Isosurfacing (Part 3)
Announcements

• Final project
  – Come in & talk with me
• Quiz #2 delayed to Nov 6th
• OH: Fri 12-1 is a bad time
  – Thurs 9-10
  – Thurs 10-11
  – Thurs 12-1
  – Thurs 1-2
  – Thurs 2-3
Announcements

• Thanksgiving lecture
• Faculty Fireside
• Project 7 & 8 likely to become 7A & 7B
Quiz & Project 5

- Change to other PPT presentation
Proj 6 debug talk

• SegmentList *
• Pixel isolines
• More on 6B at the end
Isosurfacing

Quiz: where should the isosurface go?
Isosurfacing

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Isosurfacing

Quiz: where should the isosurface go?
This is our last two cells, side by side
Isosurfacing

Uh oh ... ambiguous case is causing problem
Problem case: ambiguity!!

2D Solution: just pick one and go with it.

3D: nope, that doesn’t work here
Isosurfacing

Uh oh ... ambiguous case is causing problem
Isosurfacing

Let’s try to make something consistent
Let's try to make something consistent

Quiz: how many triangles will we need?
Isosurfacing

No! This is got us into trouble before!

Let’s try to make something consistent
Let’s try to make something consistent
Let's try to make something consistent
Let’s try to make something consistent
From a different angle...
Summary So Far For Ambiguities

• Ambiguities cause problems:
  – If you use one interpretation for one cell, and use the other interpretation for its neighboring cell, then you get gaps
  – Always making the “intuitive” choice does not solve the problem.

• If you choose consistently, then you can avoid these problems.
How to make consistent choices

- “Asymptotic Decider”
  - Analyze scalar field and make decision

Quiz: why does this result in consistent choices?
How to make consistent choices

• Conventions!
  – E.g., always separate lowest vertex
  – This is consistent across faces
  – This is how VTK (and case_checker) works
What should we do?

• Case_checker: uses conventions for consistent choices

• Our choices:
  – Figure out those conventions and reproduce them perfectly
    • Correct and additional effort
  – Ignore the conventions and accept gaps
    • Incorrect, but easier

• Note: ambiguous cases don’t come up a lot in practice
Equality

• Current case assignment:
  – $F(V) < \text{isovalue}: 0$
  – $F(V) > \text{isovalue}: 1$

• What if the field value at a vertex is equal to the isovalue?

Quiz: what is the physical interpretation of having $F(v) == \text{isovalue}$?
Equality Strategy

• Case assignment (incorporating inequality):
  – $F(V) < \text{isovalue: } 0$
  – $F(V) \geq \text{isovalue: } 1$
Equality Strategy

• Case assignment (incorporating inequality):
  – \( F(V) < \text{isovalue}: 0 \)
  – \( F(V) \geq \text{isovalue}: 1 \)

• Quiz: calculate isolines for isovalue = 5.
Accelerating Isosurfacing

- Marching Cubes:
  - For each cell,
    - Assign case
    - Use lookup table for case to generate geometry

Quiz: what is the computational complexity of this algorithm?
Answer: $O(n_{cells})$

Quiz: could we improve the computational complexity of this algorithm?
Accelerating Isosurfacing

- Marching Cubes with Scalar Trees:
  - Preprocessing step: calculate “scalar tree”
  - For each cell that contains the isovalue,
    - Assign case
    - Use lookup table for case to generate geometry

Quiz: what is the computational complexity of this algorithm?
Answer: \( O(\text{prep time}) + O(n\text{SelectedCells} \times \text{SearchTime}) + O(n\text{SelectedCells}) \)

Quiz: when would this be superior to naïve algorithm?
Scalar Trees

• The tree consists of an array of (min,max) scalar range pairs per node in the tree.
• The (min,max) range is determined from looking at the range of the children of the tree node.
• If the node is a leaf, then the range is determined by scanning the range of its corresponding cell.
  – Optimization: one leaf corresponds to multiple cells.
Scalar Tree: Example

- Cell 0 range: 0-2
- Cell 1 range: 1-3
- Cell 2 range: 0-3
- Cell 3 range: 4-8
- Cell 4 range: 0-3
- Cell 5 range: 2-6
- Cell 6 range: 8-10
- Cell 7 range: 7-9

This is the simplest version of this data structure.
Accelerating Isosurfacing

• Marching Cubes with Scalar Trees:
  – Preprocessing step: calculate “scalar tree”
  – For each cell that contains the isovalue,
    • Assign case
    • Use lookup table for case to generate geometry

Quiz: what is the computational complexity of this algorithm?

Answer: \( O(n\text{Cells} \times \log(n\text{Cells})) + O(n\text{SelectedCells} \times \log(n\text{SelectedCells})) + O(n\text{SelectedCells}) \)

Quiz: when would this be superior to naïve algorithm?
Project 6

• 6A: implement marching quads (Weds lecture), including all 16 cases
• 6B: implement marching cubes, but only a subset of the cases
  – We will use SVN to share our cases
  – There will be a case checker
    • Ambiguities are hard
• Everyone does 6A, some do 6B
• Please email if you want to do 6B
Isosurfacing