Perception

CS533C Presentation

by Alex Gukov

Papers Covered

- Current approaches to change blindness Daniel J. Simons. Visual Cognition 7, 1/2/3 (2000)
- Internal vs. External Information in Visual Perception Ronald A. Rensink. Proc. 2nd Int. Symposium on Smart Graphics, pp 63-70, 2002
- Visualizing Data with Motion Daniel E. Huber and Christopher G. Healey. Proc. IEEE Visualization 2005, pp. 527-534.
- Stevens Dot Patterns for 2D Flow Visualization. Laura G. Tateosian, Brent M. Dennis, and Christopher G. Healey. Proc. Applied Perception in Graphics and Visualization (APGV) 2006

Change Blindness

- Failure to detect scene changes

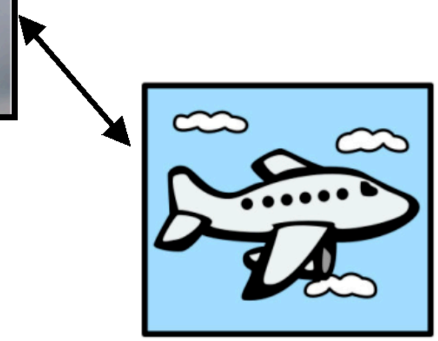
Change Blindness

- Large and small scene changes
  - Peripheral objects
  - Low interest objects
- Attentional blink
  - Head or eye movement – saccade
  - Image flicker
  - Obstruction
  - Movie cut
- Inattentional blindness
  - Object fade in / fade out

Mental Scene Representation

How do we store scene details ?

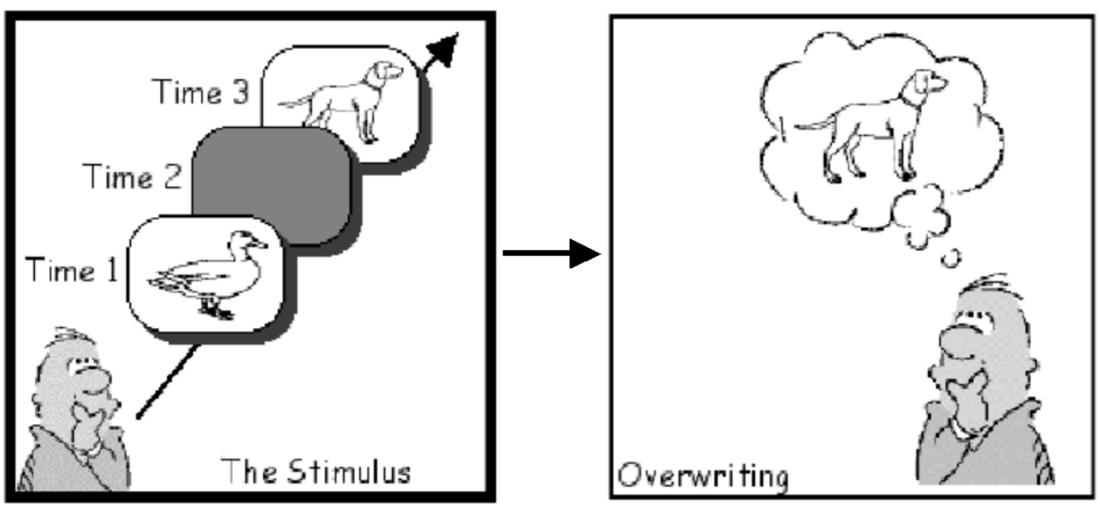
- Visual buffer
  - Store the entire image
  - Limited space
  - Refresh process unclear



- Virtual model + external lookup
  - Store semantic representation
  - Access scene for details
  - Details may change
- Both models support change blindness

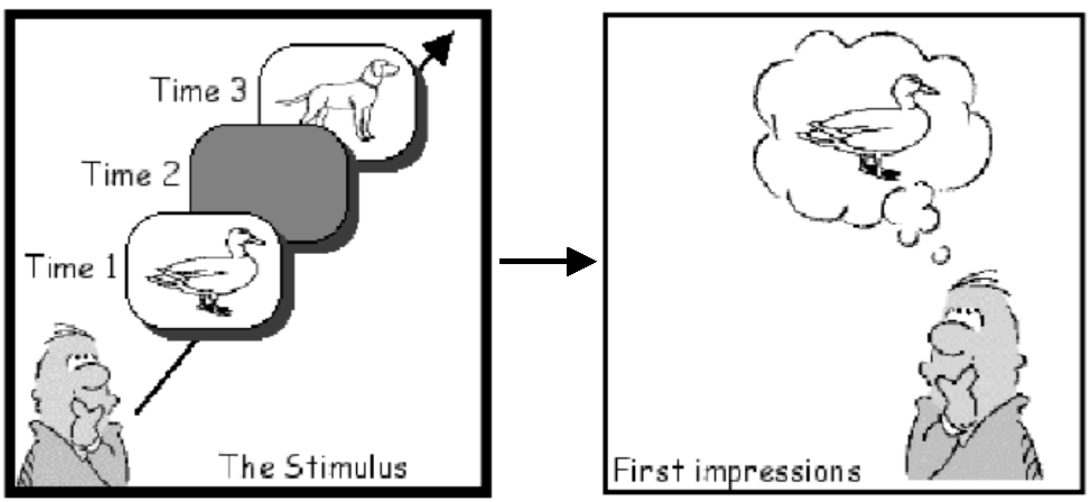
Overwriting

- Single visual buffer
- Continuously updated
- Comparisons limited to semantic information
- Widely accepted



