

Streamlines (& Volume Vis Motivation)



<http://imgur.com/TRJonQk>



<http://i.imgur.com/ZcjC9KP.jp>

Today's Class

- How to brainstorm/foster radical ideas?
- How to formally review a paper for acceptance to a conference/journal
- Readings for Today
 - "Farthest Point Seeding for Efficient Placement of Streamlines"
 - "Image Based Flow Visualization"
- Readings for Tuesday
- Spatial Data Structures Motivation / Volume Visualization Challenges

Radical Inspiration for Final Project?

- Unusual interaction
 - What could you do with touch-based interaction?
 - What could you do with direct object manipulation? (rather than sliders or buttons spatially separate from your data)
- Layers/Levels/Level of Detail/Complexity of your visualization?
- Formal Evaluation
 - How would you measure, in a controlled setting, the effectiveness of your visualization?

Drawing for Communication

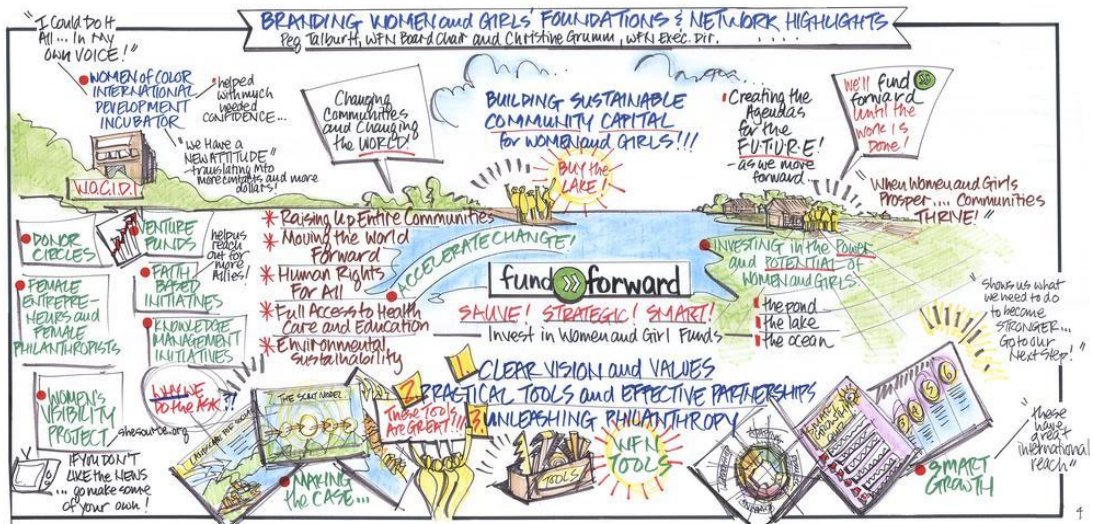


<http://arterior-motives.blogspot.com/>



<http://idcminnovations.com/facilitation/facilitation-service>

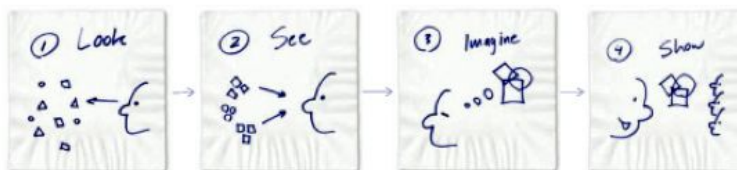
Drawing for Communication



<http://www.visualcoaches.com/training/fundamentals/>

Drawing for Communication

The 4 steps of visual thinking:



What is out there?
What am I looking at?
What are the limits?
Which way is up?

- What do I see?
- Have I seen this before?
- What patterns emerge?
- What stands out?
- What seems to be missing?

How can I manipulate these patterns?

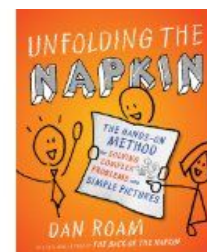
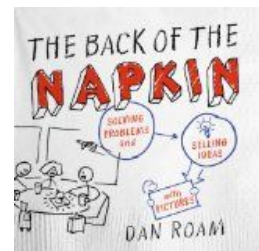
Can I fill in the gaps?

