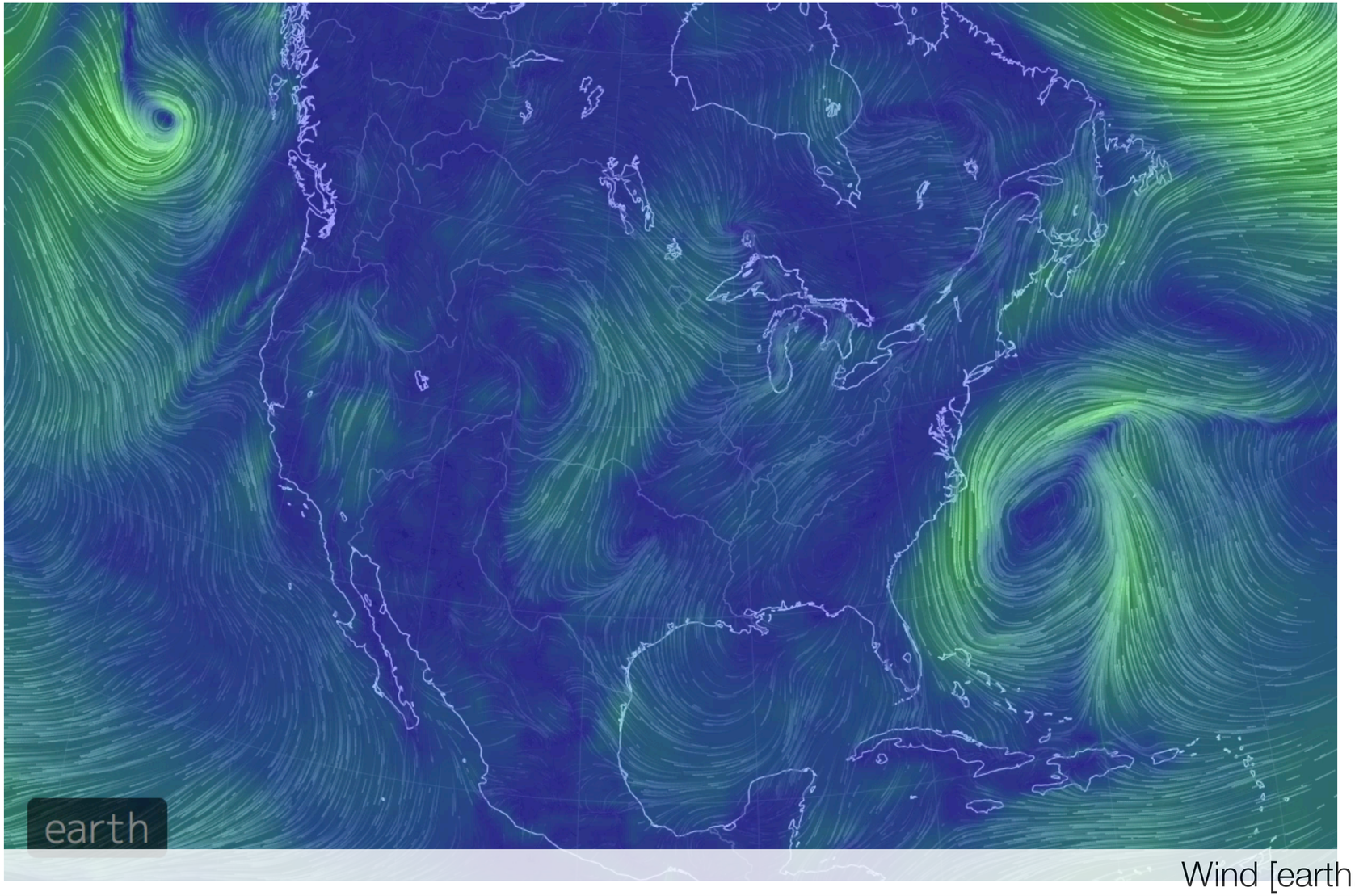
Data Visualization (CSCI 627/490)

Vector Fields & Text

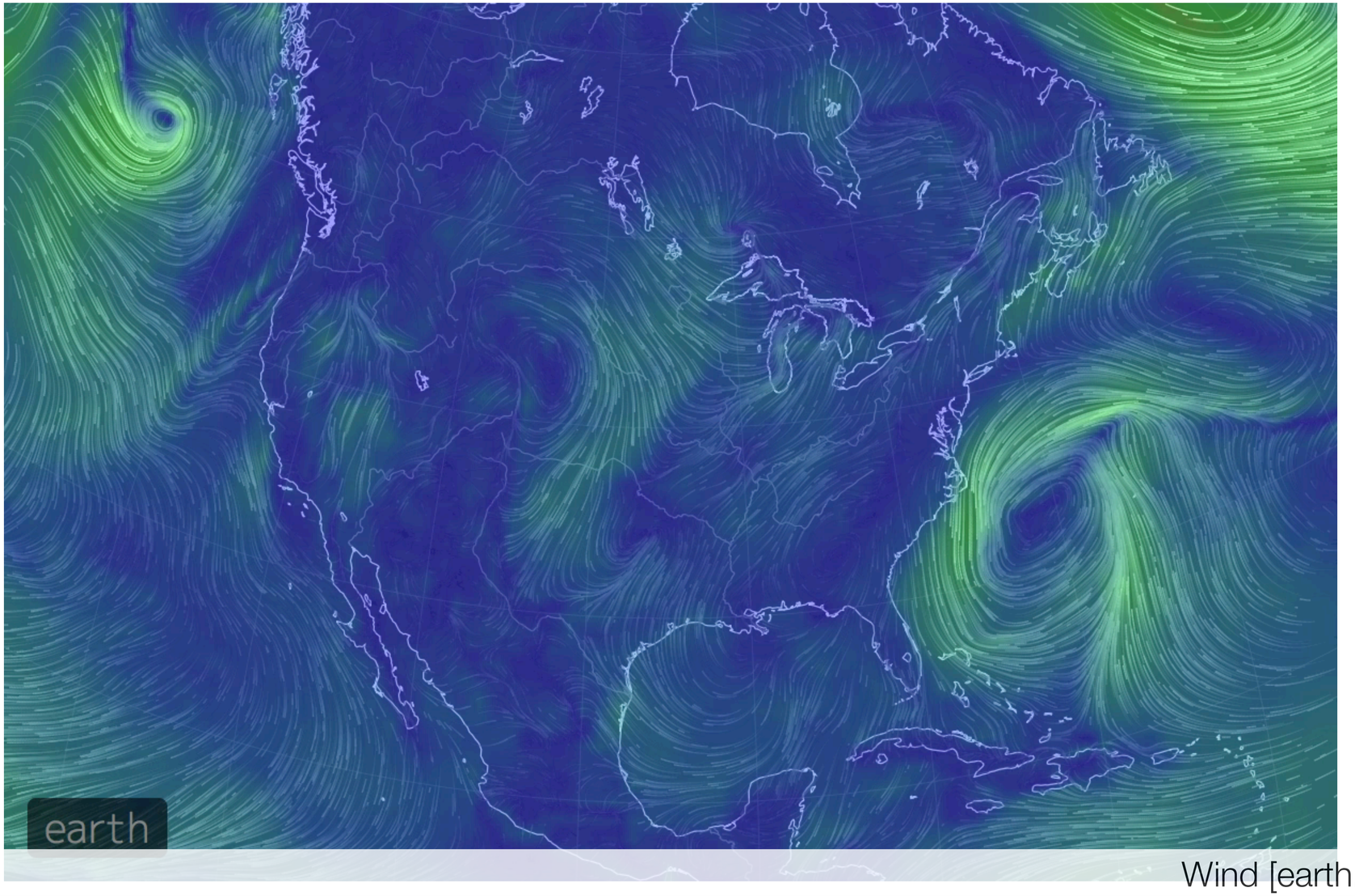
Dr. David Koop

Vector Fields



Wind [earth.nullschool.net, 2014]

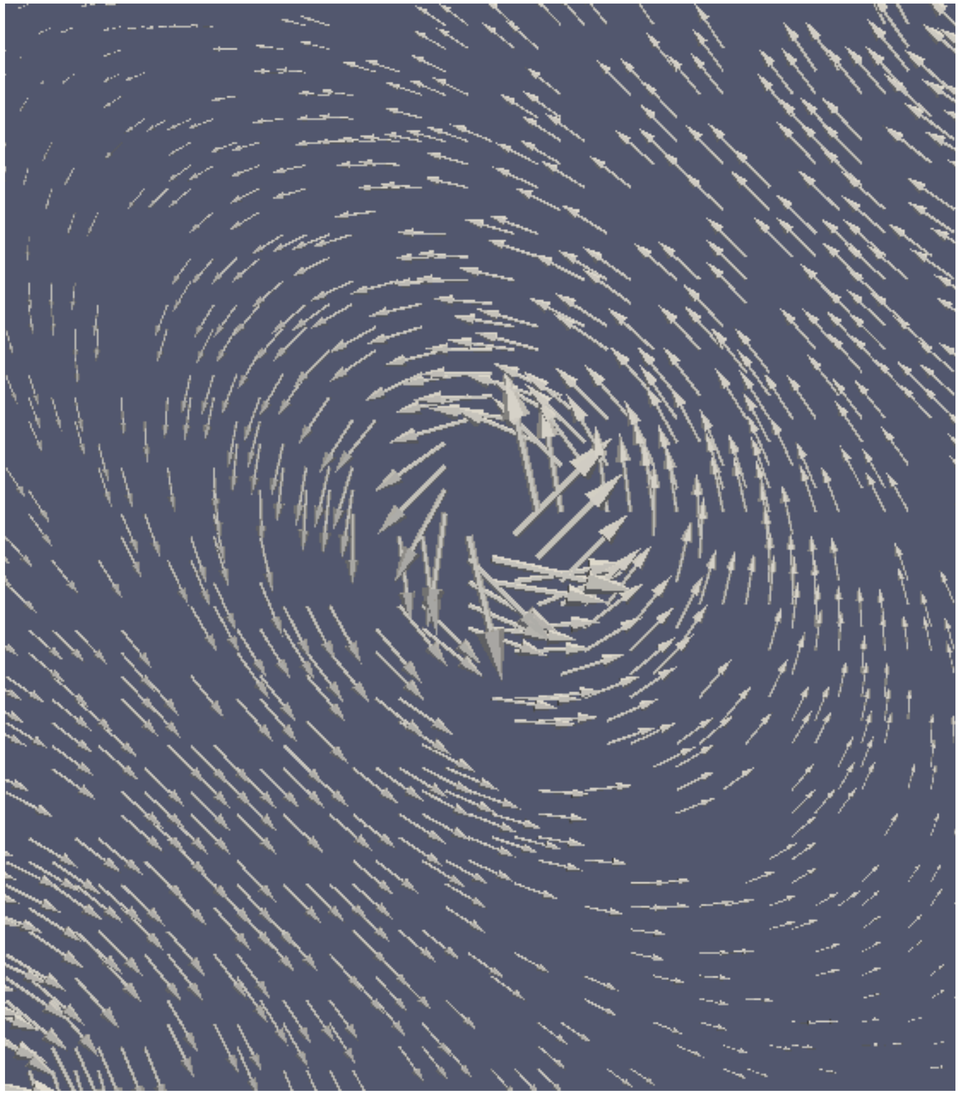
Vector Fields



Wind [earth.nullschool.net, 2014]

Glyphs

- Represent each vector with a symbol
- For vector fields, can encode direction, magnitude, scalar value
- Good:
  - Show precise local measures
  - Can encode scalar information as color
- Bad:
  - Possible sampling issues
  - Clutter (Occlusion): Can remove some points to help
  - Clutter is worse in higher dimensions

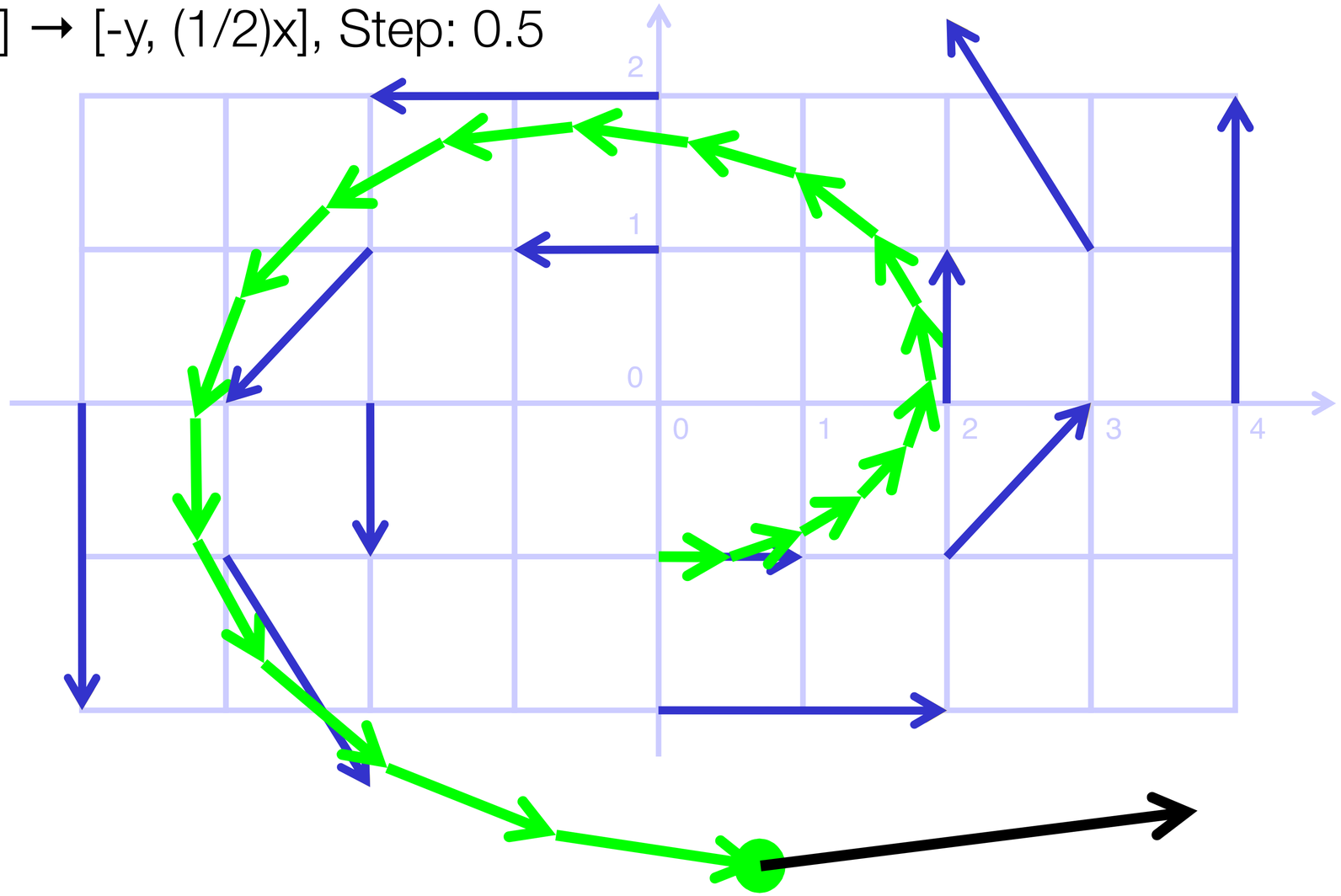


Streamlines & Variants

- Trace a line along the direction of the vectors
- Streamlines are always tangent to the vector field
- Basic Particle Tracing:
  1. Set a starting point (seed)
  2. Take a step in the direction of the vector at that point
  3. Adjust direction based on the vector where you are now
  4. Go to Step 2 and Repeat

