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Glyph-based Visualization:
Design Considerations and Challenges

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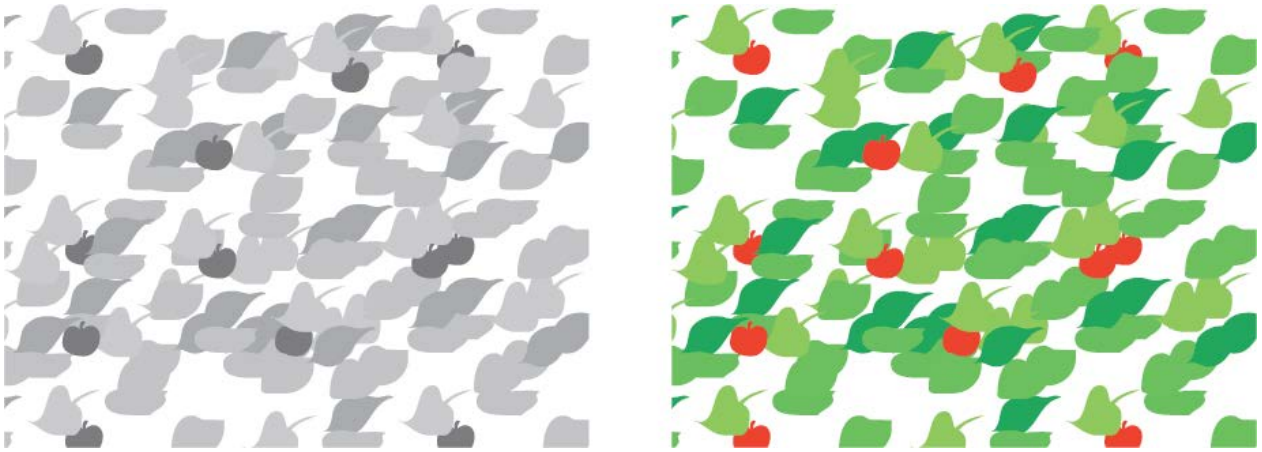
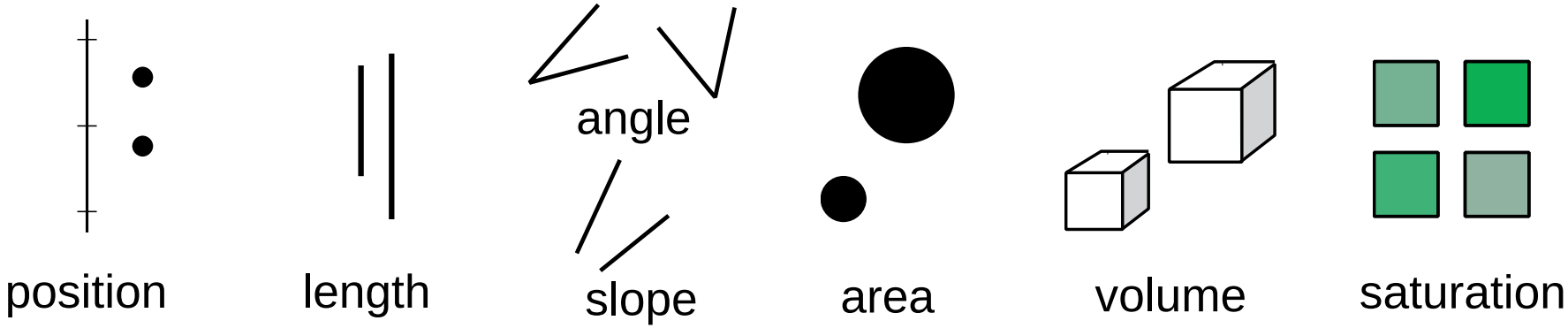
How to design a successful Glyph?