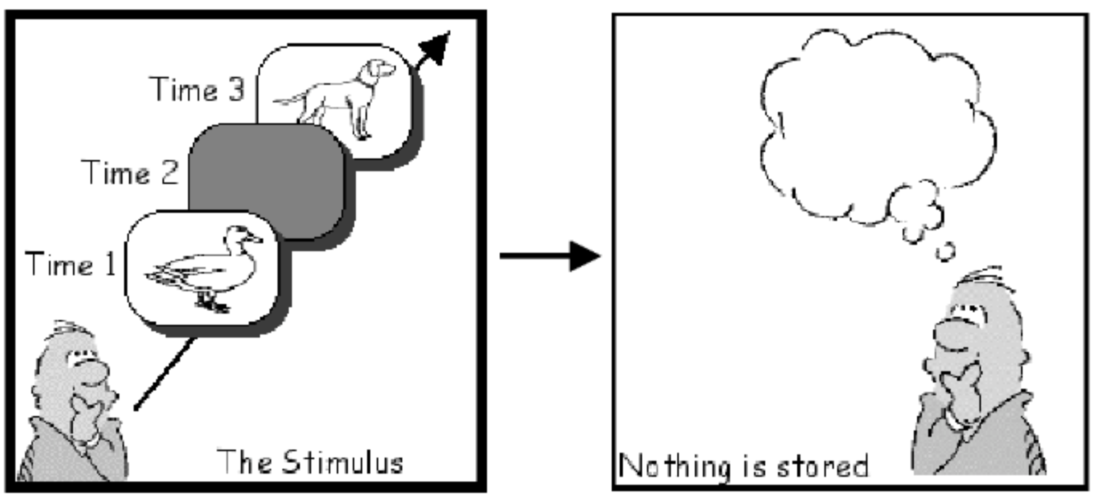
First Impression

- Create initial model of the scene
- No need to update until gist changes
- Evidence
  - Test subjects often describe the initial scene. Actor substitution experiment.



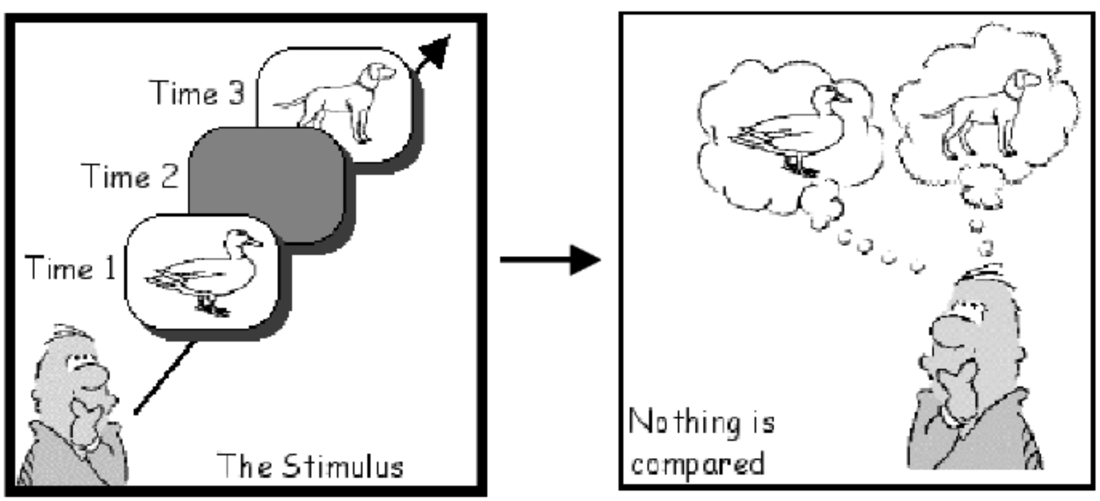
Nothing is stored(just-in-time)

- Scene indexed for later access
- Maintain only high level information (gist)
- Use vision to re-acquire details
- Evidence
    - Most tasks operate on a single object. Attention constantly switched.



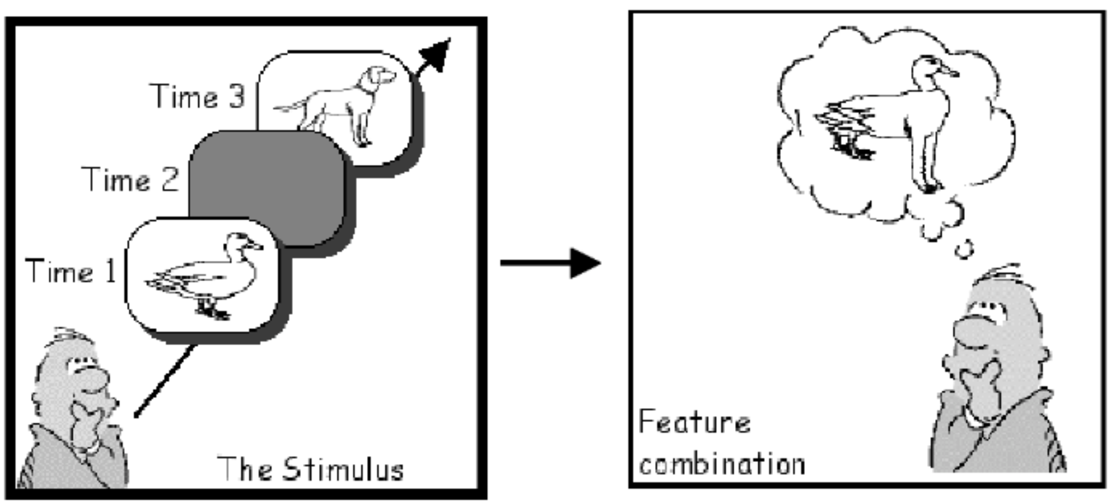
Nothing is compared

- Store all details
- Multiple views of the same scene possible
- Need a 'reminder' to check for contradictions
- Evidence
  - Subjects recalled change details after being notified of the change. Basketball experiment.