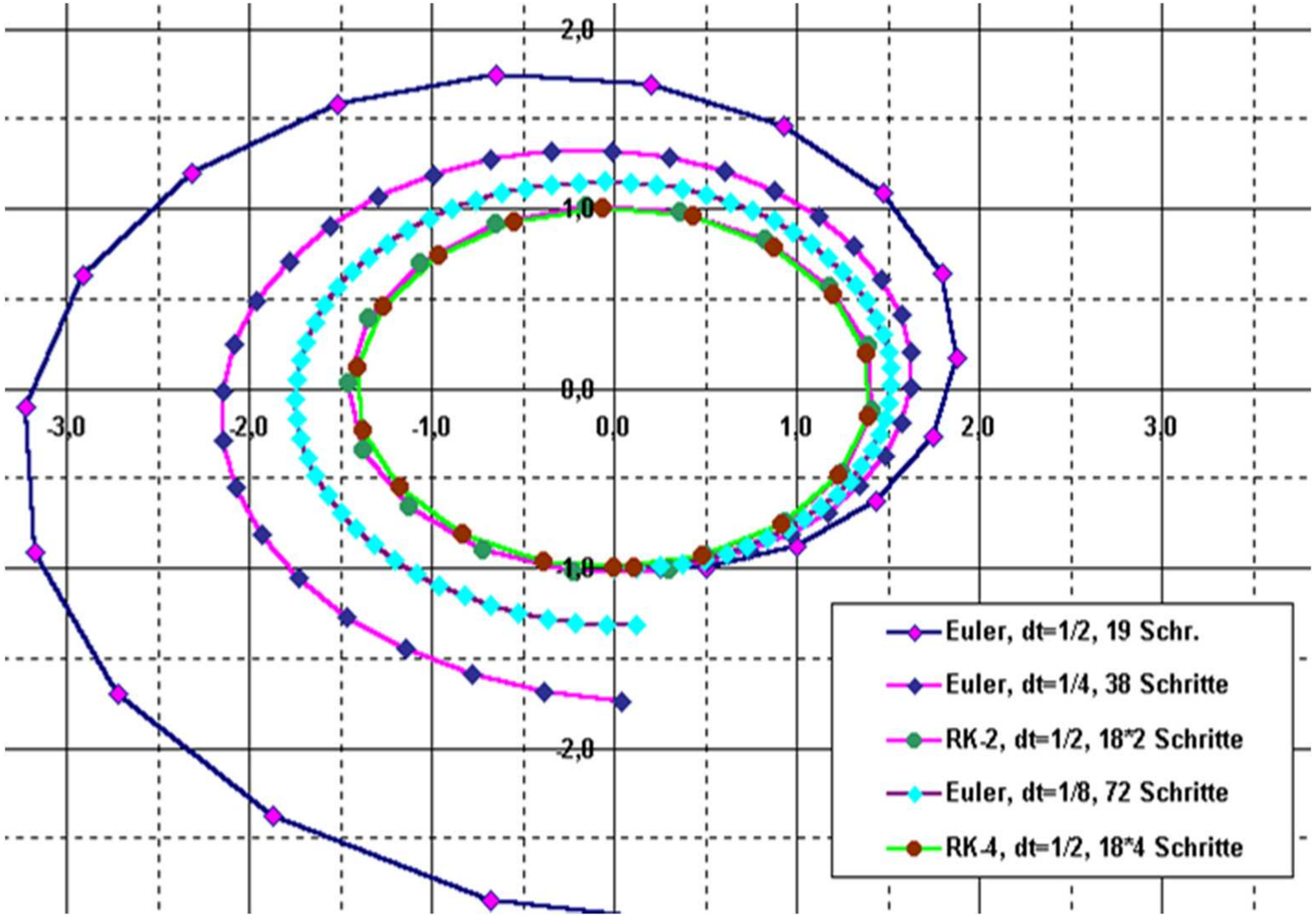
Streamlines

[x,y] → [-y, (1/2)x], Step: 0.5



[via Levine]

Higher-Order Interpolation Comparison



[via Levine]

Projects

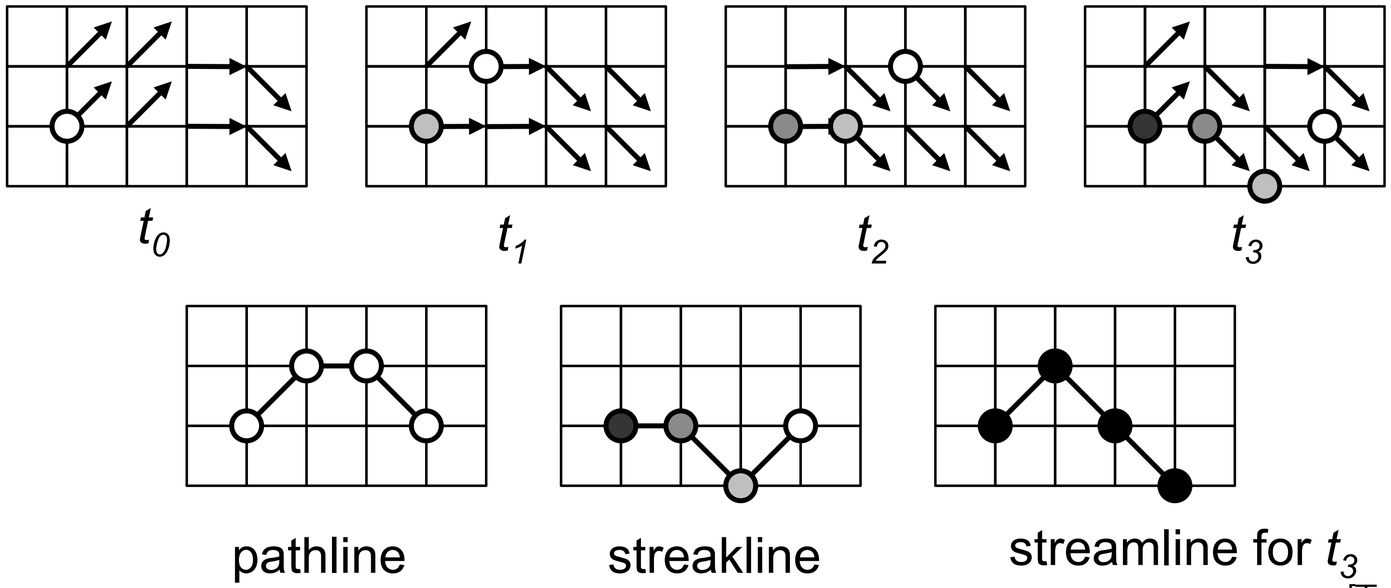
- Keep working on implementation
- Be creative, don't copy
- Think about interaction
- Presentations on the last day of class (Dec. 3)
  - Plan to use Blackboard. Please let me know if you know of tech. issues
  - Upload to Blackboard beforehand in case of technical issues

Final Exam

- December 10, 2020, 10-11:50am
- Covers all topics but emphasizes second half of the course
- Similar format as Midterm (multiple choice, free response)
- 627 Students will have a extra questions related to the research papers
- Review next Tuesday: Bring Questions

Streamlines & Variants

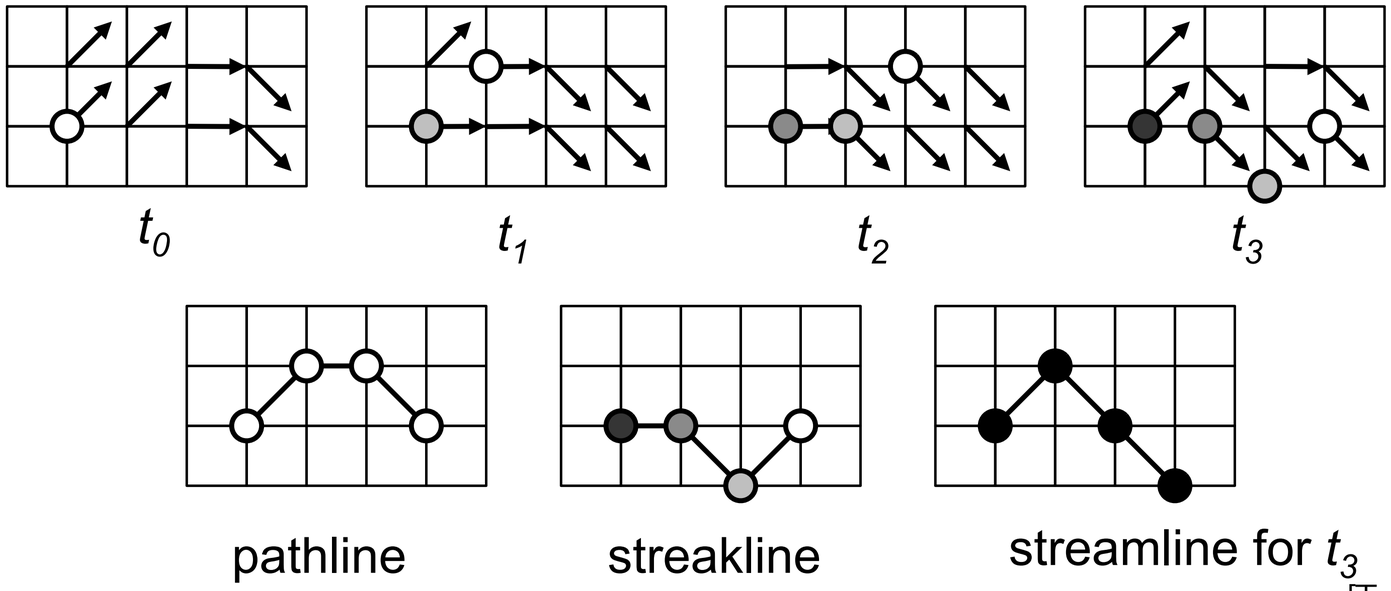
- Steady vs. **Unsteady** flows
  - In unsteady flows, the vector field **changes** over time
- Variants: **Pathlines** and **Streaklines**



[T. Möller]

Streamlines & Variants

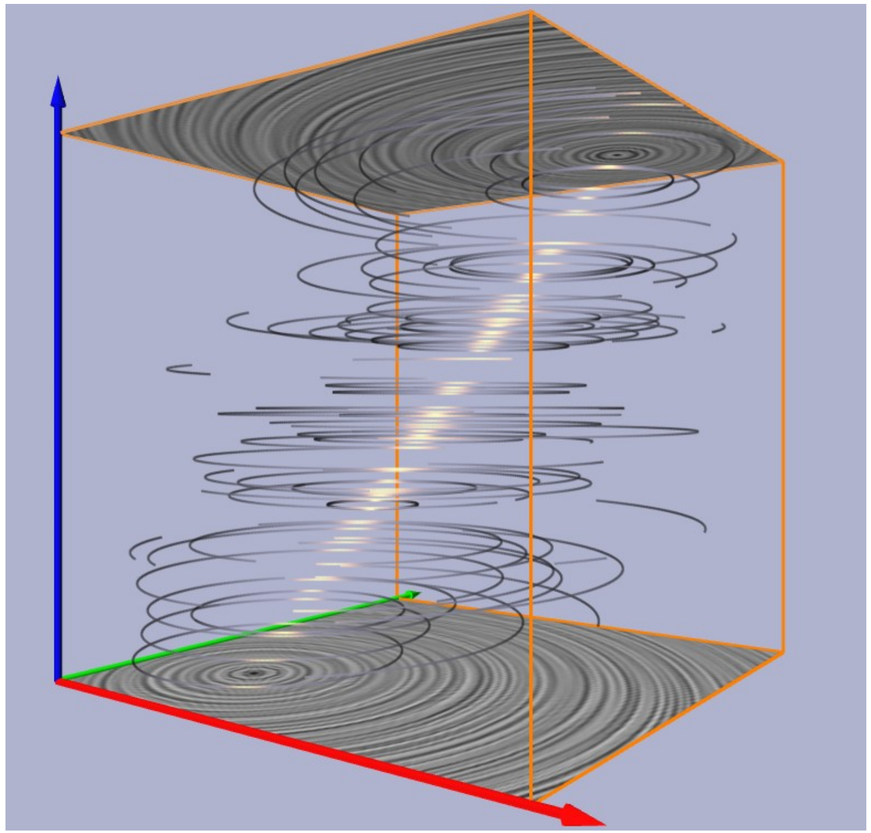
- Steady vs. **Unsteady** flows
  - In unsteady flows, the vector field **changes** over time
- Variants: **Pathlines** and **Streaklines**



