Assignments

• project
  • P4 due today 5pm (plus grace/late days)
  • project 4 demo signup sheet, for last time
    • I will scan and post so you can check your time
    • you must contact me by Fri to schedule if you weren't in class to sign up
      • otherwise 2% huntdown penalty
    • email me in advance if you need to change
      • otherwise 2% no show penalty

• homework
  • H4 solutions released Friday
    • homeworks not accepted after Thu 5pm
    • again: if you hand in late, do include time/date at top
  • H4 will be graded before exam
    • stay tuned, I'll announce on discussion group when they're ready to pick up
Office Hours

- extra TA office hours in lab 005 for P4/H4
  - Wed 4/14 2-4, 5-7 (Shailen)
  - Thu 4/15 3-5 (Kai)
  - Fri 4/16 11-4 (Garrett)
- my office hours for rest of term
  - Fri 4/16 4pm
  - by appointment - send me email to book
  - (I'm out of town 4/24-4/27, right after exam)
Graded Work

• still have some marked work not picked up, come grab it!
  • homeworks, midterms

• some extra handouts in lab
  • or print out yourself, everything posted on web site

• don't forget to check ugrad account for grading updates
  • find out what you got
  • also cross-check our records against yours
Final Exam

• Apr 23 8:30-11:30am, location DMP 310
  • across the hall
  • exam will be 2.5 hrs
  • extra 30 min in case of fire alarms, etc
• closed book
• one page notes, 8.5"x11", handwritten
  • both sides allowed, fine to reuse one side from midterm
• calculator is a good idea
• IDs out and face up
• bags/coats in front - phones off!
Final Emphasis

- covers entire course
- includes material from midterm
  - transformations
  - viewing
- more than half of exam will be on material not covered in midterm
  - color
  - rasterization
  - lighting/shading
- advanced rendering
- clipping
- hidden surfaces
- blending
- textures
- procedural approaches
- picking
- collision
- antialiasing
- modern hardware
- curves
- visualization
Exam Prep

• another sample final just posted
  • from Jan 2007

• homeworks are good practice
  • especially old homeworks from when I taught the course
Grading Reminder

• Original grading scheme for course
  • 20% midterm and 25% final

• New grading scheme for course
  • 12% midterm and 33% final

• Your course grade will automatically be the max of new and old schemes.
**Correction: Premultiplying Colors**

- specify opacity with alpha channel: \((r,g,b,\alpha)\)
  - \(\alpha=1\): opaque, \(\alpha=.5\): translucent, \(\alpha=0\): transparent

- **A over B**
  - \(C = \alpha A + (1-\alpha)B\)

- but what if \(B\) is also partially transparent?
  - \(C = \alpha A + (1-\alpha)\beta B = \beta B + \alpha A + \beta B - \alpha \beta B\)
  - \(\gamma = \beta + (1-\beta)\alpha = \beta + \alpha - \alpha \beta\)
    - 3 multiplies, different equations for alpha vs. RGB

- premultiplying by alpha
  - \(C' = \gamma C, B' = \beta B, A' = \alpha A\)
  - \(C' = B' + A' - \alpha B'\)
  - \(\gamma = \beta + \alpha - \alpha \beta\)
    - 1 multiply to find \(C\), same equations for alpha and RGB
Clarification: Midpoint Check

- \( f(x,y) = (y_0 - y_1) x + (x_1 - x_0) y + x_0 y_1 + x_1 y_0 \)
  - implicit equation: on line when \( f(x,y) = 0 \)
  - above line when \( f(x,y) < 0 \)
  - below line when \( f(x,y) > 0 \)
- check midpoint against line
  - midpoint to check is at \( x+1, y+.5 \)
  - if \( f(x+1, y+.5) < 0 \) then midpoint is below line

```plaintext
y = y_0
for (x=x_0; x <= x_1; x++) {
    draw(x,y);
    if (f(x+1, y+.5) < 0) then {
        y = y + 1;
    }
}
```
Clarification: Making It Incremental

- **d**: midpoint. Build off previous computation
- If we stayed at the same level, midpoint above line (d<0)
  - New midpoint check to set up is \( f(x+1, y) = f(x,y) + (y_0 - y_1) \)
- If we moved up one level, midpoint below line (d>0)
  - New midpoint check set up is \( f(x+1, y+1) = f(x,y) + (y_0 - y_1) + (x_1 - x_0) \)

```cpp
y = y_0
d = f(x_0 + 1, y_0 + .5)
for (x = x_0; x <= x_1; x++) {
    draw(x, y);
    if (d < 0) then {
        y = y + 1;
        d = d + (x_1 - x_0) + (y_0 - y_1)
    } else {
        d = d + (y_0 - y_1)
    }
}
```
Clarification/Correction: Integer Only