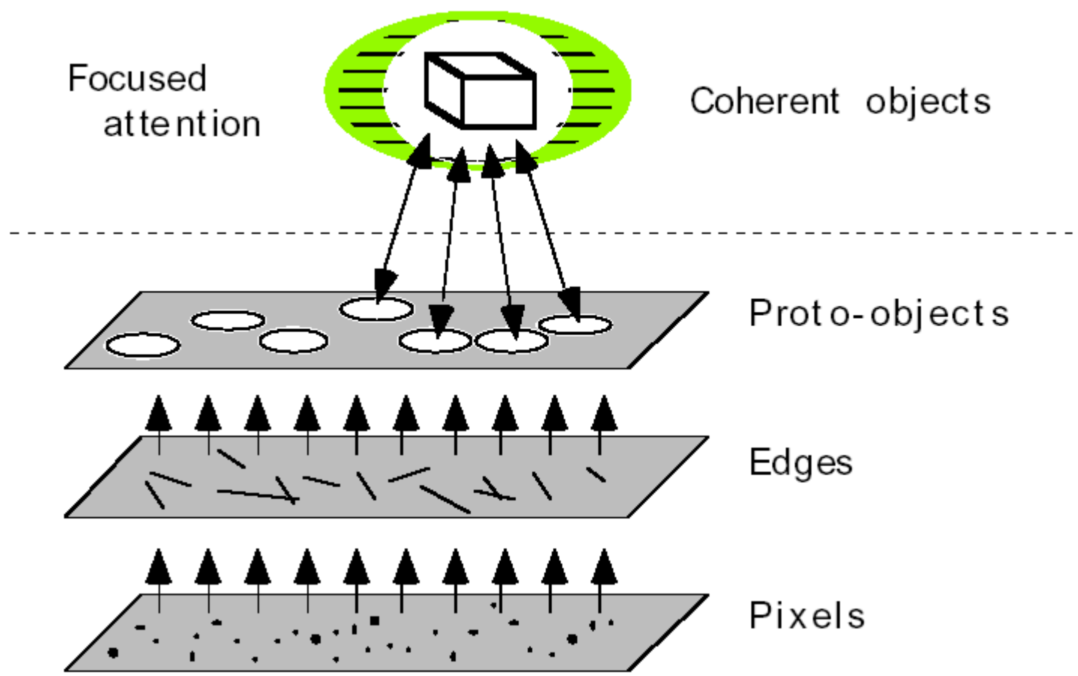
Feature combination

- Continuously update visual representation
- Both views contribute to details
- Evidence
  - Eyewitness adds details after being informed of them.



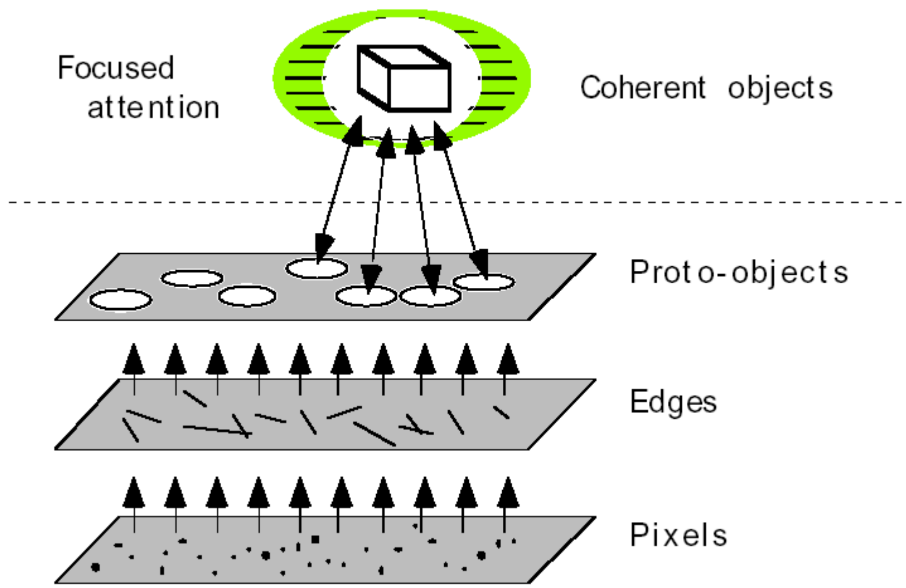
Coherence Theory

- Extends 'just-in-time' model
- Balances external and internal scene representations
- Targets parallelism, low storage



Pre-processing

- Process image data
  - Edges, directions, shapes
- Generate proto-objects
  - Fast parallel processing
  - Detailed entities
  - Link to visual position
  - No temporal reference
  - Constantly updating