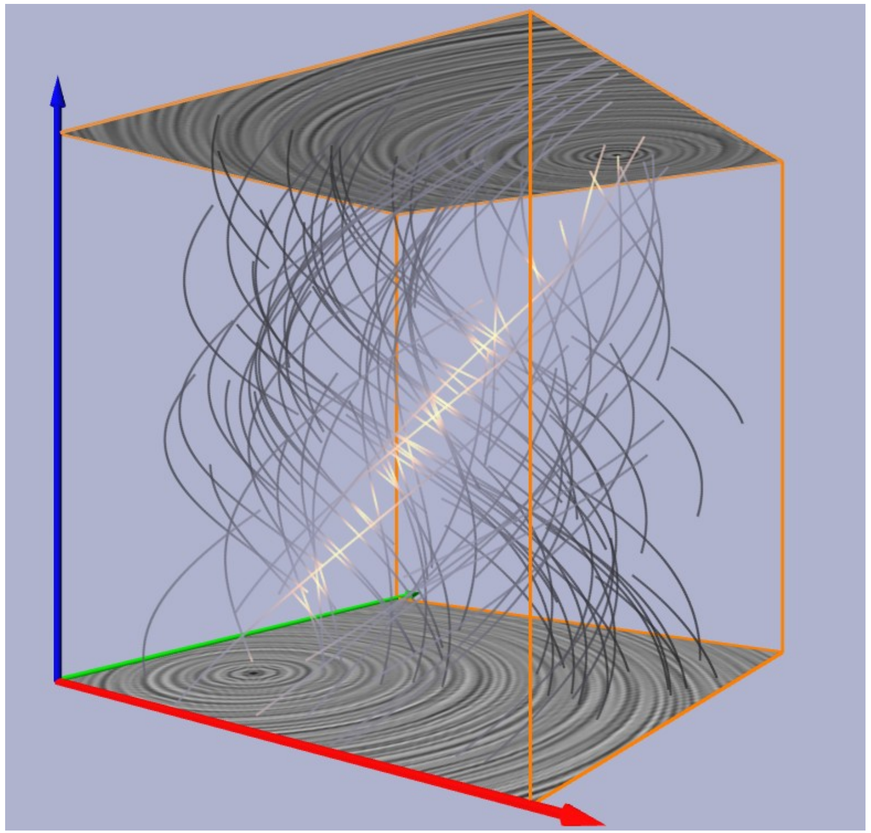
[T. Möller]

All are identical in steady flows!

Streamlines vs. Pathlines



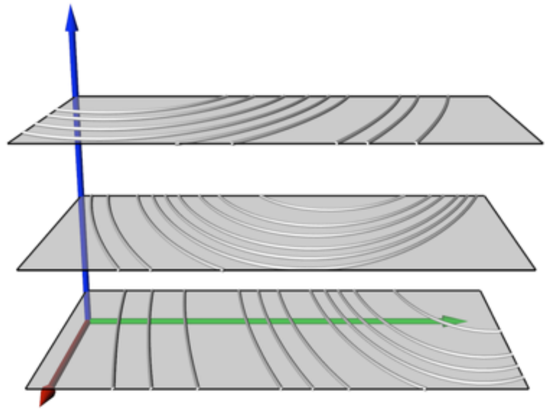
Streamlines



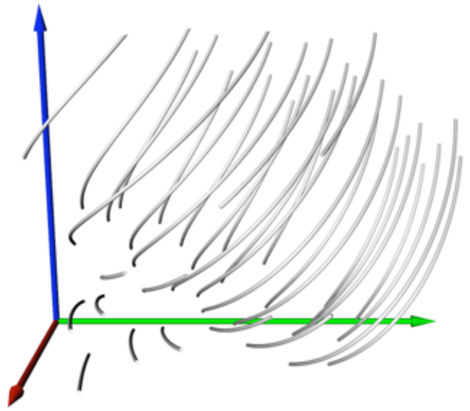
Pathlines

[Weinkauf & Theisel, 2010]

Streaklines and timelines

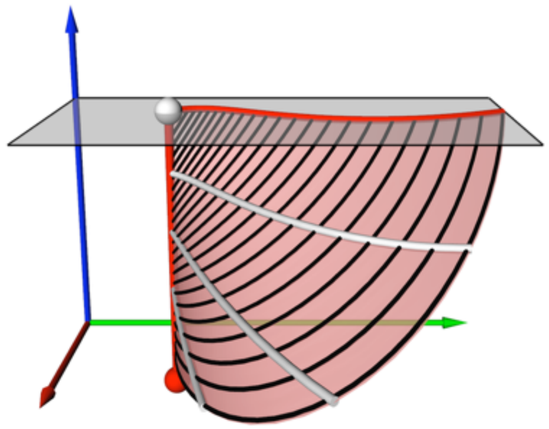


streamlines

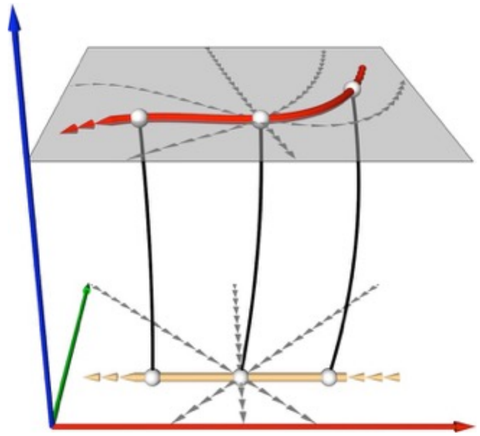


pathlines

streaklines

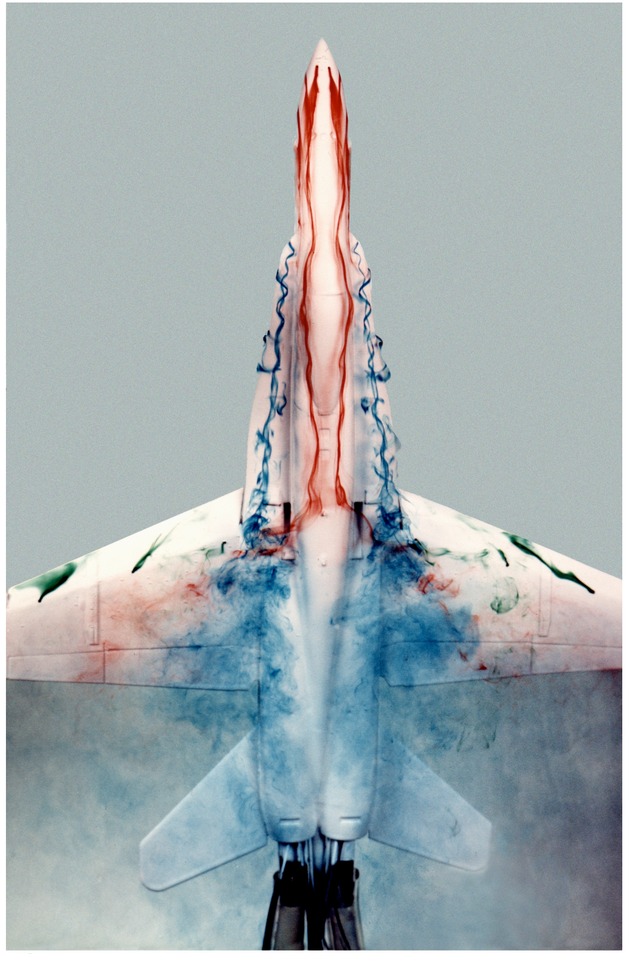


timelines



[via Levine]

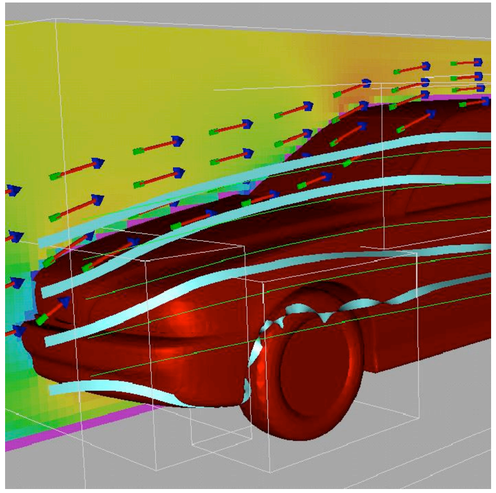
Streamline Variants



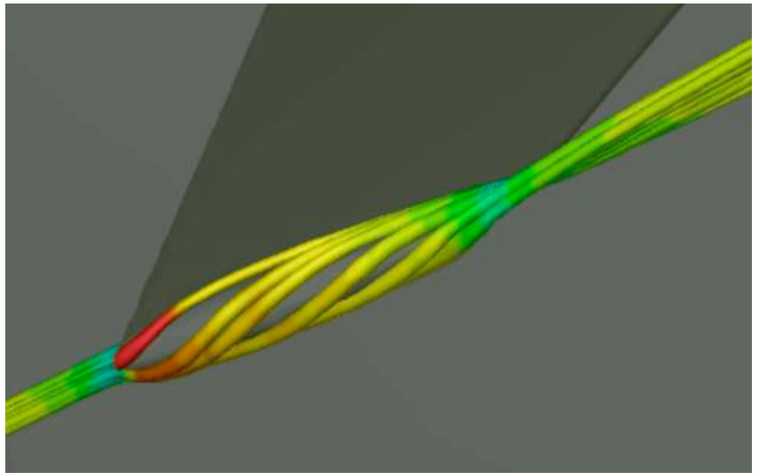
NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: ECN-33298-03 Date: 1985

1/48-scale model of an F-18 aircraft in Flow Visualization Facility (FVF)

Streaklines [NASA]

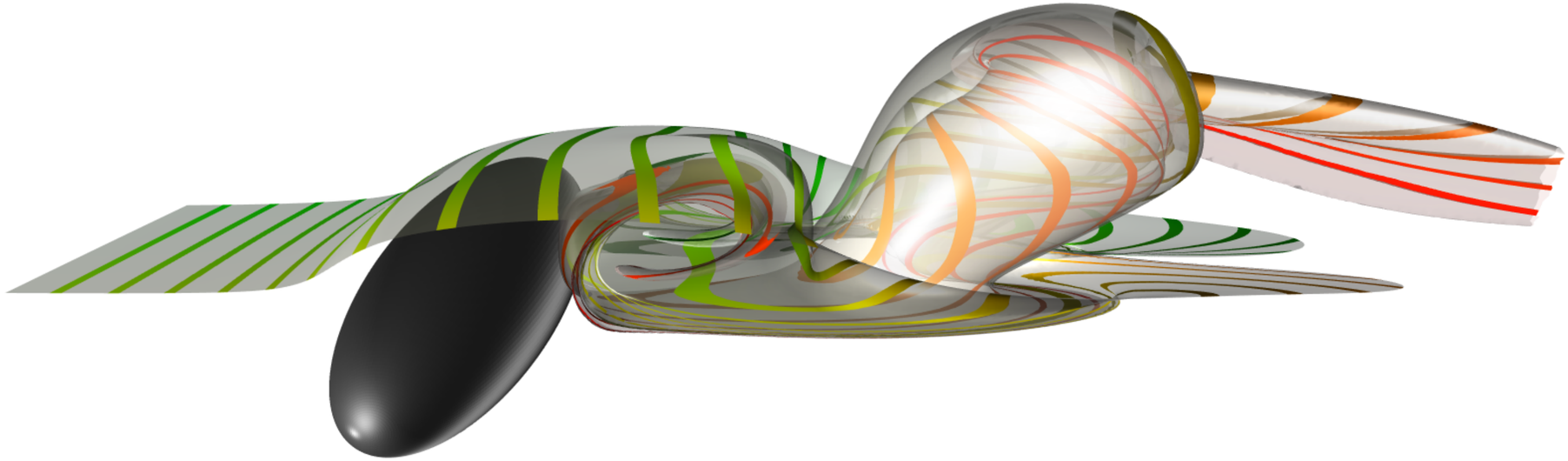


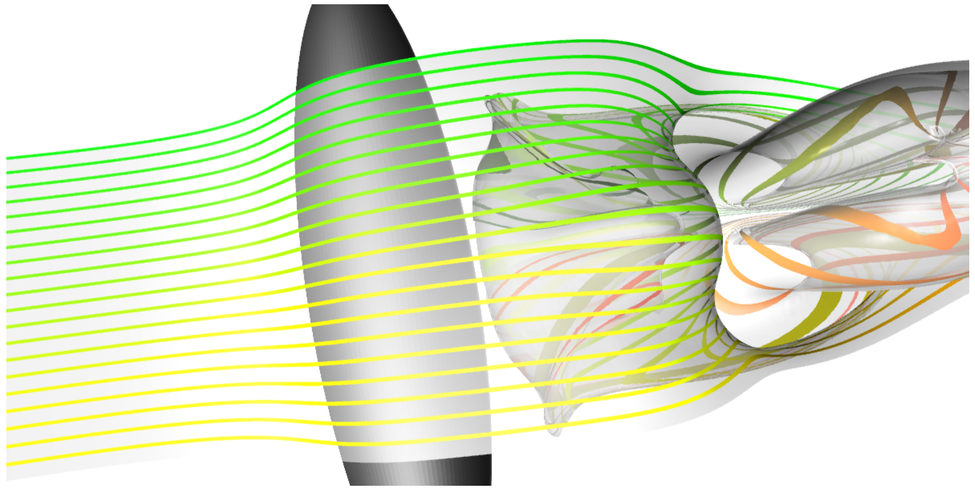
Stream Ribbons [Weiskopf/Machiraju/Möller]