- Some visual channels are more dominant



[Ware 04]

- Some can be compared more accurately



[Cleveland&McGill 84]

Challenges in Glyph Design

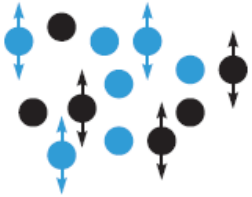
integral pairs

red-green yellow-blue

width height

size orientation

color shape



color motion

color location

separable pairs

[Ware 04]

Design Considerations

[Ward 02/08, Ware 04, Ropinski et al. 08/11, Lie et al. 09, Maguire et al. 12]

Authors / Technique	design guideline												visual channel					
	[DG1] visualization space	[DG2] complexity vs. density	[DG3] hybrid visualizations	[DG4] perceptually uniform properties	[DG5] redundant mapping	[DG6] importance-based mapping	[DG7] view point independence	[DG8] simplicity and symmetry	[DG9] orthogonality and normalization	[DG10] intuitive / semantical mapping	[DG11] balanced glyph placement	[DG12] facilitate 3D depth perception	[DG13] interactive occlusion control	color	shape	size / height / length	orientation	texture	opacity
Brewer [Bre99]: Color use guidelines																			
Cleveland & McGill [CM84]: Graphical perception	2D/3D																		
Crawfis & Max [CM93]: Vector field visualization	3D	2																	
de Leeuw & van Wijk [dLvW93]: Local flow probe	3D	-3																	
Healey & Enns [HE99]: Combining textures and colors	2.5D	1																	
Healey et al. [HBE96]: Preattentive processing	2D																		
Kindlmann & Westin [KW06]: Glyph packing	3D	2																	
Kindlmann [Kin04]: Superquadric tensor glyphs	2.5D	1.5																	
Kirby et al. [KML99]: Concepts from painting	2D	1																	
Laidlaw et al. [LAK*98]: Stochastic glyph placement	2D	2																	
Li et al. [LMvW10]: Symbol size discrimination	2D																		
Lie et al. [LKH09]: Design aspects of glyph-based 3D visualization	3D	2																	
McGill et al. [MTL78]: Variations of box plots	2D	-3																	
Meyer-Spradow et al. [MSSD*08]: Surface glyphs	2.5D	0																	
Peng et al. [PWR04]: Clutter reduction using dimension reordering	2D	1																	
Pickett & Grinstein [PG88]: Stick figures	2D	3																	
Piringer et al. [PKH04]: Depth perception in 3D scatterplots	3D																		