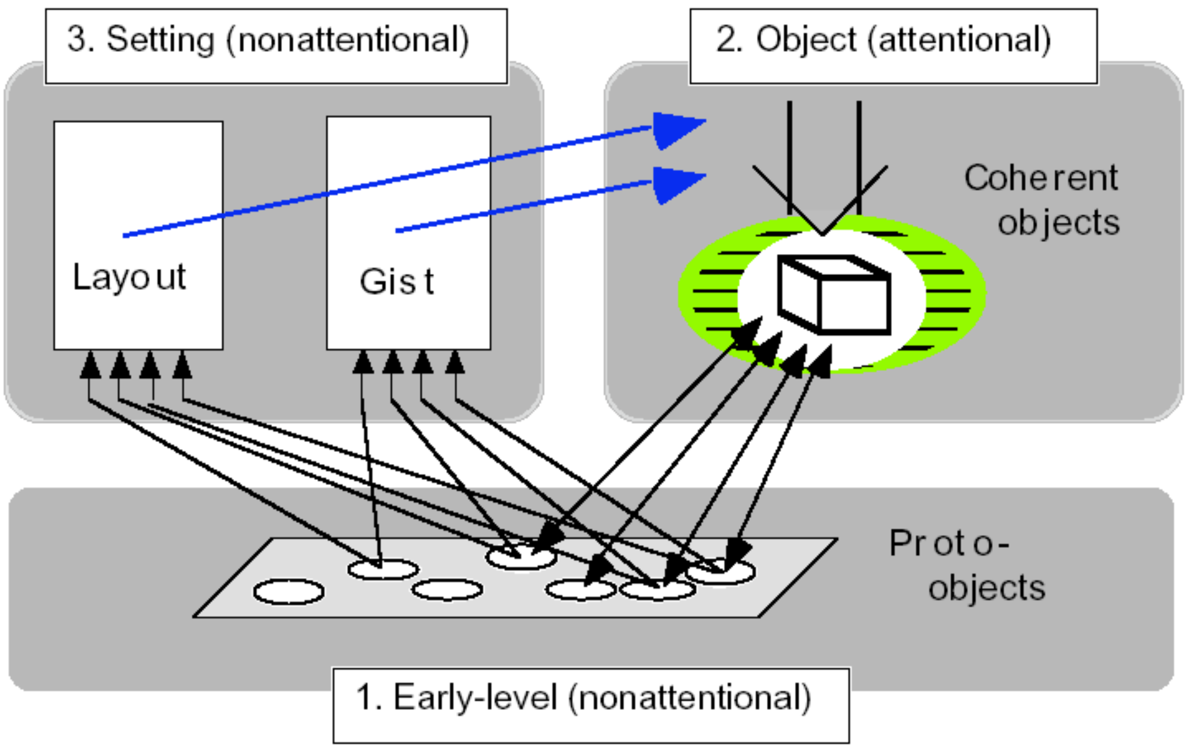
Upper-level Subsystems

- Setting (pre-attentive)
  - Non-volatile scene layout, gist
  - Assists coordination
  - Directs attention
- Coherent objects (attentional)
  - Create a persistent representation when focused on an object
  - Link to multiple proto-objects
  - Maintain task-specific details
  - Small number reduces cognitive load

Subsystem Interaction

Need to construct coherent objects on demand

- Use non-volatile layout to direct attention



Coherence Theory and Change Blindness

- Changes in current coherent objects
  - Detectable without rebuilding
- Attentional blink
  - Representation is lost and rebuilt
- Gradual change
  - Initial representation never existed

Implications for Interfaces

- Object representations limited to current task
  - Focused activity
- Increased LOD at points of attention
  - Predict or influence attention target
    - Flicker
    - Pointers, highlights..
  - Predict required LOD
    - Expected mental model
- Visual transitions
  - Avoid sharp transitions due to rebuild costs
  - Mindsight (pre-attentive change detection)

Critique

- Extremely important phenomenon
  - Will help understand fundamental perception mechanisms
- Theories lack convincing evidence
  - Experiments do not address a specific goal
  - Experiment results can be interpreted in favour of a specific theory (Basketball case)

Visualizing Data with Motion

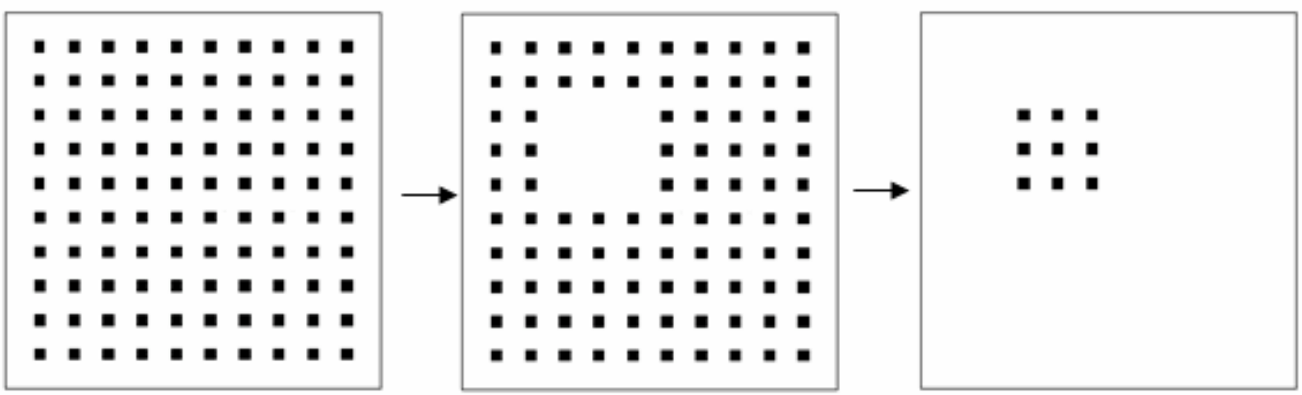
- Multidimensional data sets more common
- Common visualization cues
  - Color
  - Texture
  - Position
  - Shape
- Cues available from motion
  - Flicker
  - Direction
  - Speed

Previous Work

- Detection
  - 2-5% frequency difference from background
  - 1^{o}/s speed difference from the background
  - 20^{o} direction difference from the background
  - Peripheral objects need greater separation
- Grouping
  - Oscillation pattern – must be in phase
- Notification
  - Motion encoding superior to color, shape change

Flicker Experiment

- Test detection against background flicker
- Coherency
  - In phase / out of phase with the background
- Cycle difference
- Cycle length