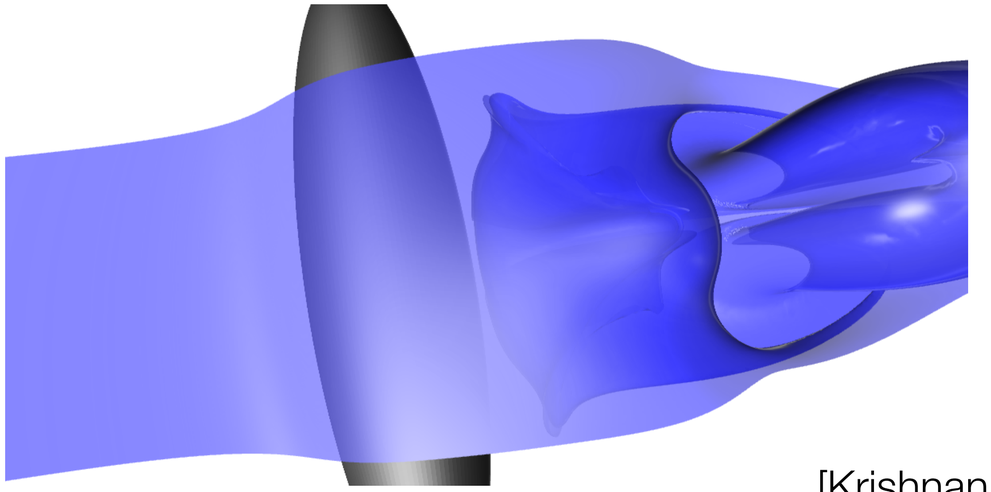


Stream Tubes [Weiskopf/Machiraju/Möller]

Streak Surfaces

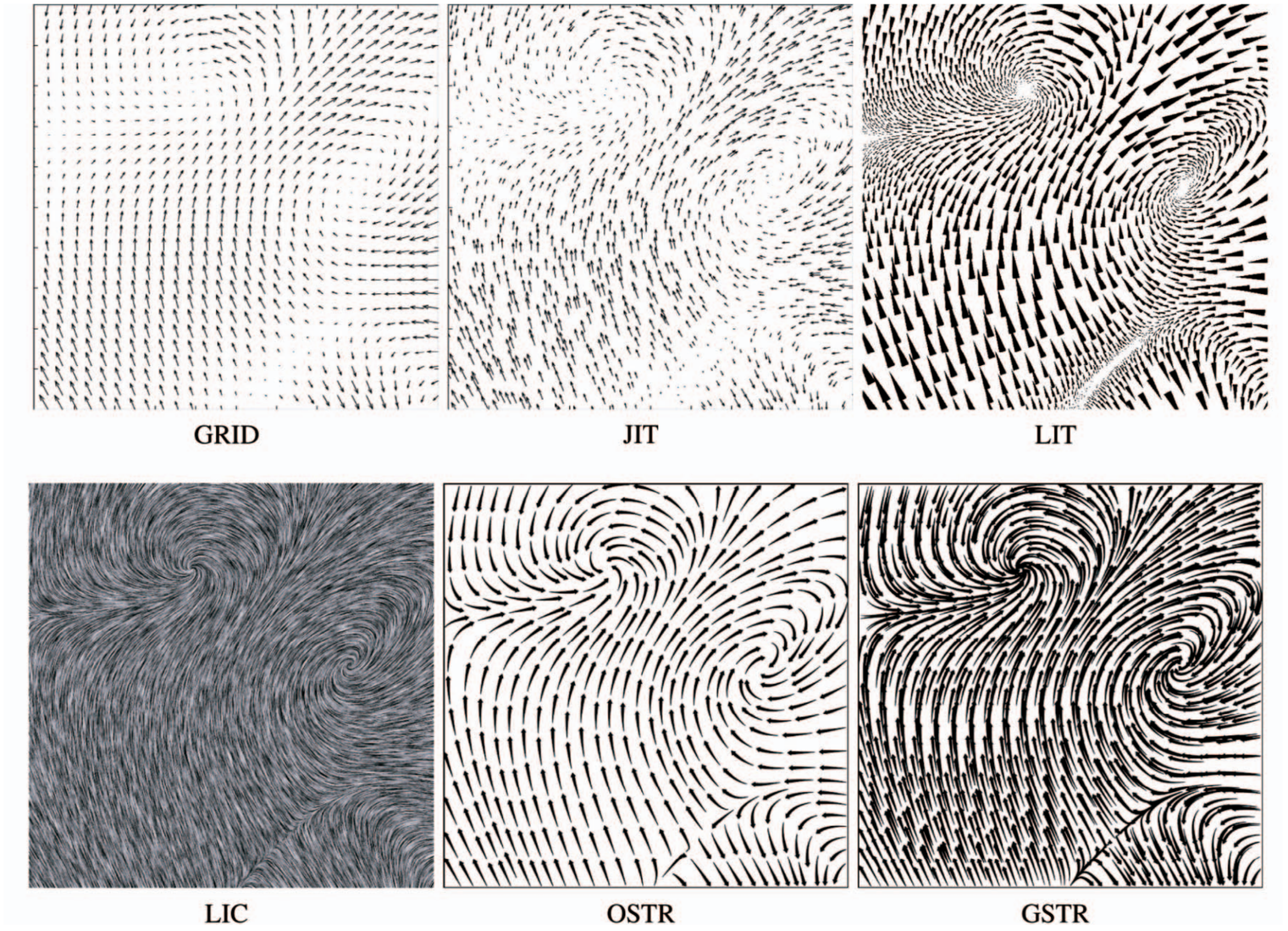






[Krishnan et al., 2009]

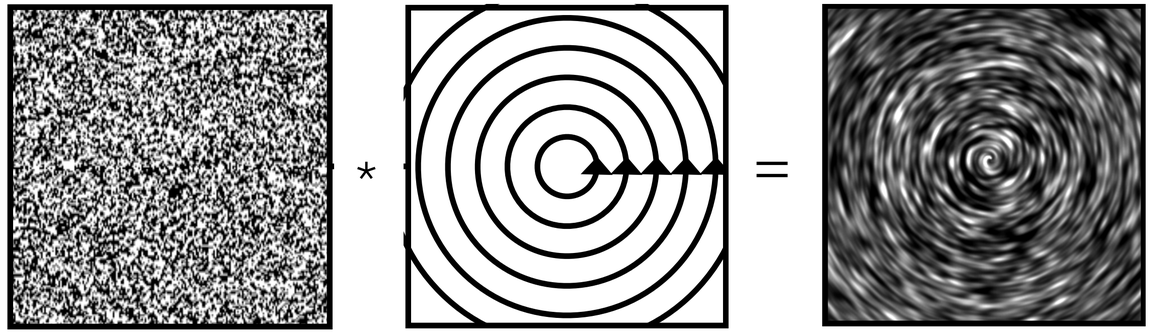
2D Vector Field Visualization Techniques



[Laidlaw et al., 2005]

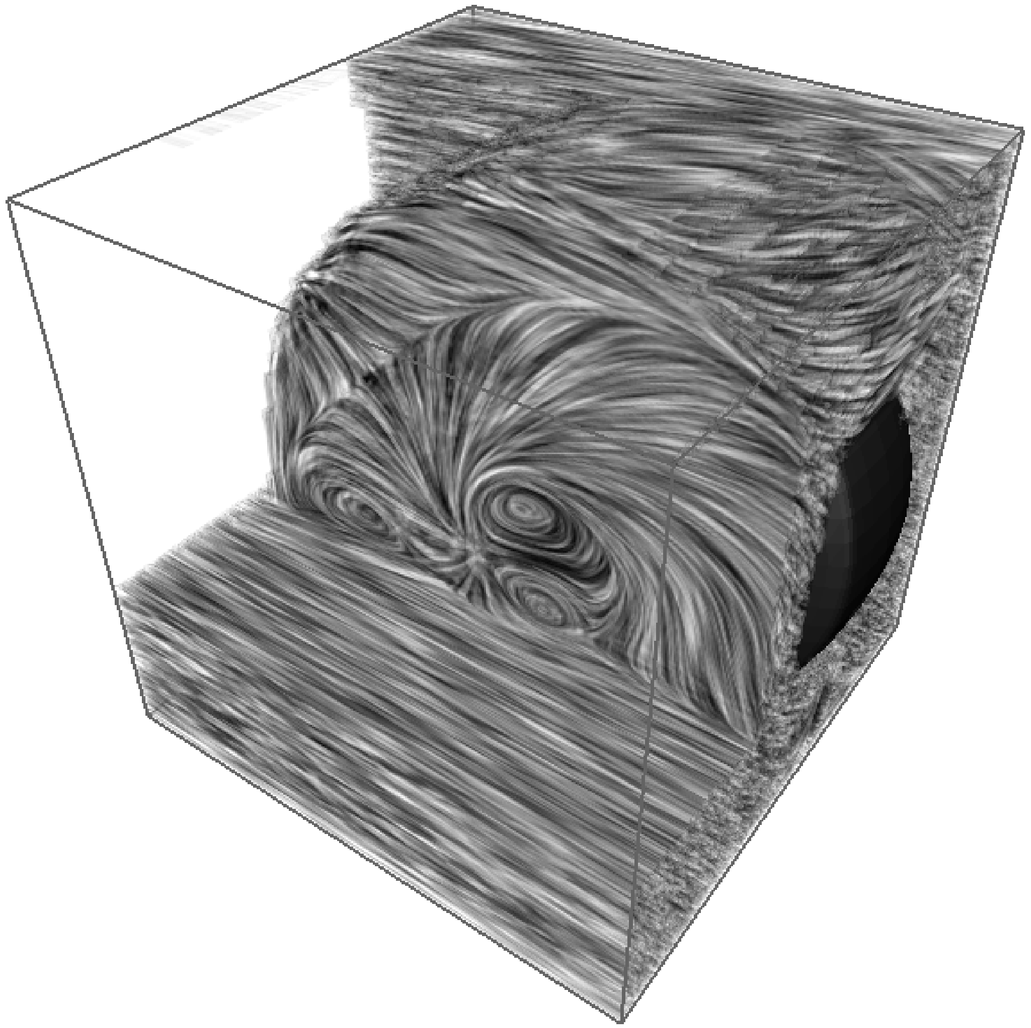
Line Integral Convolution

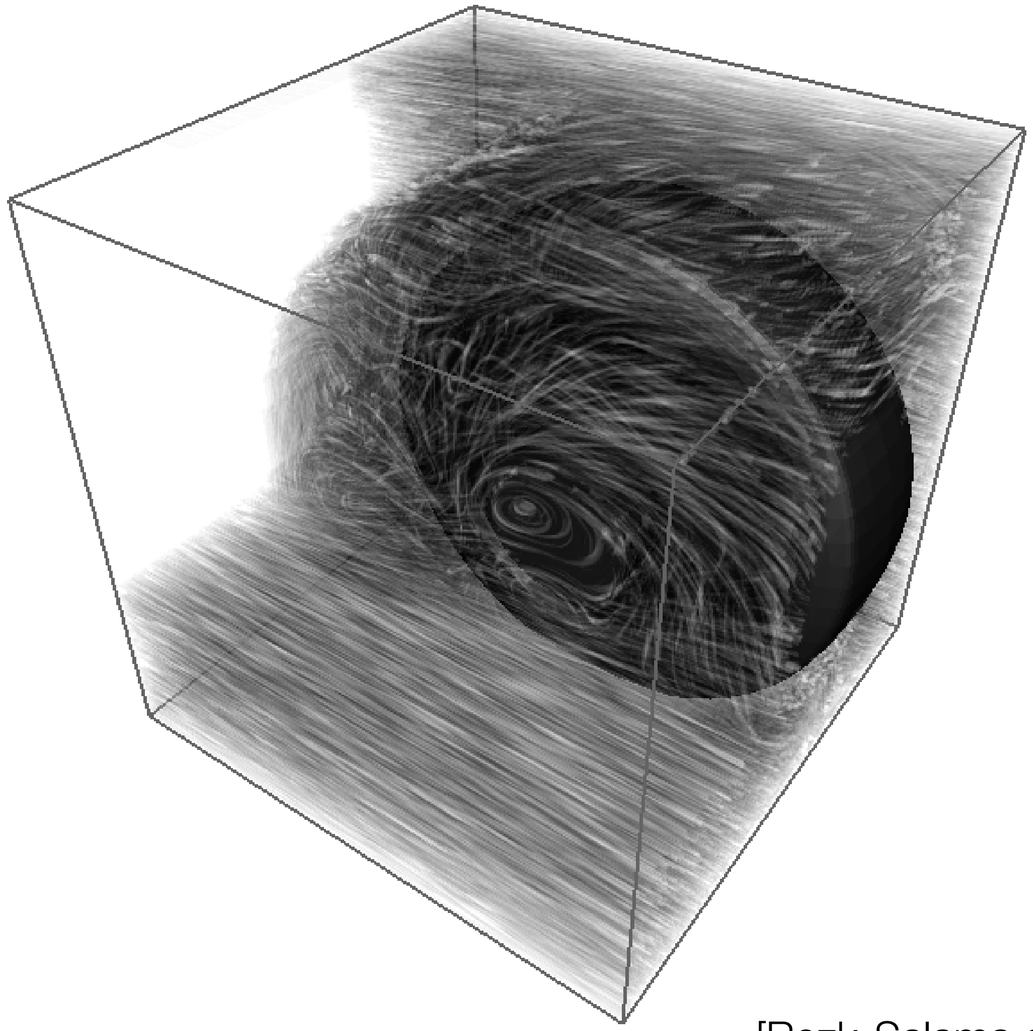
- Goal: provide a global view of a steady vector field while avoiding issues with clutter, seeds, etc.
- Remember convolution?
- Start with random noise texture
- Smear according to the vector field
- Need structured data



[Weiskopf/Machiraju/Möller]