- avoid dealing with non-integer values by doubling both sides
  - from \( f(x,y) = 0 \) to \( 2f(x,y) = 0 \)
  - \( f(x,y) = (y_0 - y_1)x + (x_1 - x_0)y + x_0y_1 + x_1y_0 \)

\[
\begin{align*}
  y &= y_0 \\
  d &= f(x_0 + 1, y_0 + 0.5) \\
  \text{for } (x=x_0; x \leq x_1; x++) 
  &\{ \\
  &\quad \text{draw}(x,y); \\
  &\quad \text{if } (d<0) \text{ then } \{ \\
  &\quad\quad y = y + 1; \\
  &\quad\quad d = d + (x_1 - x_0) + (y_0 - y_1) \\
  &\quad\} \text{ else } \{ \\
  &\quad\quad d = d + (y_0 - y_1) \\
  &\quad\} \\
  &\}
\end{align*}
\]

\[
\begin{align*}
  y &= y_0 \\
  d &= \frac{2}{2}(y_0 - y_1)(x_0 + 1) + (x_1 - x_0)(2y_0 + 1) + 2x_0y_1 - 2x_1y_0 \\
  \text{for } (x=x_0; x \leq x_1; x++) 
  &\{ \\
  &\quad \text{draw}(x,y); \\
  &\quad \text{if } (d<0) \text{ then } \{ \\
  &\quad\quad y = y + 1; \\
  &\quad\quad d = d + 2(x_1 - x_0) + 2(y_0 - y_1) \\
  &\quad\} \text{ else } \{ \\
  &\quad\quad d = d + 2(y_0 - y_1) \\
  &\quad\} \\
  &\}
\end{align*}
\]
Evaluations - Right Now

• official TA evaluations
  • still on paper, not online yet

• unofficial course evaluations - my custom form
  • much more specific questions than the official ones
  • I do not look at these until after official ones returned, long after grades are out
  • if you missed class, blanks will be in extra handouts container in lab, can turn in anonymously to the front desk on 2nd floor
  • your feedback helps me improve the course in later years

• please also fill out official teaching surveys for instructor (me!) at the CoursEval website
  https://eval.olt.ubc.ca/science
Review: Direct Volume Rendering

- Classify
- Shade
- Interpolate
- Composite
Review: Visual Encoding

marks: geometric primitives
- points
- lines
- areas

attributes
- position
- size
- grey level
- texture
- color
- orientation
- shape

- attributes
  - parameters
  - control mark appearance
  - separable channels
    flowing from retina to brain
Review: Channel Ranking By Data Type

[MacKainlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986]
Review: Integral vs. Separable Channels

- not all channels separable

[Colin Ware, Information Visualization: Perception for Design. Morgan Kaufmann 1999.]
Review: Preattentive Visual Channels

- color alone, shape alone: preattentive
  ![Preattentive Visual Channels Example 1]
  ![Preattentive Visual Channels Example 2]

- combined color and shape: requires attention
  - search speed linear with distractor count
  ![Preattentive Visual Channels Example 3]
  ![Preattentive Visual Channels Example 4]

[Christopher Healey, [www.csc.ncsu.edu/faculty/healey/PP/PP.html]]
Nonspatial/Information Visualization II
3D vs 2D Representations

- curve comparison difficult: perspective distortion, occlusion
- dataset is abstract, not inherently spatial
- after data transformation to clusters, linked 2D views of representative curves show more

[van Wijk and van Selow, Cluster and Calendar based Visualization of Time Series Data, InfoVis99]
Space vs Time: Showing Change

- animation: show time using temporal change
  - good: show process
  - good: flip between two things
  - bad: flip between between many things
    - interference between intermediate frames

[Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg]
[www.astroshow.com/ccdpho/pluto.gif]
[Edward Tufte. The Visual Display of Quantitative Information, p 172]
Space vs Time: Showing Change

- small multiples: show time using space
  - overview: show each time step in array
  - compare: side by side easier than temporal
    - external cognition vs internal memory
  - general technique, not just for temporal changes

[Edward Tufte. The Visual Display of Quantitative Information, p 172]
Composite Views

• pixel-oriented views
  • overviews with high information density

• superimposing/layering
  • shared coordinate frame
  • redundant visual encoding


[Munzner. Interactive Visualization of Large Graphs and Networks. Stanford CS, 2000]
Composite Views: Glyphs