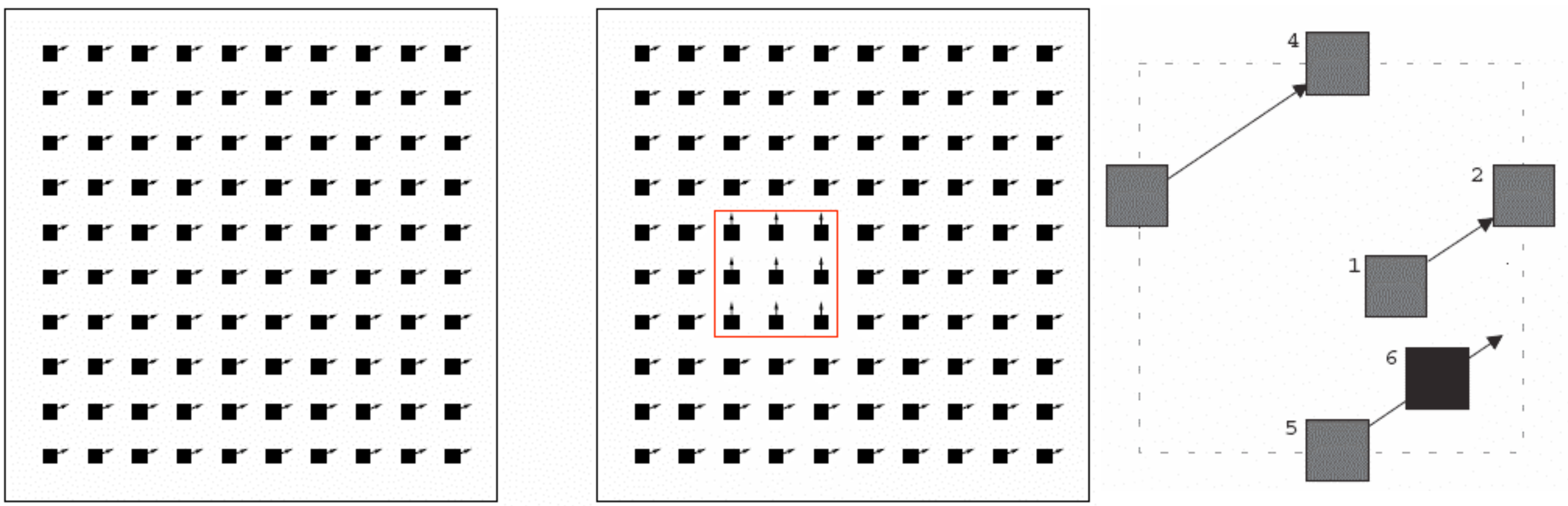


Flicker Experiment - Results

- Coherency
  - Out of phase trials detection error ~50%
  - Exception for short cycles - 120ms
    - Appeared in phase
- Cycle difference, cycle length (coherent trials)
  - High detection results for all values

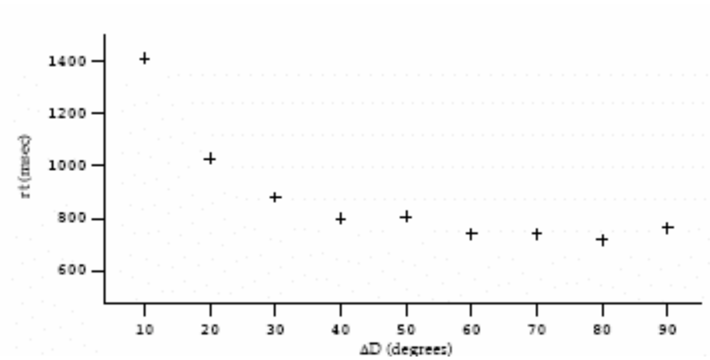
Direction Experiment

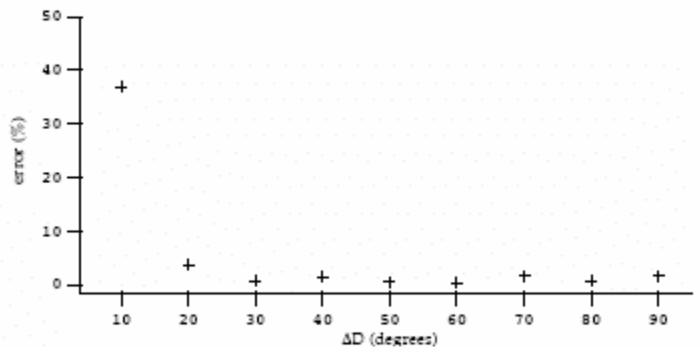
- Test detection against background motion
- Absolute direction
- Direction difference



Direction Experiment - Results

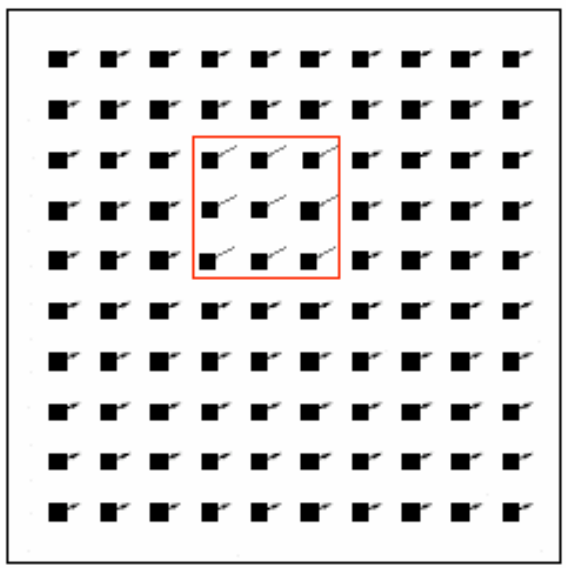
- Absolute direction
  - Does not affect detection
- Direction difference
  - 15^{o} minimum for low error rate and detection time
  - Further difference has little effect





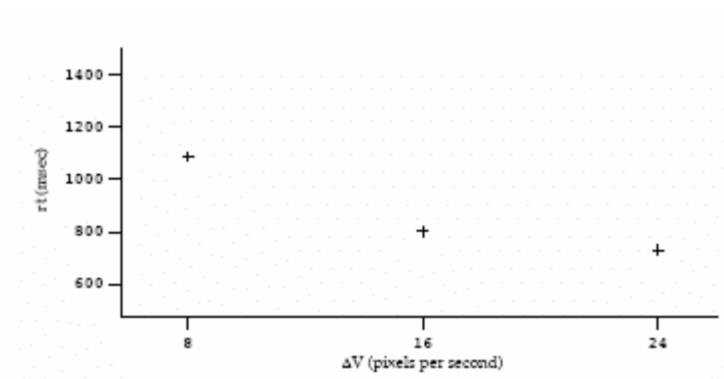
Speed Experiment

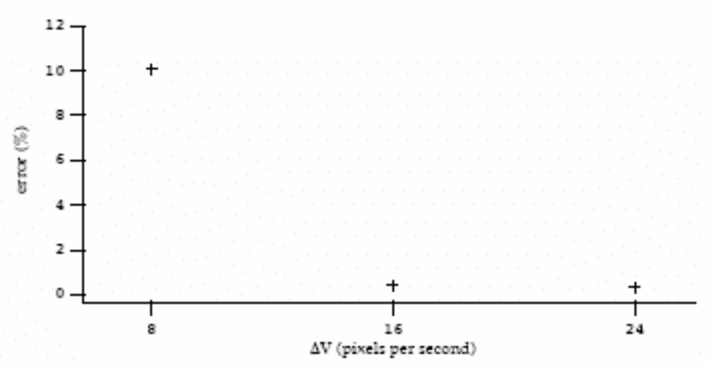
- Test detection against background motion
- Absolute speed
- Speed difference