3D LIC

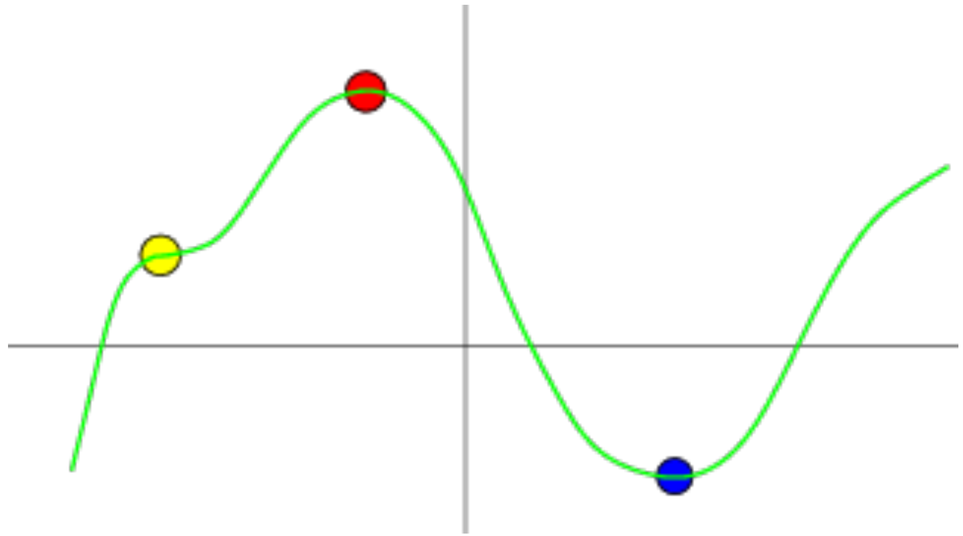




[Rezk-Salama et al., 1999]

Critical Points

- Remember finding min/max for functions?
- Want to understand the general structure of a field, not the exact values
- Find critical points, understand there is a general trend in between
- How?
  - Derivative for functions
  - For fields…gradients

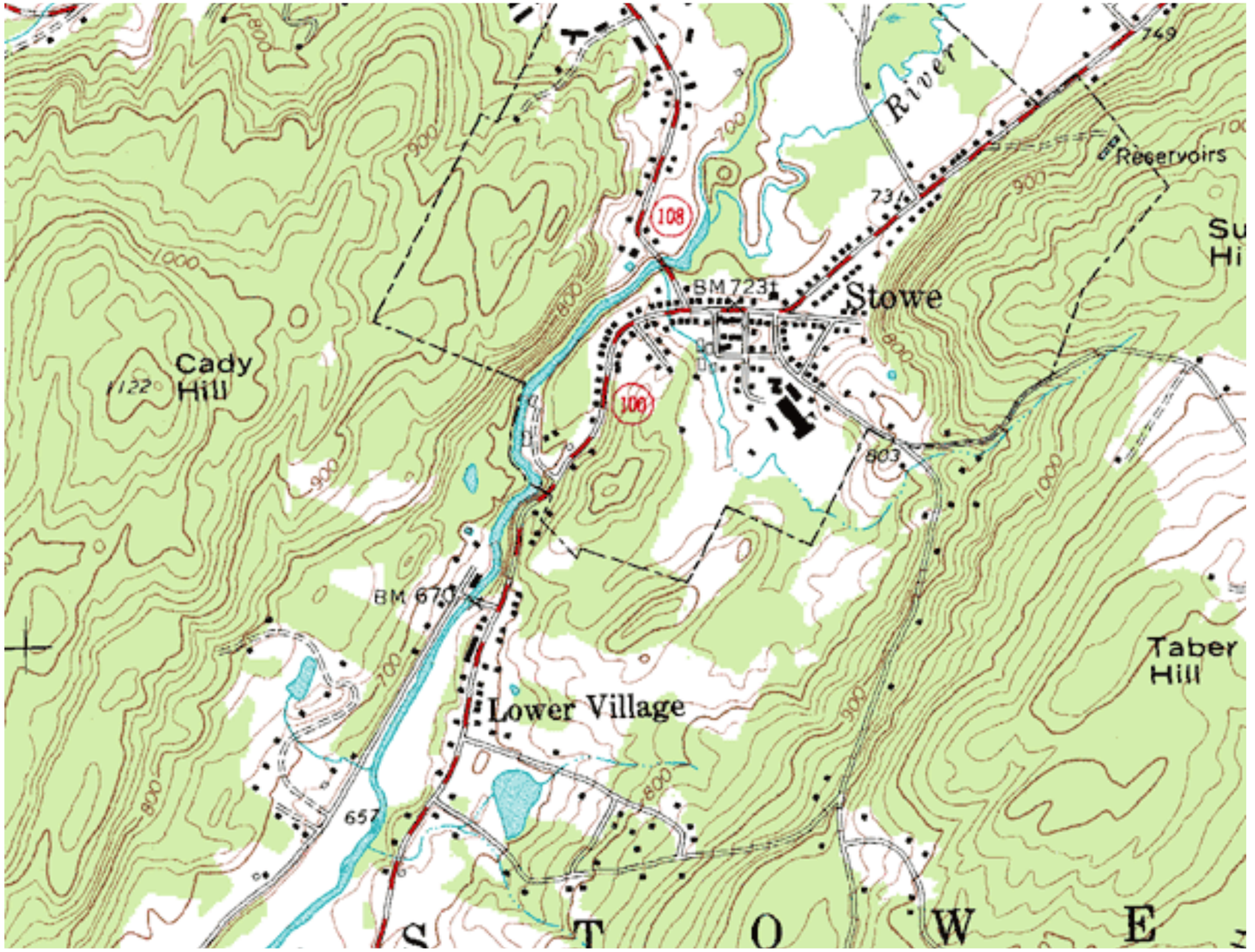


[DQ Nykamp, MathInsight]

Topology

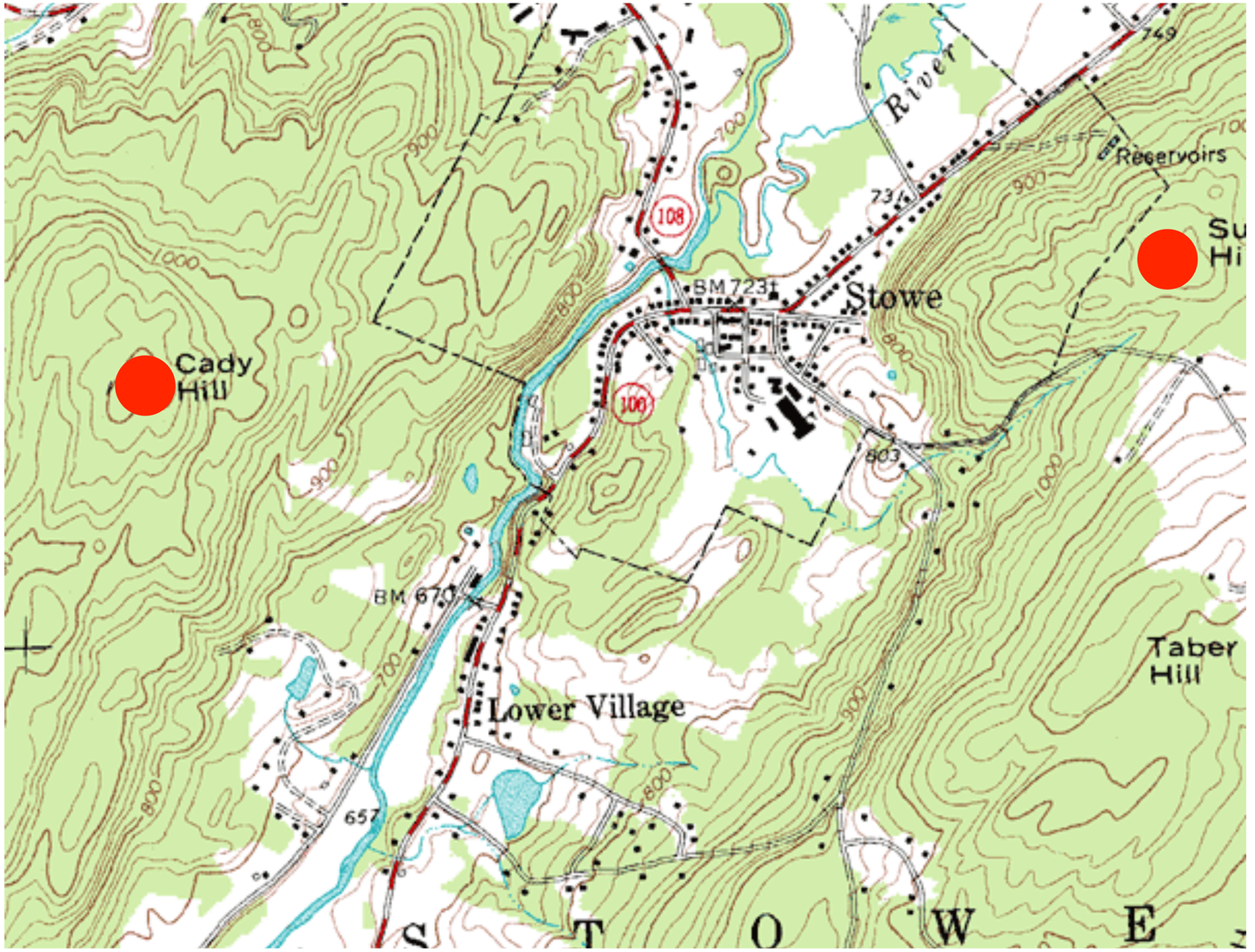
- The general shape of data
- Visualizations that can be "stretched" to resemble each other are topologically equivalent
- Technically, continuous transformations don't change anything
- Connect critical points to obtain a general picture of the data
- Can talk about topology in both scalar and vector fields

2D Scalar Field Topology



[Wikipedia]

2D Scalar Field Topology

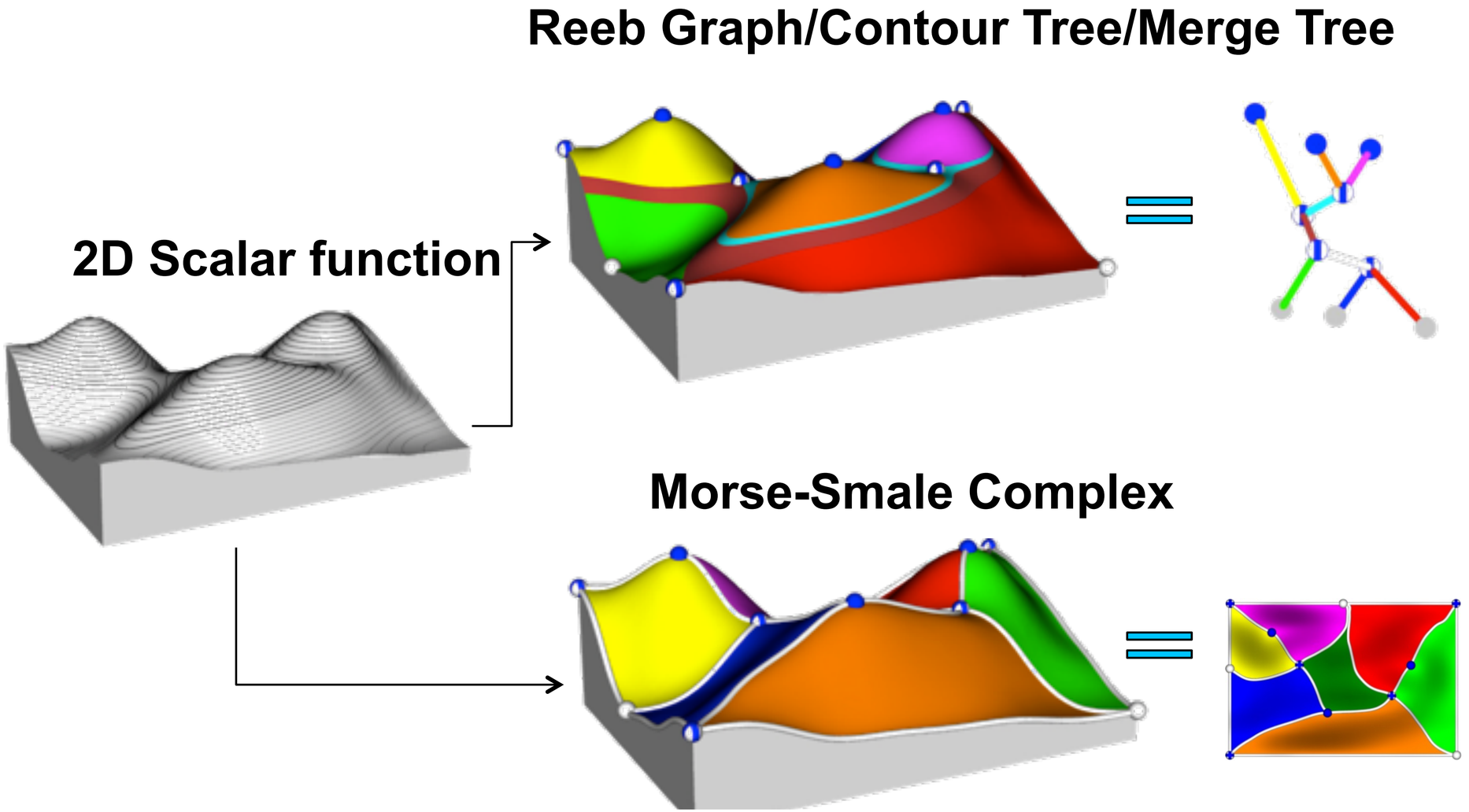


[Wikipedia]

Scalar Field Topology

- Examine the gradient (changes between points on the grid) of the scalar field
- Where the gradient is zero, we have critical points (max, min, saddle)
- Can build Reeb Graph, Contour Tree, or Morse-Smale Complex from this information to show the topology (with some reasonable assumptions about how the scalar field looks)

Scalar Field Topology



[via Levine]

Vector Field Topology

- Instead of “guessing” correct seed points for streamlines to understand the field, try to identify structure (topology) of the field