Have I seen enough – or do I need to go back and look at more?

This is what I saw, and
this is what I think it
means.

Is this what I
expected... or not?

When you look at this,
do you see the same
things?



<http://www.danroam.com/the-back-of-the-napkin/>

How to Brainstorm Ideas?

Do:

- Establish the question/objective (but don't get bogged down in this -- Maybe this is a pre-meeting homework assignment)
- Generate LOTS OF ideas (don't say no to ideas at the start)
- Let everyone write (the scribe has too much power? Afraid we might overwhelm the scribe)
- Listen to other ideas
- Write your idea down, then focus on the other people
- Make sure the right people are in the room (experts in the necessary areas, representatives from the appropriate communities...)
- Be creative -- even wacky ideas might have good pieces,
- Multiple sessions (design is not linear), take a break, etc. always be willing to go back to brainstorming, be willing to start over (& potentially discard work)
- Merge ideas, bring the positive aspects together
- All things in moderation -- these are guidelines
 - Should have some deadlines (make sure an experienced project manager helps with the timeline) to ensure you make progress, move forward
- Stay organized, take notes, etc

Don't: (or do later)

- Don't attach names to ideas (avoid ownership & blame & defensiveness)
- Avoid shooting down ideas... don't question idea to death
- Don't get bogged down in the details of the idea (yet!)
- Don't actually *discard* work, keep it as reference
 - Keep the ideas, but re-do the work?

How to encourage/foster/recognize radical new ideas?

- Be open-minded
- Brainstorming rule: generate ideas, no negativity, no early criticism/rejection
- Be a "Paper Champion", not a "Paper Killer"
- Suggest other applications/datasets
- Don't say what's wrong, say how to improve it
- Really specific comments, not general criticism
- Use "I" statements (Say "I think..." or "I feel")
 - Not "your paper is bad" but "I feel your paper could be better if you do..."

Formal task of paper reviewer (1 of 2)

- **Description:** Briefly describe the paper and its contribution to computer graphics and interactive techniques. Please give your assessment of the scope and magnitude of the paper's contribution.
- **Clarity of Exposition:** Is the exposition clear? How could it be improved?
- **Quality of References:** Are the references adequate? List any additional references that are needed.
- **Reproducibility:** Could the work be reproduced from the information in the paper? Was any code or data submitted with the supplemental materials? If so, does it support the claims in the paper? Are all important algorithmic or system details discussed adequately in the paper?

Review form for SIGGRAPH

Formal task of paper reviewer (2 of 2)

- **Rating:** Please rate this paper on a continuous scale from 1 to 5, where:
 - 1 = Definitely reject. I would protest strongly if it's accepted.
 - 2 = Probably reject. I would argue against this paper.
 - 3 = Possibly accept, but only if others champion it.
 - 4 = Probably accept. I would argue for this paper.
 - 5 = Definitely accept. I would protest strongly if it's not accepted.Please base your rating on the paper as it was submitted.
- **Reviewer Expertise:** Please rate your expertise in the subject area of the paper on a continuous scale from 1 to 3, where:
 - 1=Beginner
 - 2=Knowledgeable
 - 3=Expert.
- **Explanation of Rating:** Explain your rating by discussing the strengths and weaknesses of the submission, contributions, and the potential impact of the paper. Include suggestions for improvement and publication alternatives, if appropriate. Be thorough. Be fair. Be courteous. Your evaluation will be forwarded to the authors during the rebuttal period.
- **Private Comments:** You may enter private comments for the papers committee here. These comments will not be sent to the paper author(s). Please do not mention any other papers that are currently in review, or the names of people associated with these papers.