- internal structure where subregions have different visual channel encodings

Variations on Profile glyphs
Stars and Anderson/metroglyphs
Sticks and Trees

Autoglyph and box glyph
Face glyphs
Arrows and Weathervanes


Adjacent: Multiple Views

- different visual encodings show different aspects of the data
- linked highlighting to show where contiguous in one view distributed within another

[Weaver. http://www.personal.psu.edu/cew15/improvise/examples/census]
Adjacent Views

• overview and detail
  • same visual encoding, different resolutions
• small multiples
  • same visual encoding, different data
Data Reduction

• overviews as aggregation
• focus+context
  • show details embedded within context
  • distortion: TreeJuxtaposer video
  • filtering: SpaceTree demo


Dimensionality Reduction

• mapping from high-dimensional space into space of fewer dimensions
  • generate new synthetic dimensions

• why is lower-dimensional approximation useful?
  • assume true/intrinsic dimensionality of dataset is (much) lower than measured dimensionality!
    • only indirect measurement possible?
      • fisheries: want spawn rates.
        have water color, air temp, catch rates...
    • sparse data in verbose space?
      • documents: word occurrence vectors.
        10K+ dimensions, want dozens of topic clusters
DR Example: Image Database

- 4096 D (pixels) to 2D (hand gesture)
  - no semantics of new synthetic dimensions from alg.
  - assigned by humans after inspecting results
DR Technique: MDS

• multidimensional scaling
  • minimize differences between interpoint distances in high and low dimensions
• minimize objective function: stress

\[
stress(D, \Delta) = \sqrt{\frac{\sum_{ij} (d_{ij} - \delta_{ij})^2}{\sum_{ij} \delta_{ij}^2}}
\]

D: matrix of lowD distances
\(d_{ij}\)
\(\delta_{ij}\)

\(\Delta\): matrix of hiD distances

• Glimmer: MDS on the GPU

Parallel Coordinates

- only two orthogonal axes in the plane
- instead, use parallel axes!

Parallel Coordinates

- point in Cartesian coords is line in par coords
- point in par coords is line in Cartesian n-space

[Inselberg and Dimdale. Parallel Coordinates: A Tool for Visualizing Multi-Dimensional Geometry. IEEE Visualization '90.]
Par Coords: Correlation

Figure 3. Parallel Coordinate Plot of Six-Dimensional Data Illustrating Correlations of $\rho = 1, .8, .2, 0, -.2, -.8, \text{ and } -1$. 

Hierarchical Parallel Coords: LOD

[Hierarchical Parallel Coordinates for Visualizing Large Multivariate Data Sets. Fua, Ward, and Rundensteiner. IEEE Visualization '99.]
Node-Link Graph Layout

- minimize
  - crossings, area, bends/curves
- maximize
  - angular resolution, symmetry
- most criteria individually NP-hard
  - cannot just compute optimal answer
  - heuristics: try to find something reasonable
- criteria mutually incompatible
Force-Directed Placement

- nodes: repel like magnets
- edges: attract like springs
  - start from random positions, run to convergence
- very well studied area!
  - many people reinvent the wheel

Interactive Graph Exploration

• geometric and semantic fisheye

van Ham and van Wijk. Interactive Visualization of Small World Graphs. Proc. InfoVis 2005
Treemaps

- containment rather than connection
  - emphasize node attributes, not topological structure

[van Wijk and van de Wetering. Cushion Treemaps. Proc InfoVis 1999]

[Fekete and Plaisant. Interactive Information Visualization of a Million Items. Proc InfoVis 2002.]
Cushion Treemaps

- show structure with shading
  - single parameter controls global vs local view

[van Wijk and van de Wetering. Cushion Treemaps. Proc InfoVis 1999]
Now What?
Beyond 314: Other Graphics Courses

• 424: Geometric Modelling
  • will be offered next year
• 426: Computer Animation
  • was offered this year

• 514: Image-Based Rendering - Heidrich
• 526: Algorithmic Animation - van de Panne
• 533A: Digital Geometry - Sheffer
• 533B: Animation Physics - Bridson
• 533C: Information Visualization - Munzner
Beyond UBC CS

• SIGGRAPH conference in Vancouver next year!
  • August 7 - August 11 2011
  • ~20K people: incredible combination of research, entertainment, art
  • Electronic Theater, Exhibit, ETech, ...
  • pricey: but student rate, student volunteer program

• local SIGGRAPH chapter
  • talk series, SPARK FX festival, ...
  • http://siggraph.ca