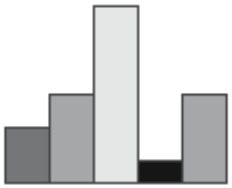
Visualization Space

2D

Star glyphs

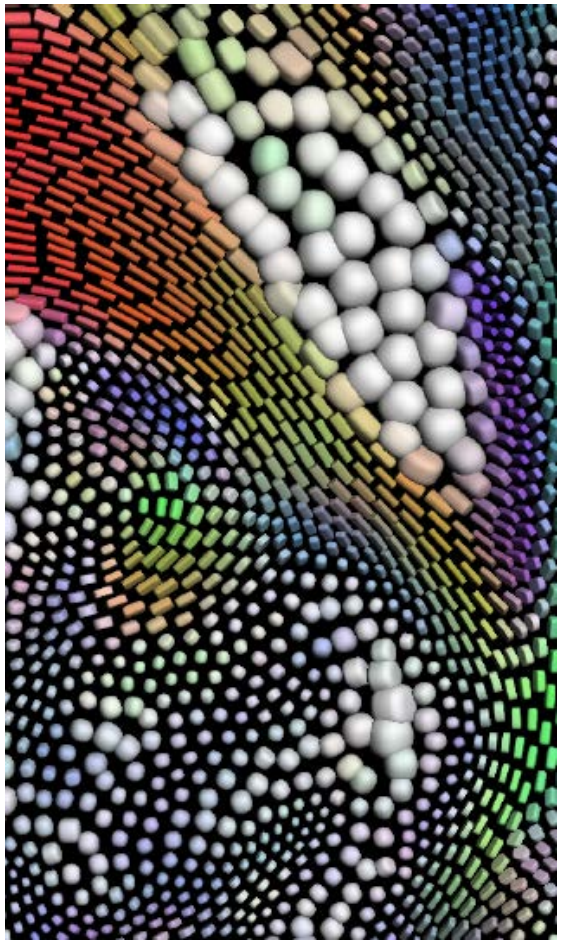
Stick figures

Chernoff faces



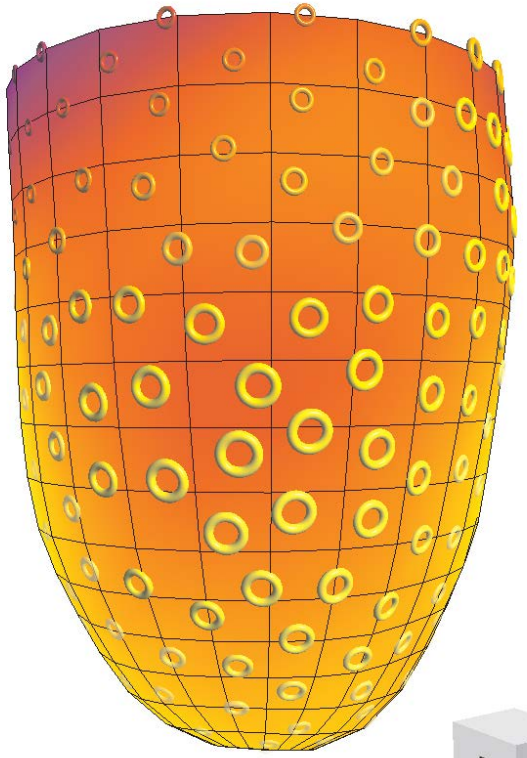
Profile glyphs

3D



[Kindlmann&Westin 06]

Surface glyphs

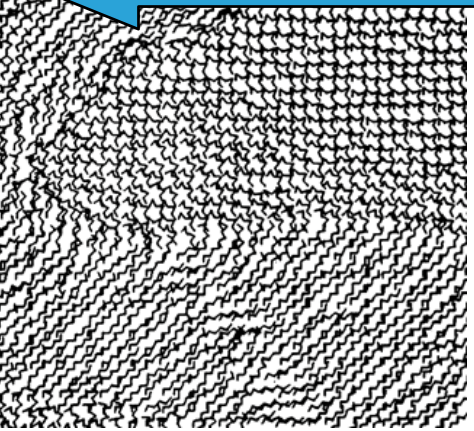


[Meyer-Spradow et al. 08]

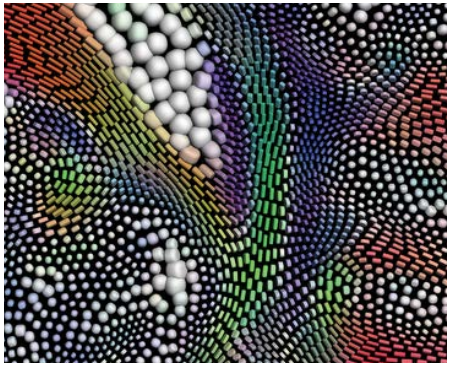
Complexity vs. Density

dense & simple

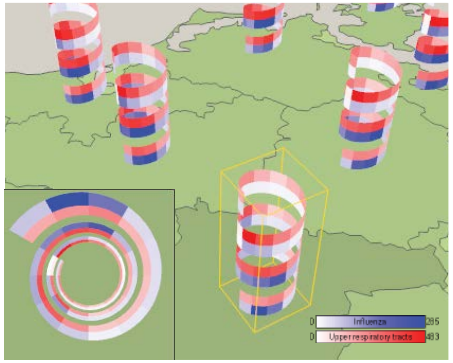
sparse & complex



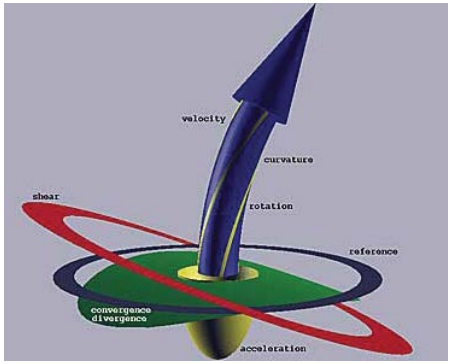
Stick figures
[Pickett&Grinstein 88]