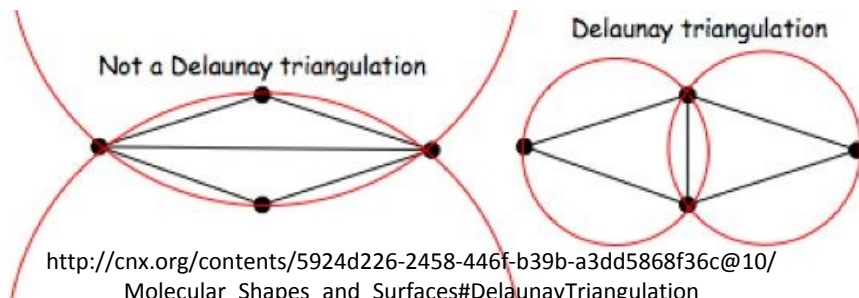
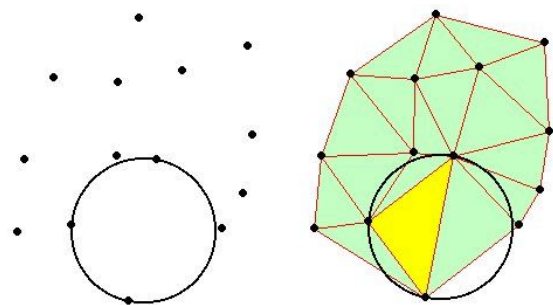
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Delaunay Triangulation http://www.ian-ko.com/resources/triangulated_irregular_network.htm

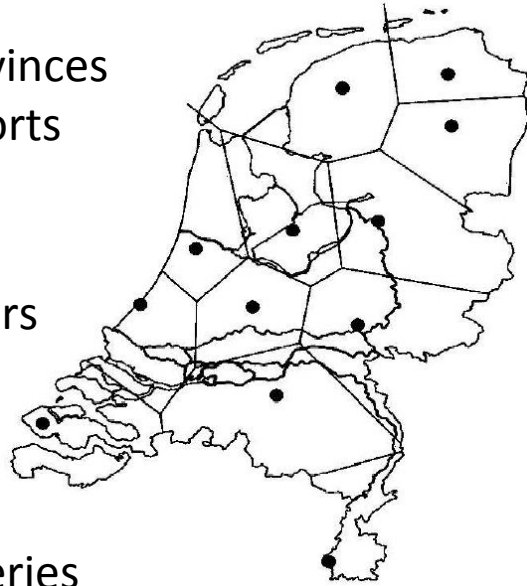
- Contains a triangle connecting 3 points if and only if the circumcircle does not contain any other points from the set



http://cnx.org/contents/5924d226-2458-446f-b39b-a3dd5868f36c@10/Molecular_Shapes_and_Surfaces#DelaunayTriangulation

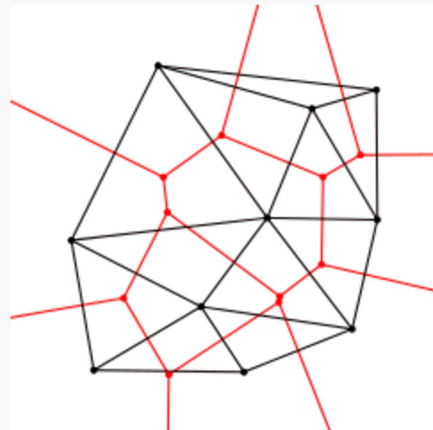
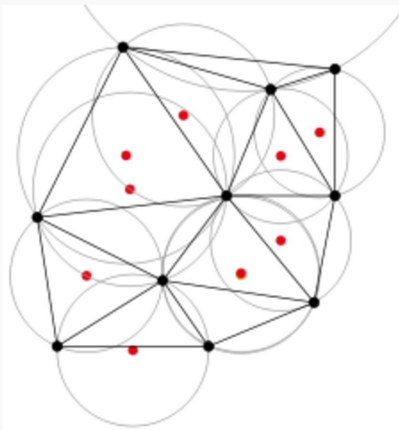
Voronoi Diagram/Cells/Regions