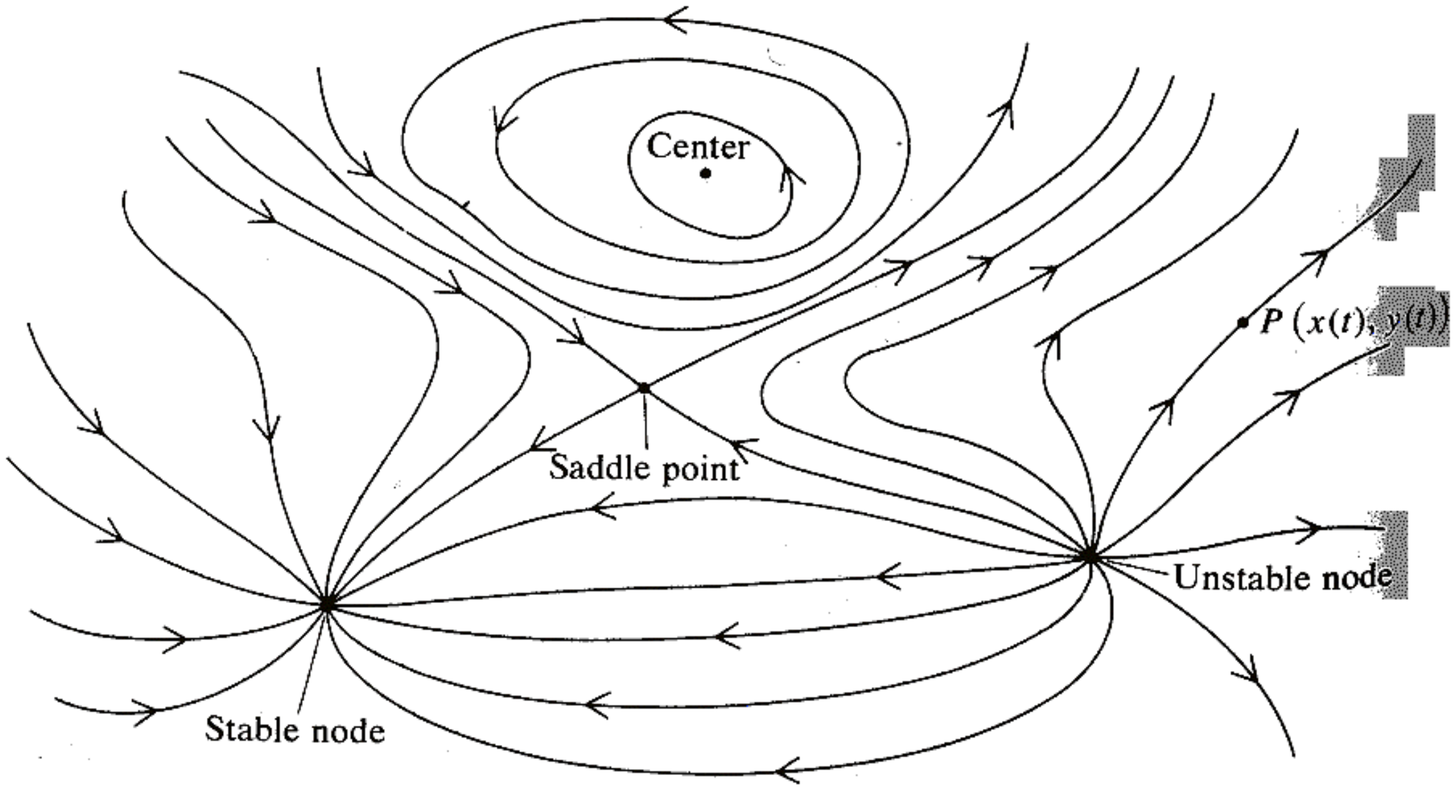
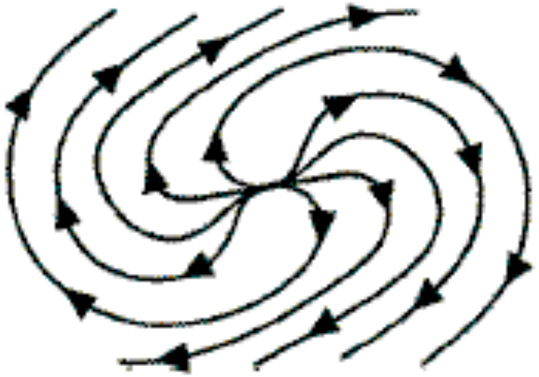


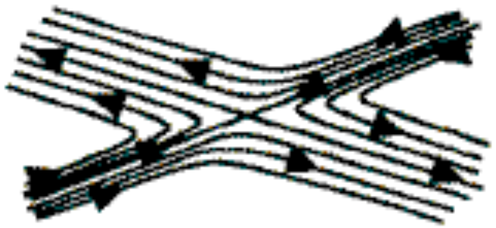
Figure 7.1 A phase portrait.

[M. Henle]

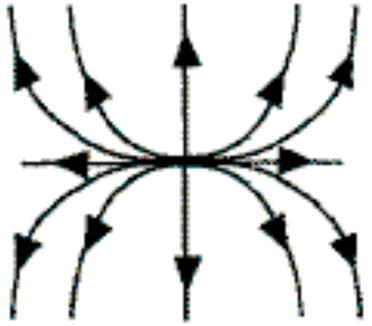
Critical Points



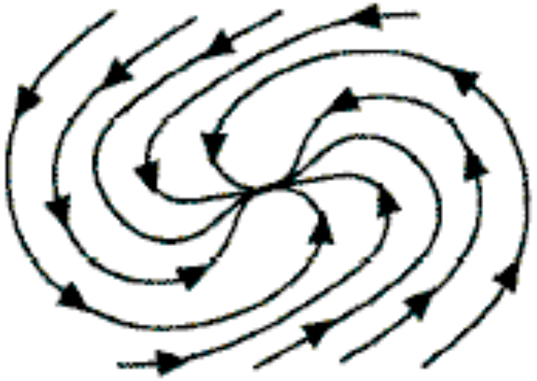
Repelling Focus
R1, R2 > 0
I1, I2 != 0



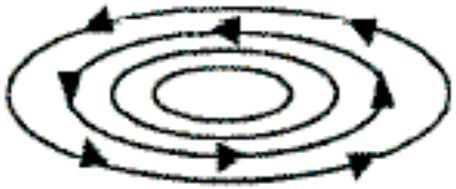
Saddle Point
R1 * R2 < 0
I1, I2 = 0



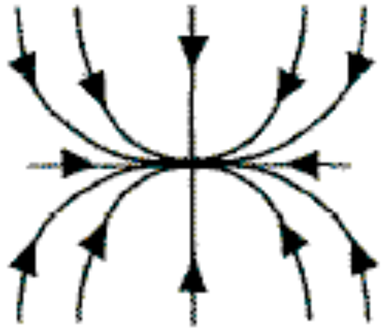
Repelling Node
R1, R2 > 0
I1, I2 = 0



Attracting Focus
R1, R2 < 0
I1, I2 != 0



Center
R1, R2 = 0
I1, I2 != 0



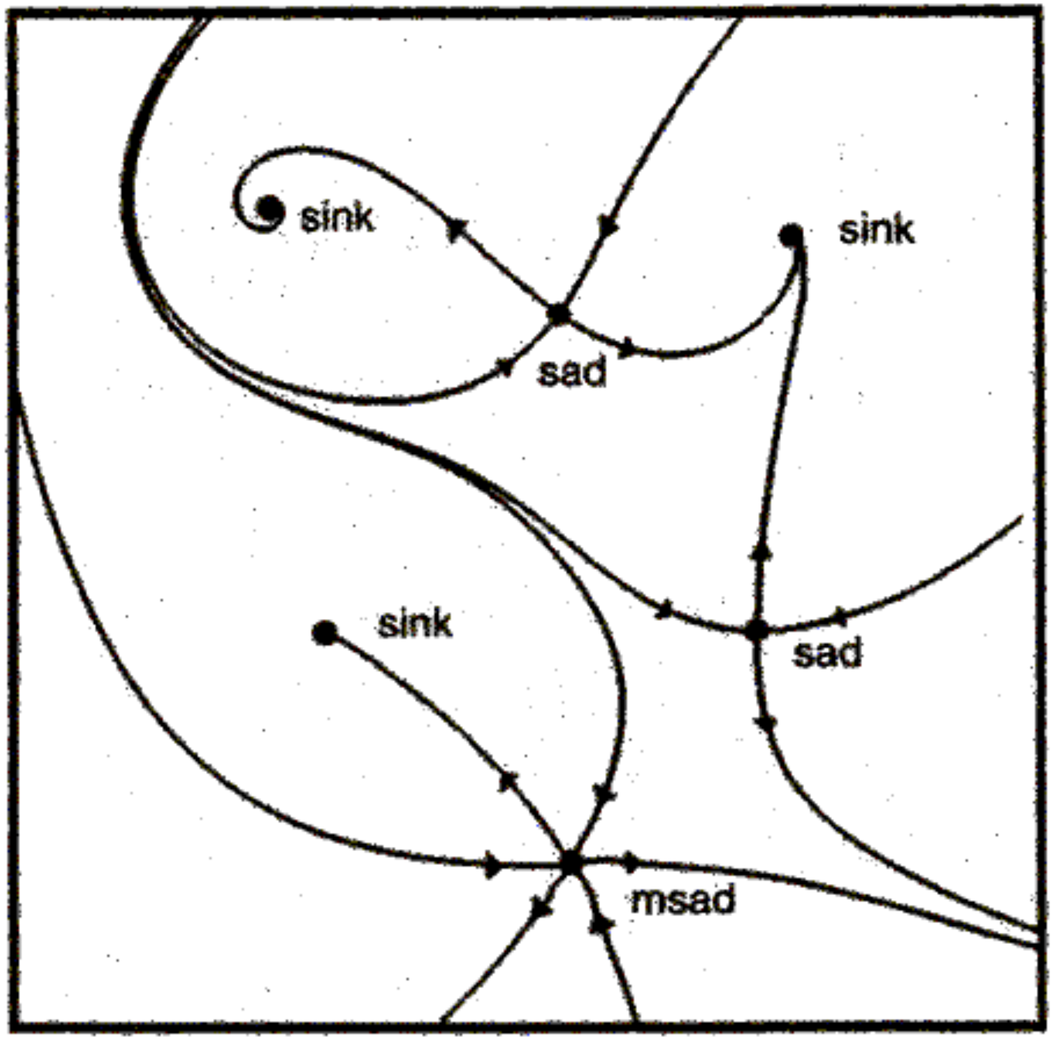
Attracting Node
R1, R2 < 0
I1, I2 = 0

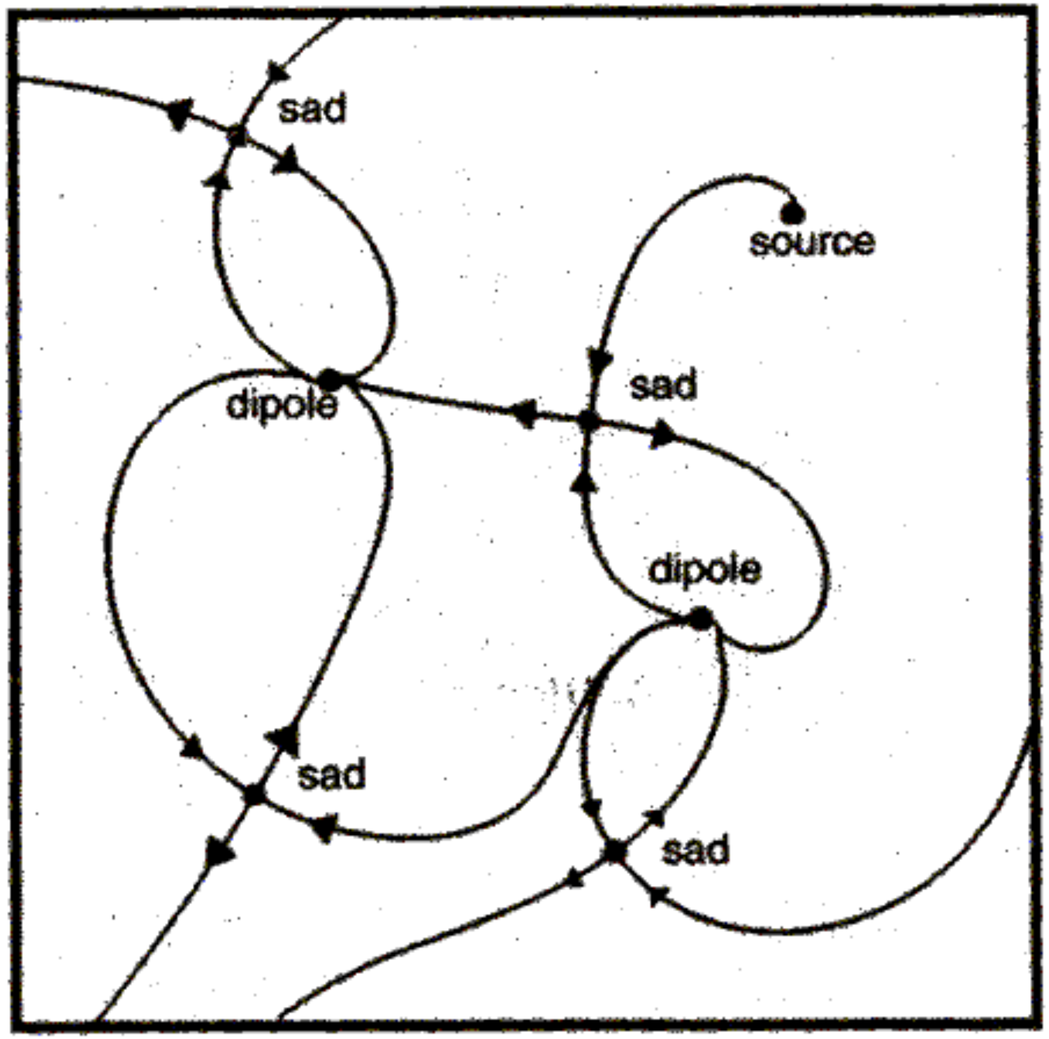
[Helman & Hesselink]