Speed Experiment - Results

- Absolute speed
  - Does not affect detection
- Speed difference
  - 0.42°/s minimum for low error rate and detection time
  - Further difference has little effect

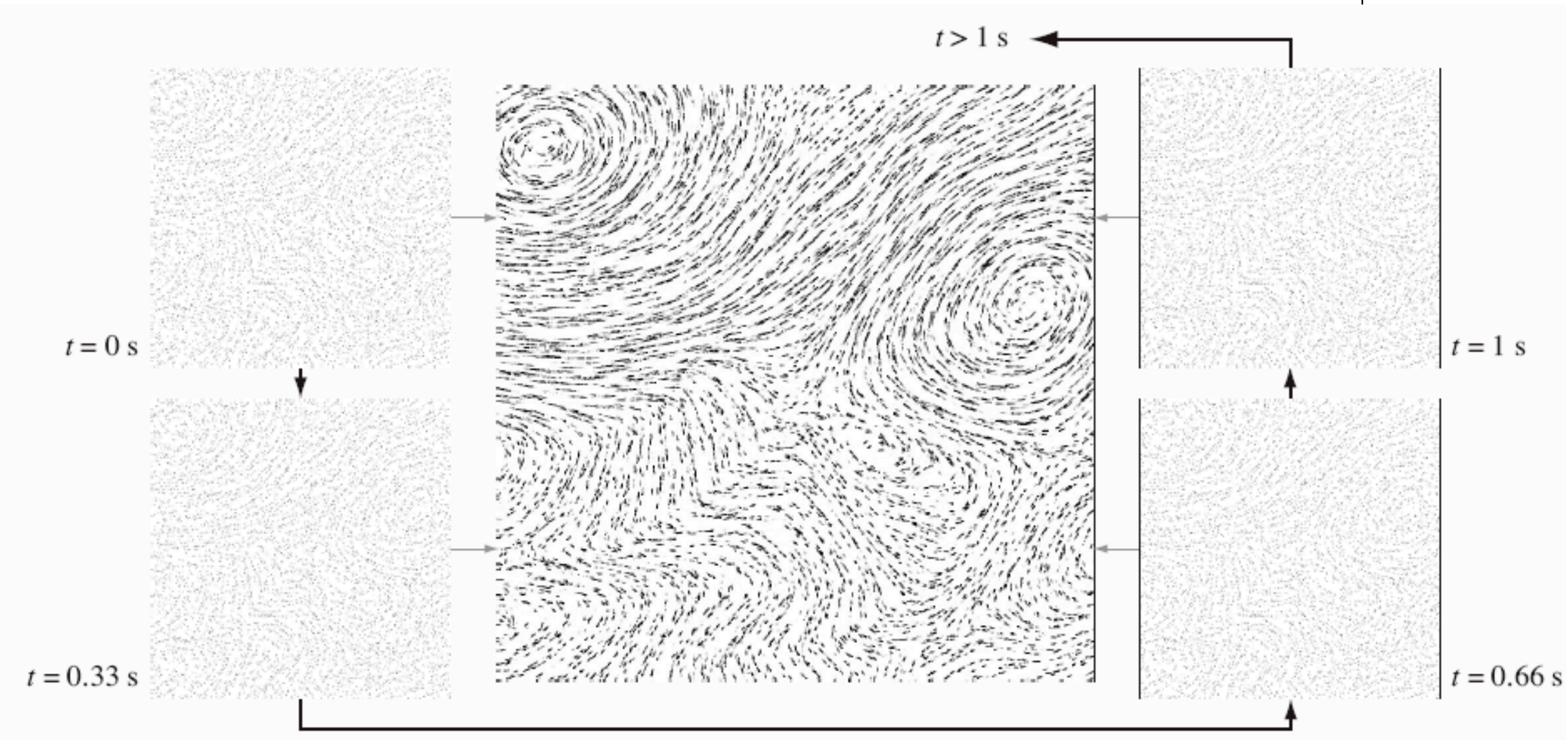




Applications

- Can be used to visualize flow fields
  - Original data 2D slices of 3D particle positions over time (x,y,t)
  - Animate keyframes