Glyph packing
[Kindlmann&Westin 06]



Helix glyphs
[Tominski et al. 05]

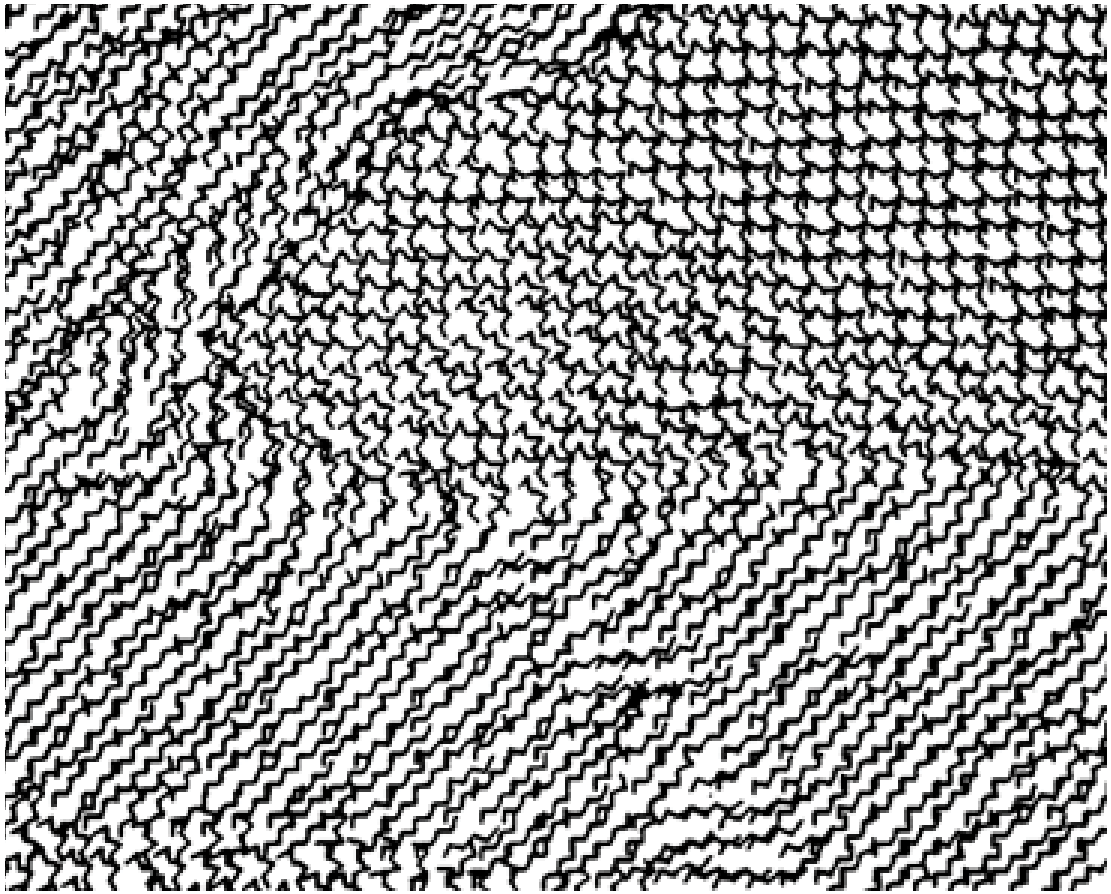


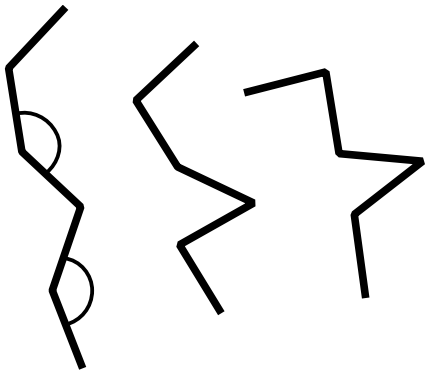
Local flow probe
[de Leeuw&van Wijk 93]

