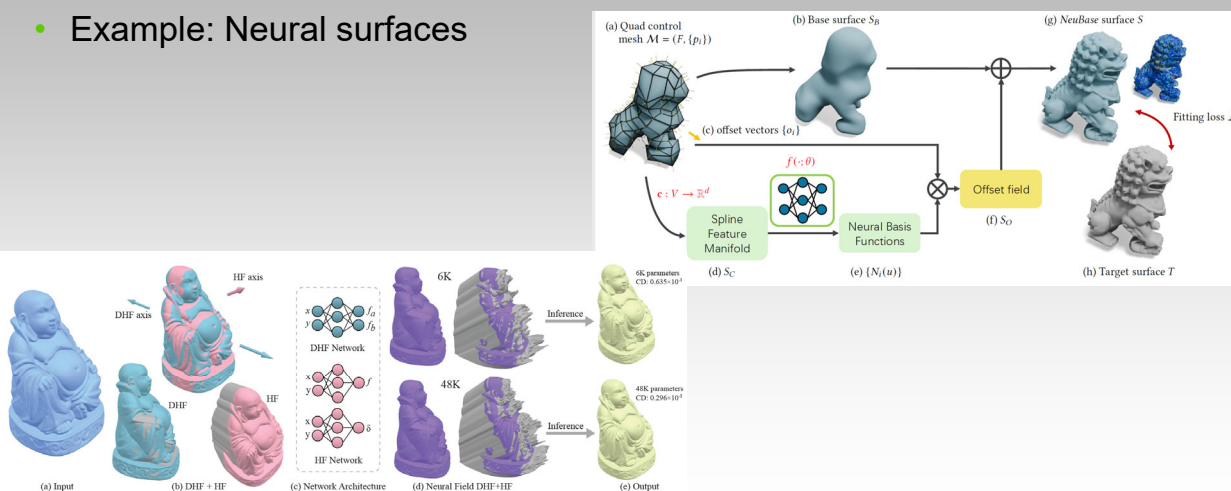
Analytical

Discrete (voxels)

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Syllabus (II): Surfaces and Meshes

- Example: Neural surfaces



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Syllabus (III): Advanced topics (**you pick**)



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