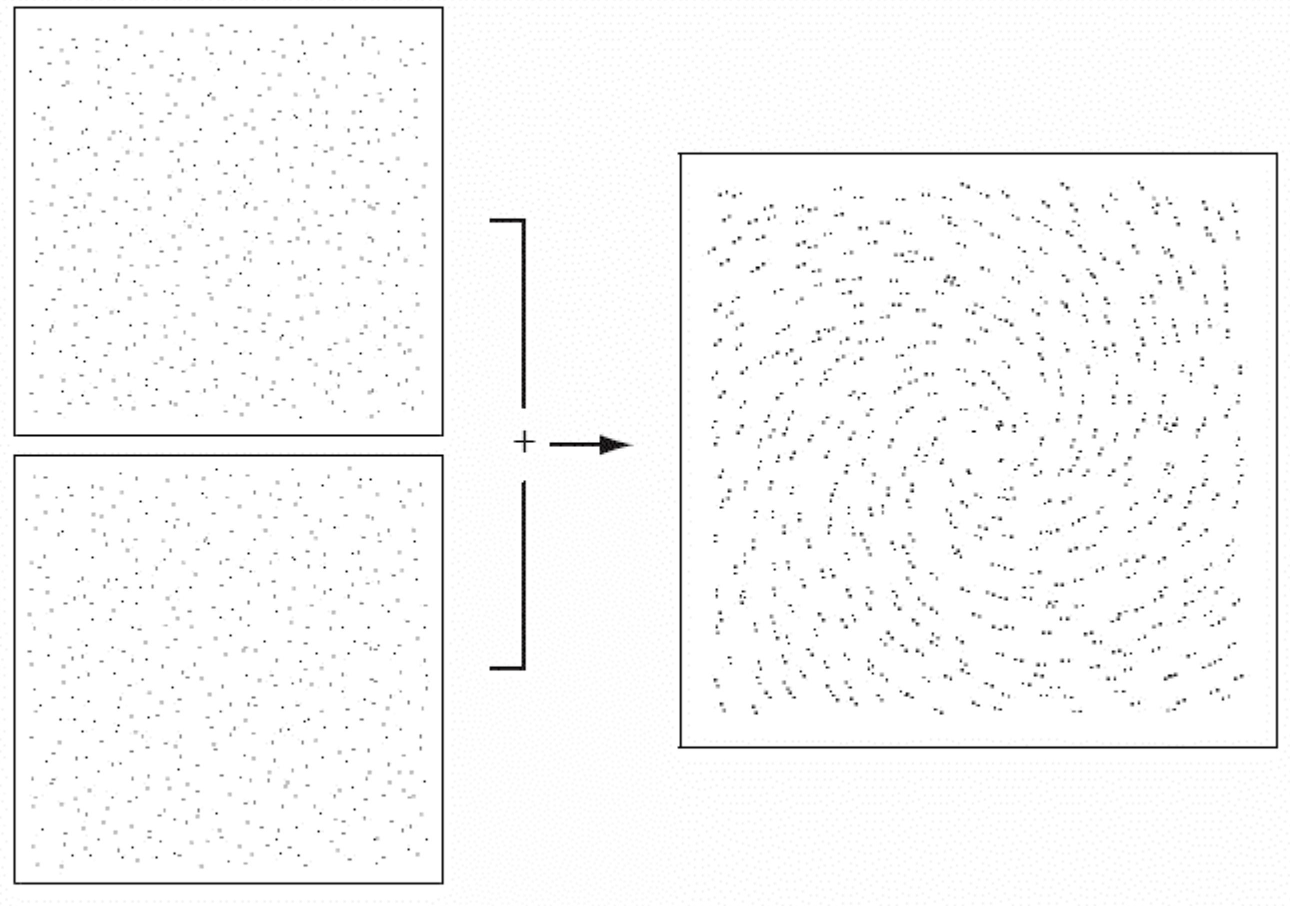
Applications



Critique

- Study
  - Grid density may affect results
  - Multiple target directions
- Technique
  - Temporal change increases cognitive load
    - Color may be hard to track over time
    - Difficult to focus on details

Stevens Model for 2D Flow Visualization



(a)

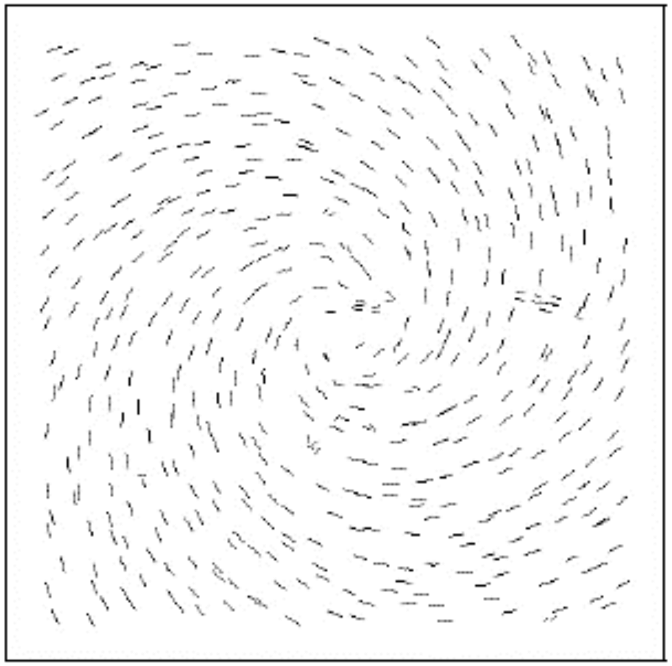
(b)

Idea

- Initial Setup
  - Start with a regular dot pattern
  - Apply global transformation
  - Superimpose two patterns
- Glass
  - Resulting pattern identifies the global transform
- Stevens
  - Individual dot pairs create perception of local direction
  - Multiple transforms can be detected

Stevens Model

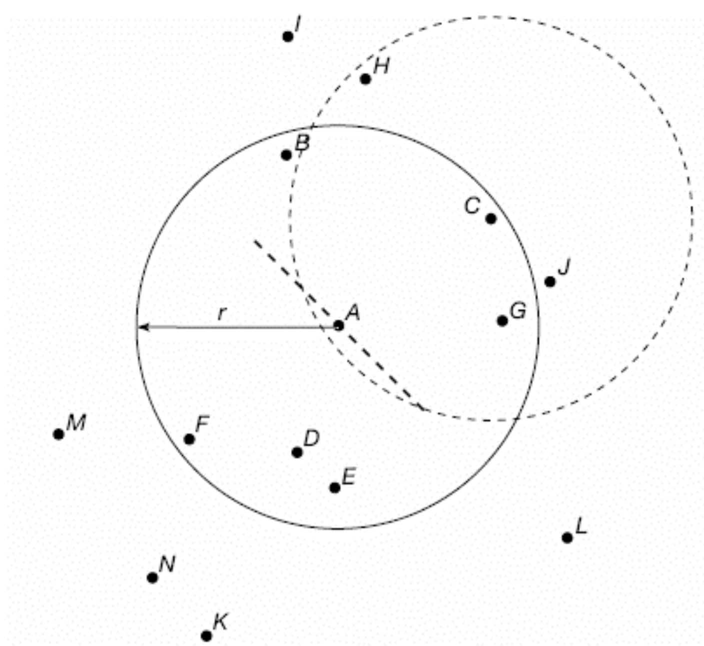
- Predict perceived direction for a neighbourhood of dots
  - Enumerate line segments in a small neighbourhood
    - Calculate segment directions
    - Penalize long segments
    - Select the most common direction
  - Repeat for all neighbourhoods