- How to re-district the Netherlands into provinces so that everyone reports to the closest capital
- Cell edges are the perpendicular bisectors of nearby points
- 2D or 3D
- Supports efficient *Nearest Neighbor* queries



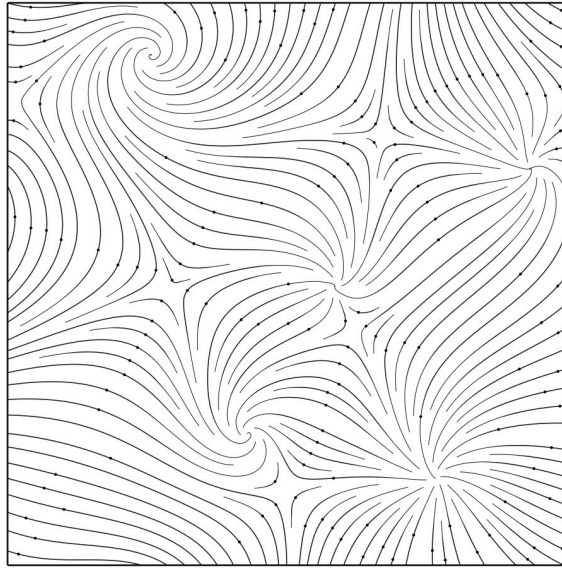
<http://ccc.inaoep.mx/~rodrigo/robotica/Trigui.pdf>

Delaunay / Voronoi Duality



https://en.wikipedia.org/wiki/Delaunay_triangulation

- "Farthest Point Seeding for Efficient Placement of Streamlines", Mebarki, Alliez, & Devillers, IEEE Visualization 2005.



- Start at the furthest away
- Favors long streamlines
- Retain uniformity with increasing density
- 200X Faster, but comparable quality to previous techniques
- Streamline:
 - curve that is everywhere tangent to the vector/flow field,
 - path traced by a massless particle dropped into a steady flow field
 - Stops at boundary or when it gets too close to another streamline
 - Streamlines are better if they uniform, of desired density, and longer rather than shorter
 - Termination points of streamline will be inferred as flow field singularities (source & sink), so avoid misinterpretations...

How to choose seedpoints for streamline placement?

- Uniform grid: streamlines won't be evenly placed & will form undesirable patterns
- Randomly placed: Does not improve upon uniform
- Turk & Banks use “streamlets” & energy decreasing optimization to combine, delete, create, lengthen, & shorten streamlets
 - High quality but slow
- Jobard & Lefer seed new streamlines near existing streamlines
 - Faster, but can have empty spaces
- Verma et al. seed streamlines near critical points
 - Good capture of flow features, but poor density control