Critical Points

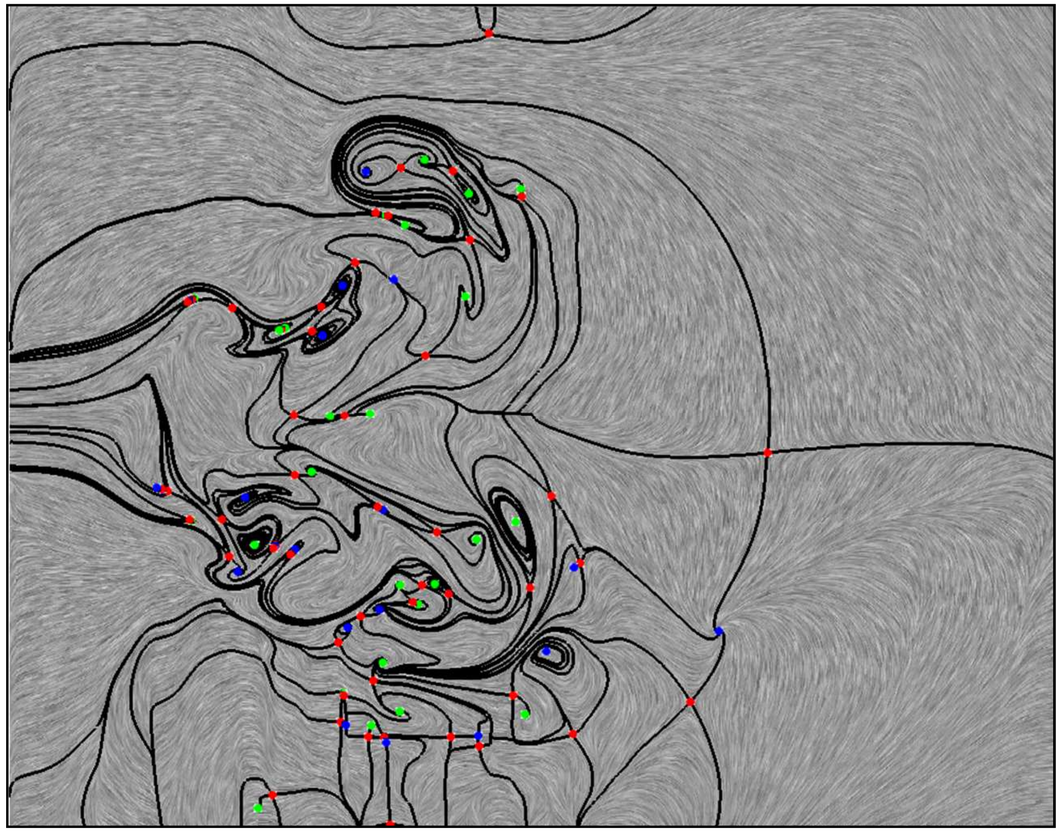
- Critical Points
  - Find where the vector field vanishes (the zero vector or undefined)
  - Attracting Nodes (Sinks), Repelling Nodes (Sources), Attracting Foci, Repelling Foci, Saddles, Centers
- How to find such points?
  - Can use a similar idea to Marching Cubes
  - Use the eigenvalues of the Jacobian matrix to classify

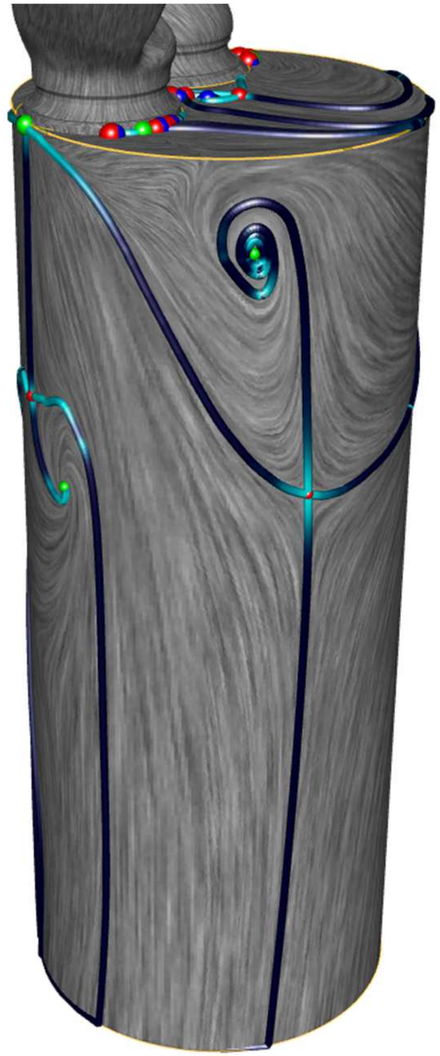
Topological Skeleton





More Examples





[Levine]

Text

Text Visualization

- Why visualize text? Text is already visual, right?
- How much text? What granularity? (What is an item?)
  - Single string
  - Words/lines
  - One document
  - Multiple documents (corpus)
- Considerations:
  - Legibility
  - Variable length
  - Locality
  - Occurence

Data Sources

- Literature: books, poetry
- Social Media: tweets, posts
- Web: Pages, posts, emails
- Code

Tag Cloud (One Document)

- Derived data: number of occurrences of words
- Channel: Font size
- Potential problem: Think about ink…

[Scray, CC-BY-SA-3.0]

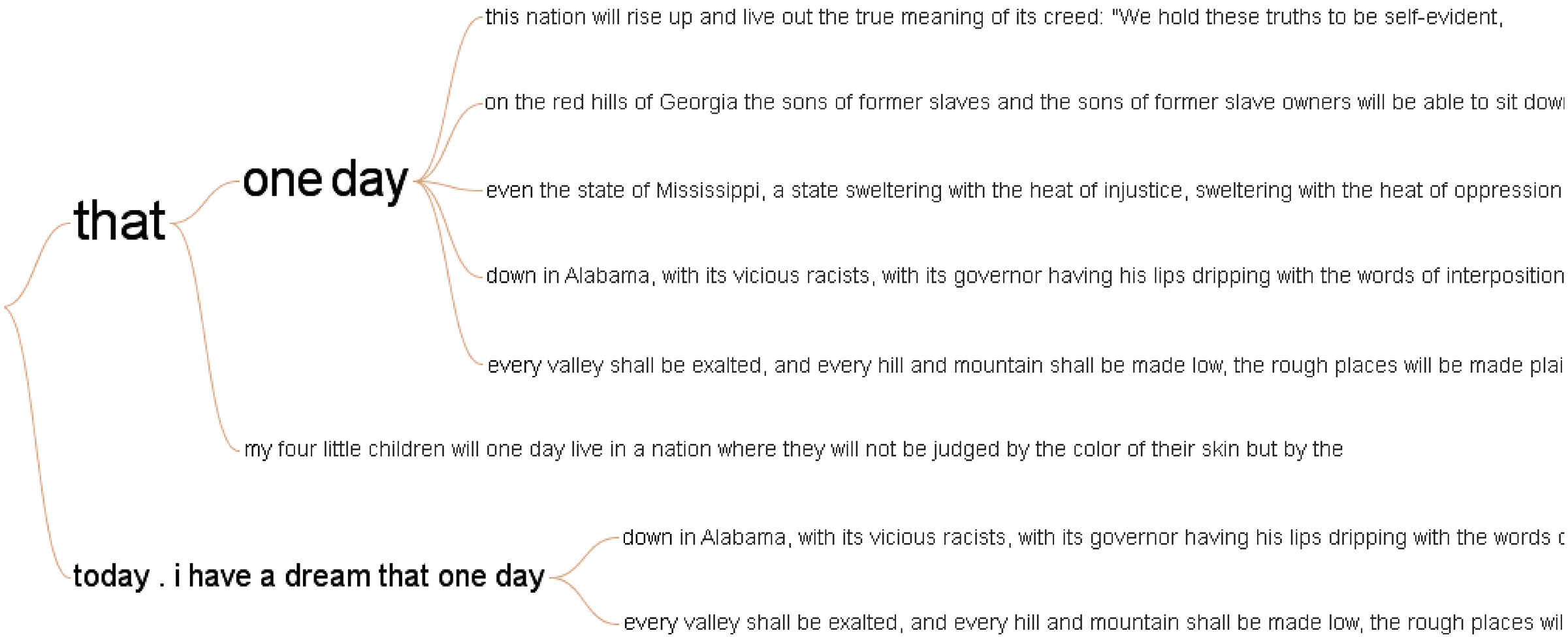
TextArc (One Document)

[textarc.org]

TextArc

- Three rules:
  - Show the entire text in an ellipse around the page: line-by-line and word-by-word
  - Like tag clouds, use larger font-size and brighter text for frequent words
  - Central words move to the middle (links to its mentions)

Word Tree (One Document)

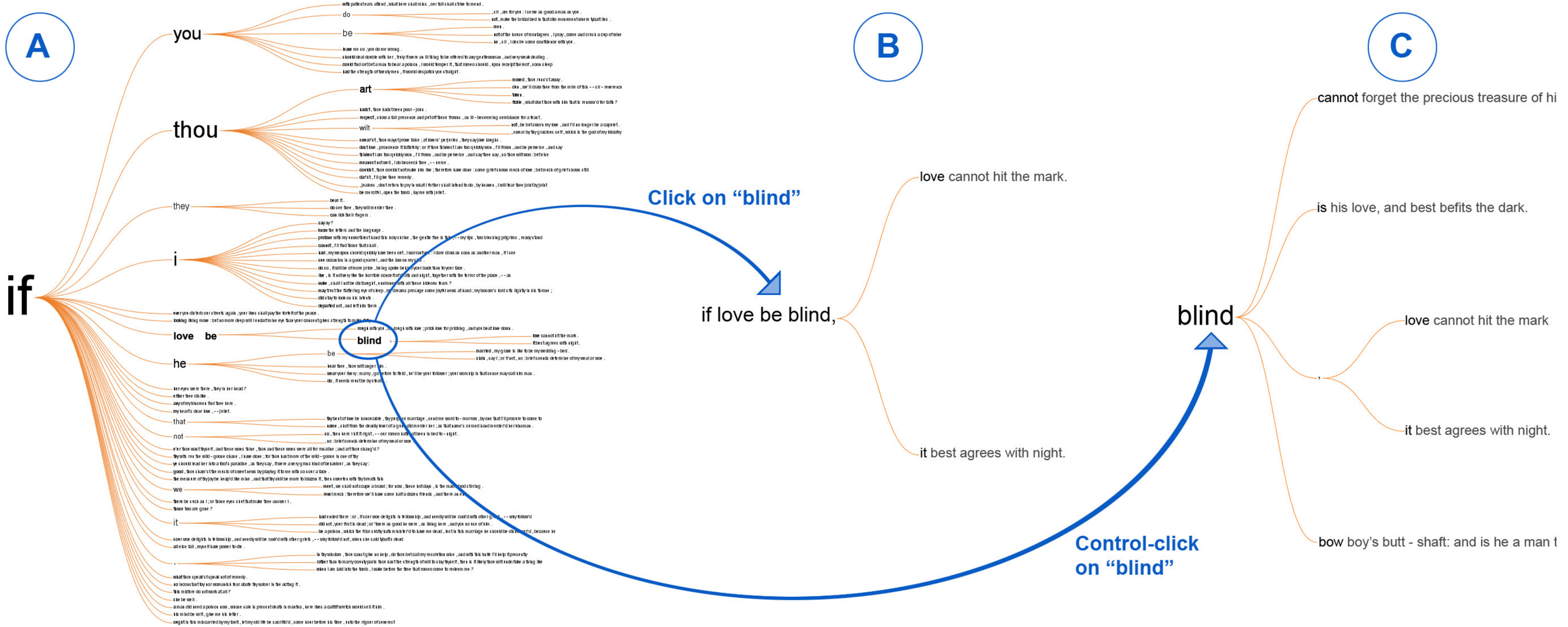


[Wattenberg & Viegas, 2007]

Word Tree

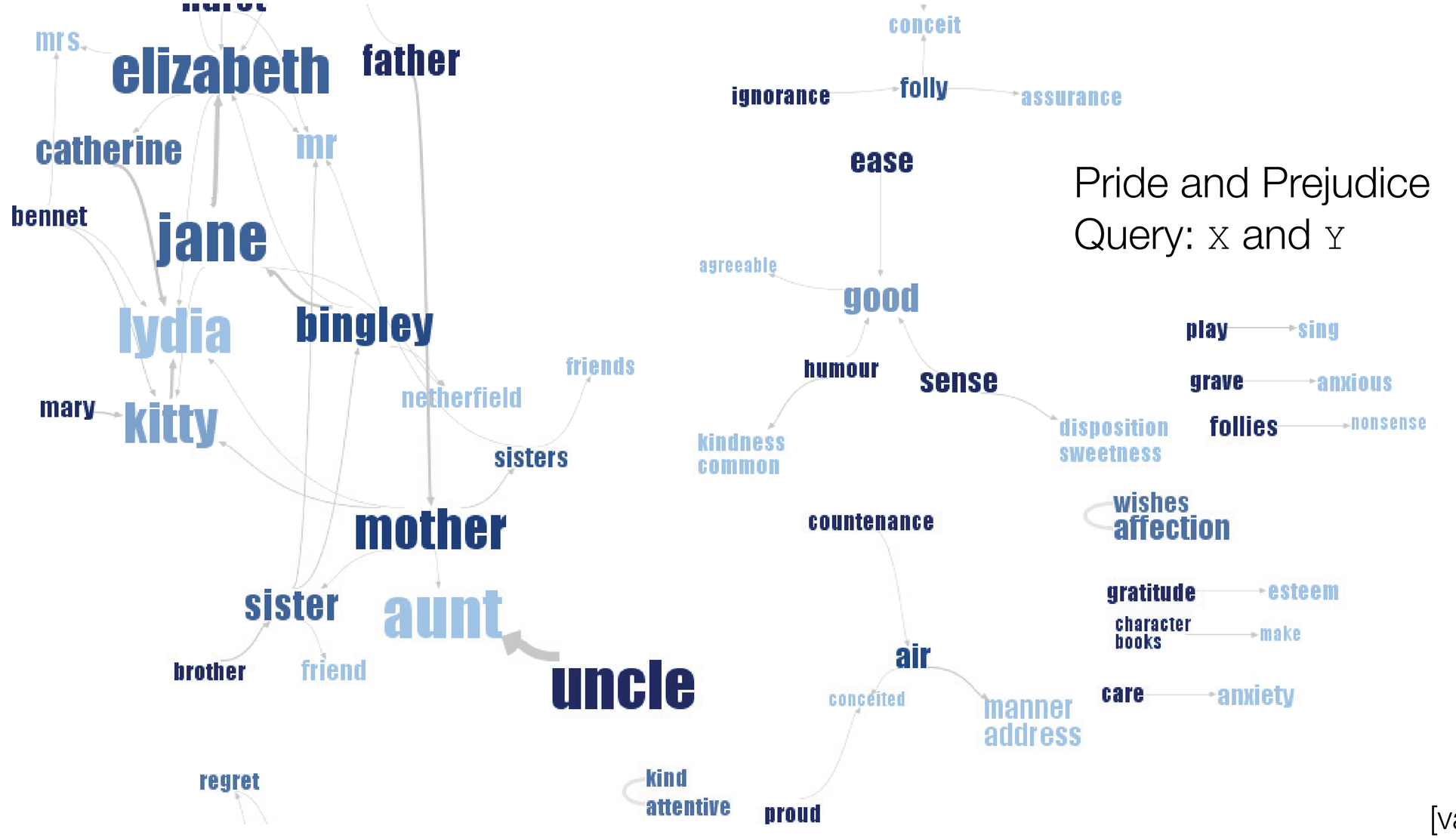
- A "Visual Concordance"
- Shows phrasing, relationships between words
- Starting point is a single word or snippet
- Branches to show common words/phrases that follow
- Goal is to show context: "keyword-in-context"