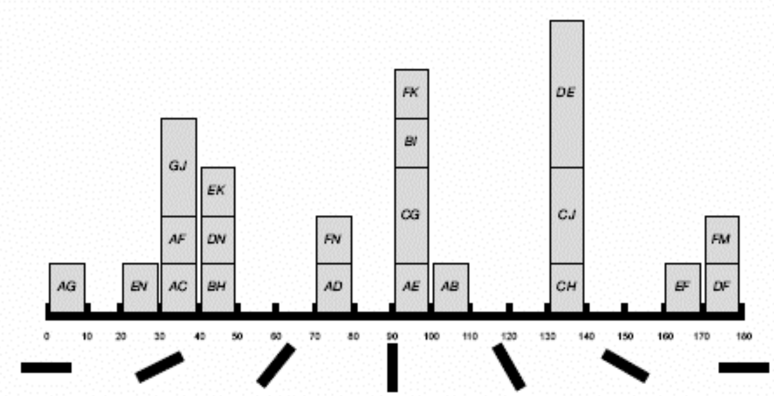


Stevens Model

Segment weight

$$w = \begin{cases} 1, & \text{if } l \leq \frac{1}{4}r \\ \frac{2}{3}, & \text{if } \frac{1}{4}r < l \leq \frac{1}{2}r \\ \frac{1}{3}, & \text{if } \frac{1}{2}r < l \leq r \end{cases}$$





Stevens Model

- Ideal neighbourhood – empirical results
  - 6-7 dots per neighbourhood
  - Density 0.0085 dots / pixel
- Neighbourhood radius
  - 16.19 pixels
- Implications for visualization algorithm
  - Multiple zoom levels required

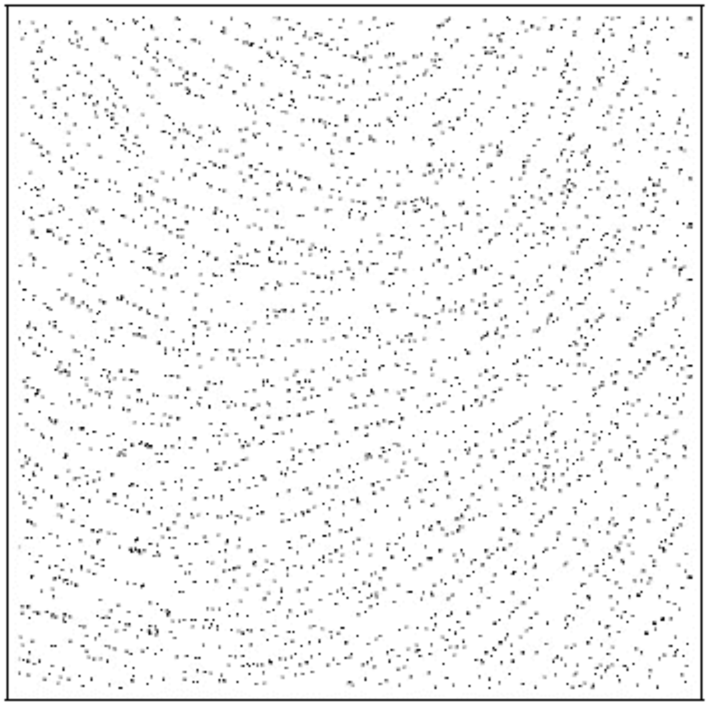
2D Flow Visualization

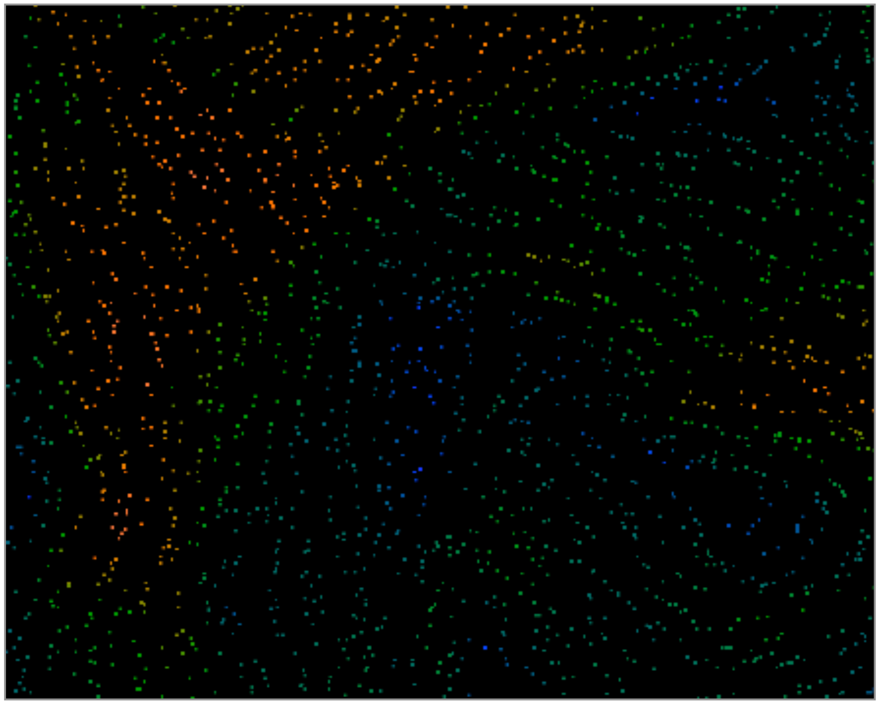
- Stevens model estimates perceived direction
- How can we use it to visualize flow fields ?
  - Construct a dot neighbourhoods such that the desired direction matches what is perceived

Algorithm

- Data
  - 2D slices of 3D particle positions over a period of time
- Algorithm
  - Start with a regular grid
  - Calculate direction error around a single point
    - Desired direction: keyframe data
    - Perceived direction: Stevens model
  - Move one of the neighbourhood points to decrease error
  - Repeat for all neighbourhoods

Results





Critique

- Model
  - Shouldn’t we penalize segments which are too short ?
- Algorithm
  - Encodes time dimension without involving cognitive processing
  - Unexplained data clustering as a visual artifact
    - More severe if starting with a random field