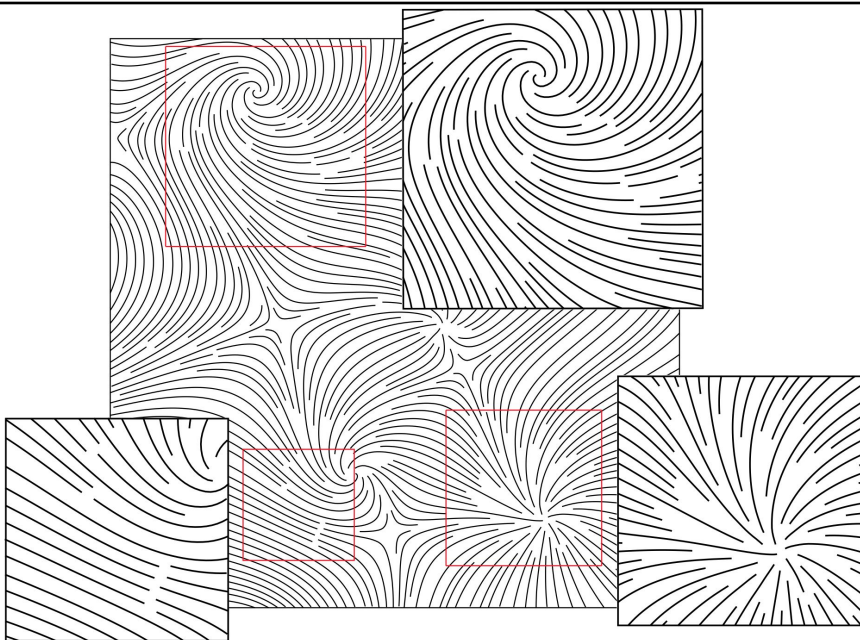


Figure 2: Local seeding strategy produces empty spaces due to the consecutive stopping of a series of streamlines (bottom right closeup). Some discontinuities also appear near singularities (top right closeup) and in laminar areas (bottom left closeup). Figure reproduced from [12].

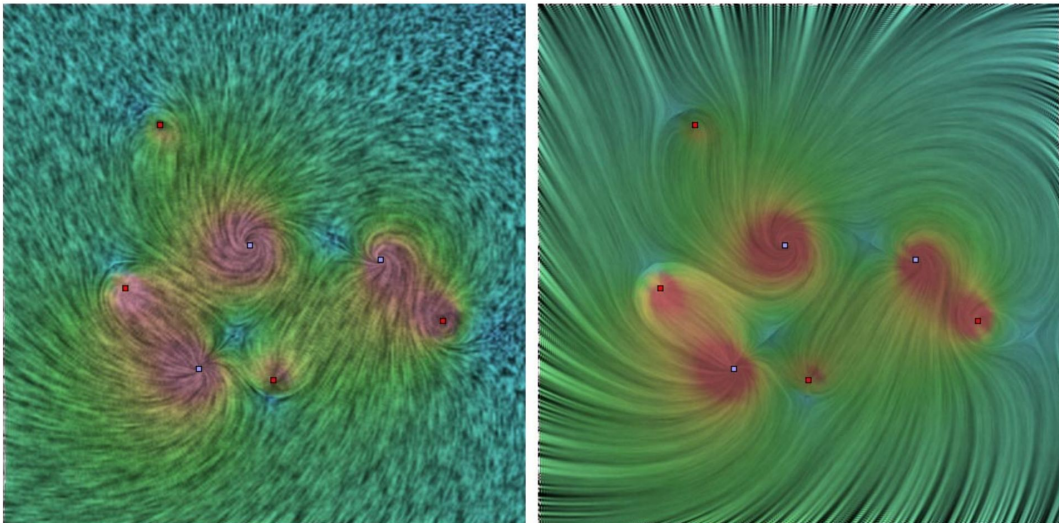
- Data structures are important for streamline computation!
- Implemented in C++! Open source (CGAL)!
- Amazing results
 - fast,
 - looks pretty good, but not perfect when zoomed in, those artifacts not discussed in paper
 - Curious about adding color, texture, or animation
 - How could it extend to 3D?
- Detailed writing
 - Great Diagrams
 - Pseudocode: “confident I could implement it”
“even a data structures student could implement it!”
- Good comparison to prior work
- Motivation could be presented more compellingly
- How is the step size chosen?

- Choose seedpoints that are furthest away from ALL existing streamlines (center of biggest void)
 - Favors long streamlines
 - Amenable to multiresolution placement (each streamline placed increases density)
- Use Delaunay Triangulation
 - Find (approximate?) biggest cavities
 - add point to triangle with largest circumcircle diameter
 - Integrate forward & backward to trace curve through flow (steady state flow only?)
 - Only re-add triangles to priority queue if their circumcircle is bigger than threshold for density & saturation.
- Ok to be somewhat sloppy/inaccurate about the Delaunay triangulation
 - when streamlines form tight curls
 - Use local maximum circumcircle
- Advanced Features
 - Variable density, Multiresolution

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- "Image Based Flow Visualization", Jarke J. van Wij, SIGGRAPH 2002.