Interaction in Word Tree



[Wattenberg & Viegas, 2007]

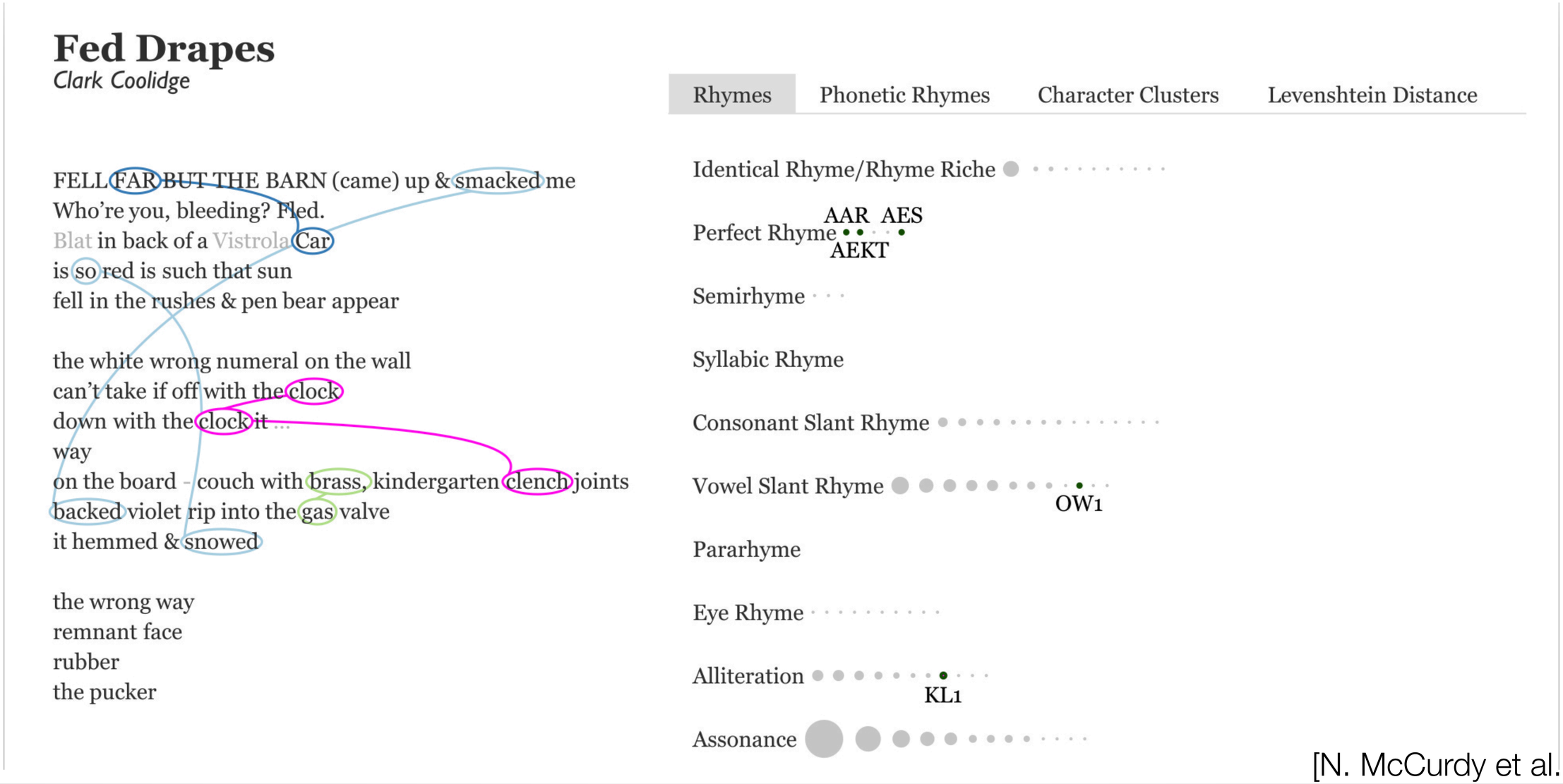
Phrase Nets



Pride and Prejudice
Query: `X` and `Y`

[van Ham, 2009]

Words are more than just character sequences



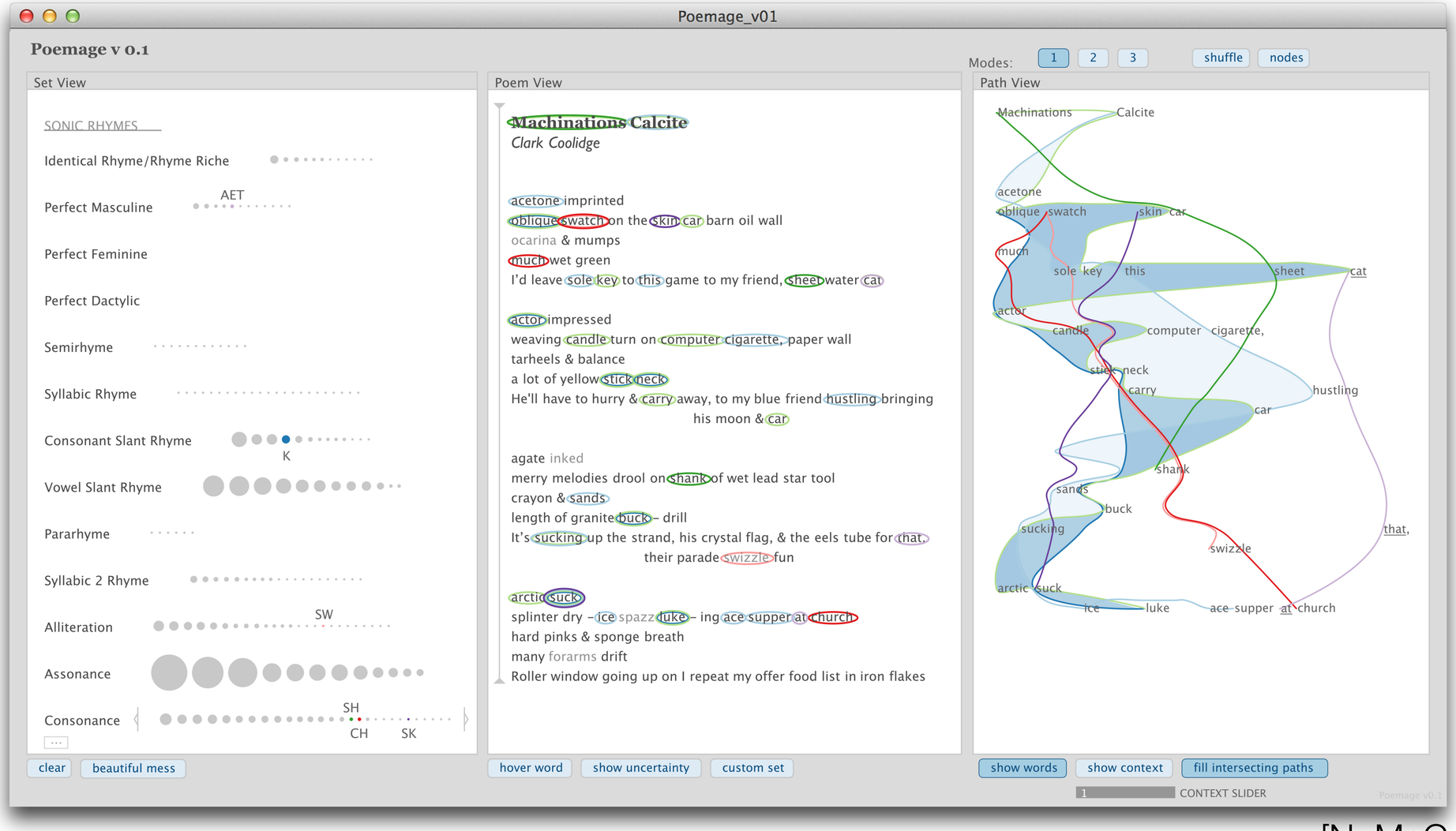
[N. McCurdy et al., 2015]

Poemage

- Support close reading—in-depth reading to generate as much productive meaning as possible
- Search for poetic devices: affect, imagery, pun, metaphor
- Sound and linguistic devices → Rhyming
  - Identical: pare/pair
  - Perfect: picky/tricky
  - Assonance & consonance: blue/estuaries, shell/chiffon
  - Eye rhyme: cough/bough
- Support exploration: scholars do not want computers to "solve" poems

[N. McCurdy et al., 2015]

Interface



[N. McCurdy et al., 2015]

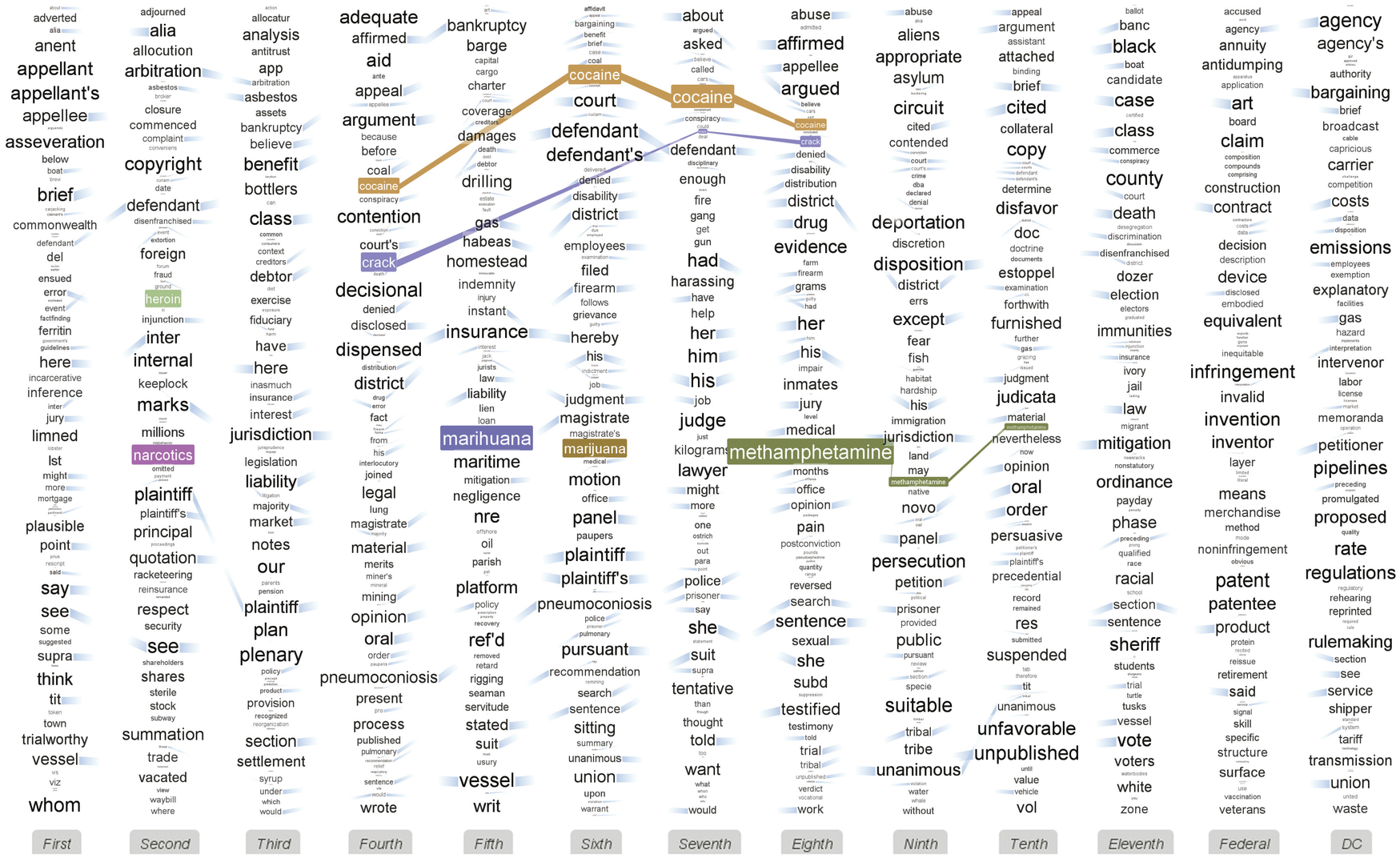
Comparing Documents

- Word choice/usage
- Relationships
- Phrasing

Tag Cloud (Two Documents)

[Pyrsmis, CC-BY-SA-3.0]

Parallel Tag Clouds (Multiple Documents)



[Collins et al., 2009]

Jigsaw (Multiple Documents)

Visual Analytics Support for Intelligence Analysis
Case Study: The 9/11 Report

Carsten Görg
Youn-ah Kang
Zhicheng Liu
John Stasko

Information Interfaces Group
Georgia Institute of Technology

[http://www.cc.gatech.edu/gvu/ii/jigsaw/]

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