- Advection: “the transfer of heat or matter by the flow of a fluid, especially horizontally in the atmosphere or the sea”
- Blend warped previous frame w/ a selected background image
- Applications: Weather, climate, industrial processes, cooling, heating
- Moving particles, streamlines, moving textures, topological images
- Contributions:
 - Handles unsteady flow
 - w/ other techniques, hard to reconstruct flow
 - Efficient
 - Best performance to date (50 fps) by using graphics card features
 - Easy to implement
 - Other techniques need user to place particles (with poor placement, important features can be missed)
 - Small amount of code!

- White noise
- Pink noise: remove high frequency from white noise, both in space & time
- Pathline: position of a particle in a dynamic flow field
- Streamline: same as pathline, but for single point in time (or a constant/steady flow field)
- Particle & streamline tracking: focus on world space coordinates
- Line integral convolution: focus on screen space coordinates
- Image Based Flow Visualization: focus on images as basic primitive
- Data structures are essentially irrelevant for image based flow visualization!
- Implemented in Object Pascal (??)

- Frequency analysis (yeah “Signals & Systems”!) to understand & create background images to minimize artifacts from undersampling
- If G changes over time, then texture will “move with the flow”
 - not new random image, but spots that appear & disappear (cosine, square, exponential decay, sawtooth)
- Computation
 - Distorted mesh calculated on CPU
 - Rendering & blending on GPU
- Lots of control over results
 - Background image choice
 - Dye injection
 - Alpha values choice (decay)

- Good attempt to compare running time of different algorithms from different eras on different hardware
- Great discussion/comparison of results
- Method was unintuitive (author should take that as a compliment, right?) & really clever
 - “Work smarter not harder”
- How does resolution affect quality?
- What is coarse vs fine texture?
- Produces a visual result, but can’t be used other than to “look at” (results can’t be fed back into simulation/computation)
- Somewhat confused about “dye” and “decay of dye”
- What is the motivation for this paper?
- Use of gradient/color to help reader understand direction of flow is very important



Oct. 30, 2012 - Hurricane Sandy



Oct. 29, 2012 - Hurricane Sandy: landfall



Sept. 19, 2012



Sept. 7, 2012



August 29, 2012 - Hurricane Isaac



August 28, 2012 - Hurricane Isaac



June 26, 2012 - Tropical Storm Debby



May 5, 2012



March 27, 2012

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Volume Rendering

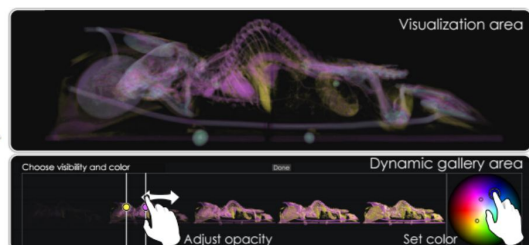
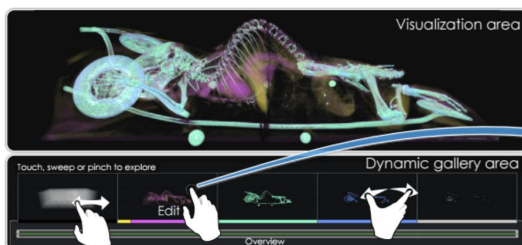
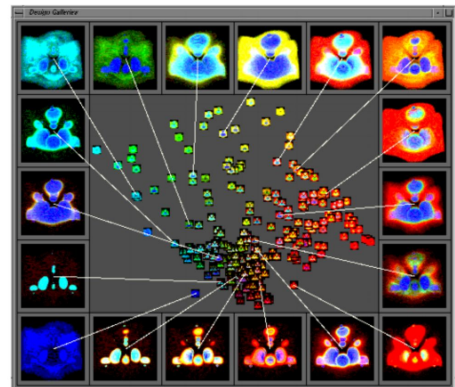
- Try to display a 3D data set (the whole thing, not just a surface)
- Must determine the opacity of every pixel (voxel)
- Often called the “transfer function”
- Almost always medical images



<http://idav.ucdavis.edu/~okreylos/ResDev/VolVis/LinkSupersampling.html>

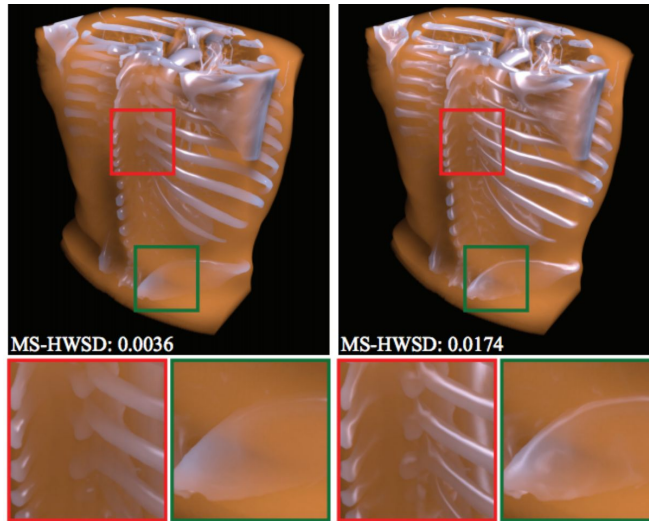
Readings for Friday: *(pick one)*

- “Intuitive Exploration of Volumetric Data Using Dynamic Galleries”
Jönsson, Falk, & Ynnerman
IEEE Visualization 2015



Readings for Friday: *(pick one)*

- “Anisotropic Ambient Volume Shading”
Ament & Dachsbacher, IEEE Visualization 2015



Readings for Friday: *(pick one)*

- “Interactive Dynamic Volume Illumination with Refraction and Caustics”
Magnus & Bruckner, IEEE TVCG 2017

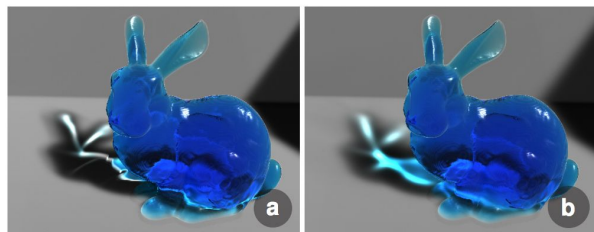


Fig. 3: Effects of light filtering. (a) No filtering. (b) Filtering of light and light direction.

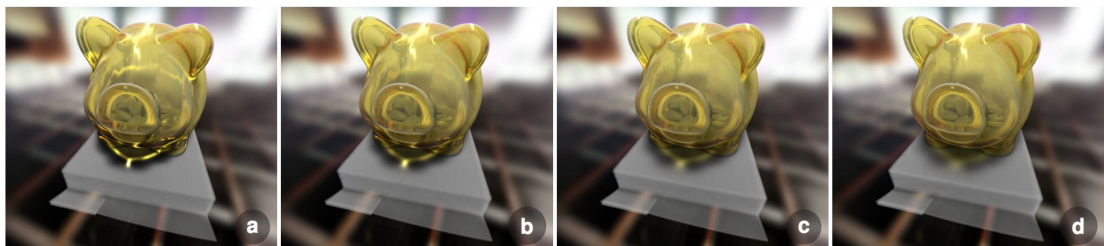


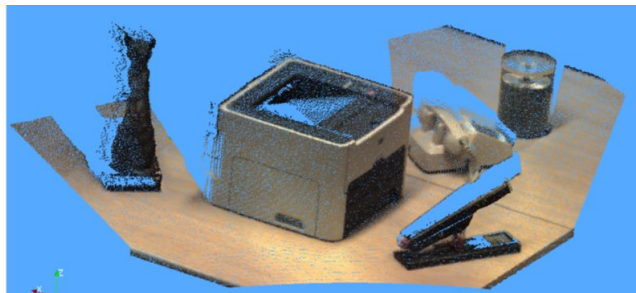
Fig. 7: CT scan of a piggy bank with refraction and combination of transmissive and reflective material properties and increasing light source softness from (a) to (d).

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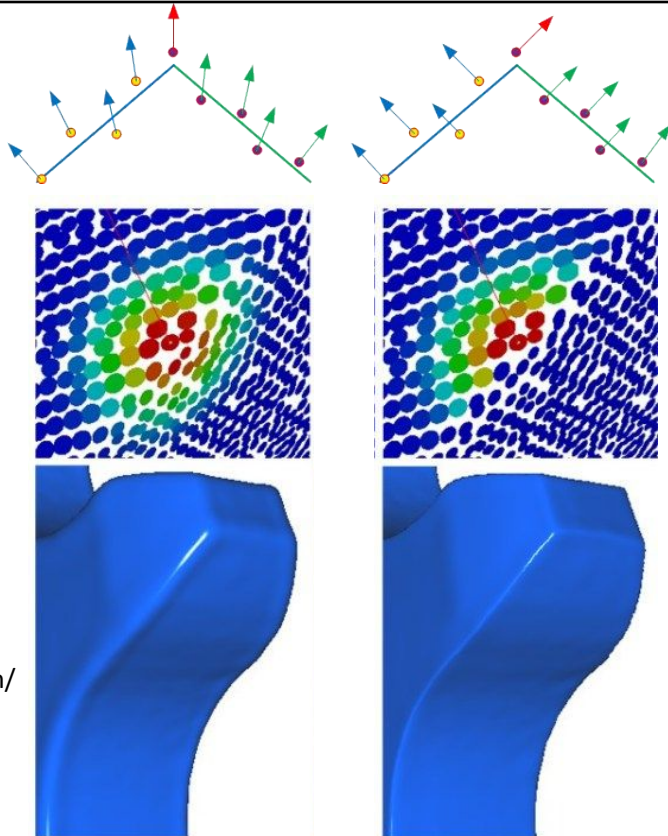
Motivation for Spatial Data Structures

- Closest Point
 - Collision detection
 - Surface normal estimation
- Line-Polygon Intersection
 - Ray casting (& recursive ray tracing)
 - Shadow calculation
- Want to do significantly better than the linear $O(n)$, $n = \#$ of objects, brute force solution!



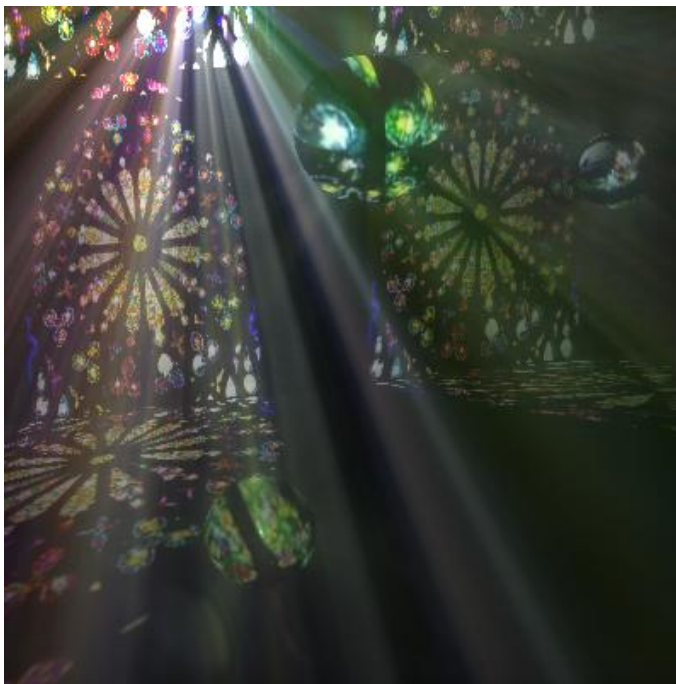
<http://i.imgur.com/Xz3Z2iL.jpg>

Surface Normal Estimation



<http://taylorwang.wordpress.com/>

Light Rays in a Dusty Room



Annie Ding, MIT
6.837 Final Project
December, 2004

Ray Tracing Participating Media