Complexity vs. Density

dense & simple

sparse & complex





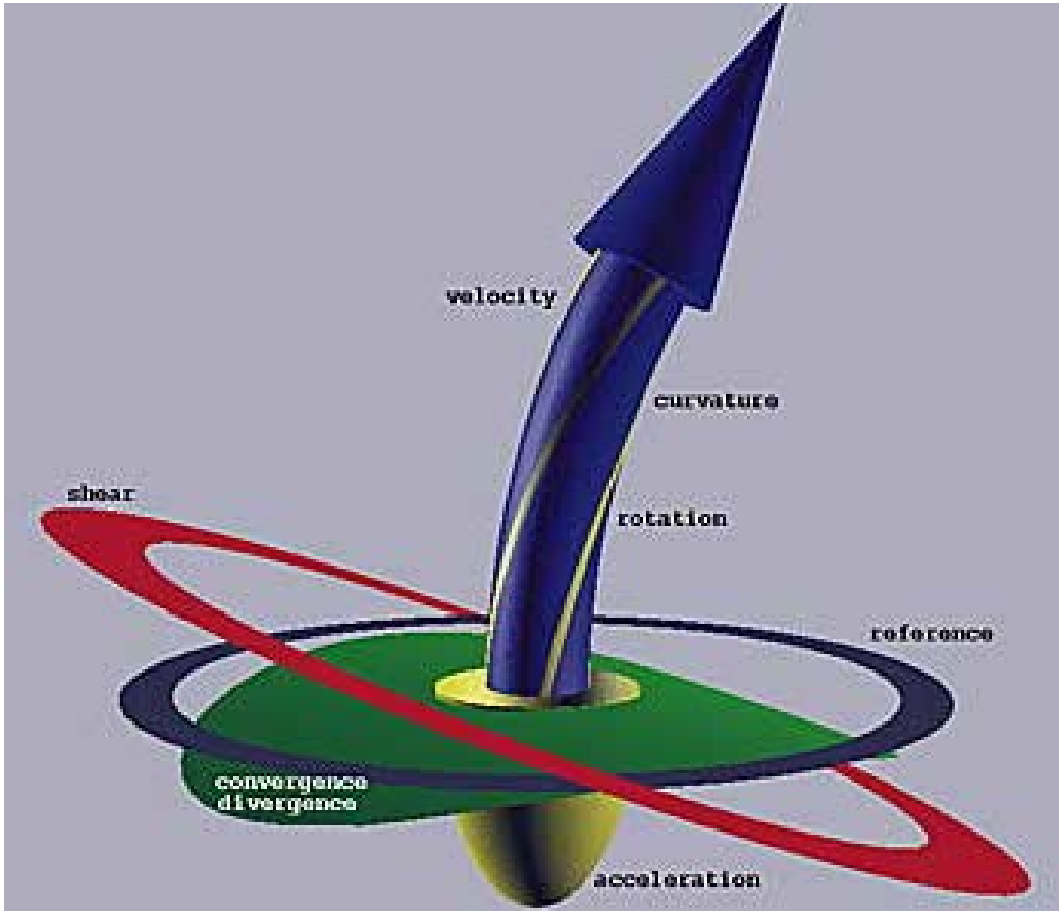
- attributes mapped to angles
- texture patterns

Stick figures
[Pickett&Grinstein 88]

Complexity vs. Density

dense & simple

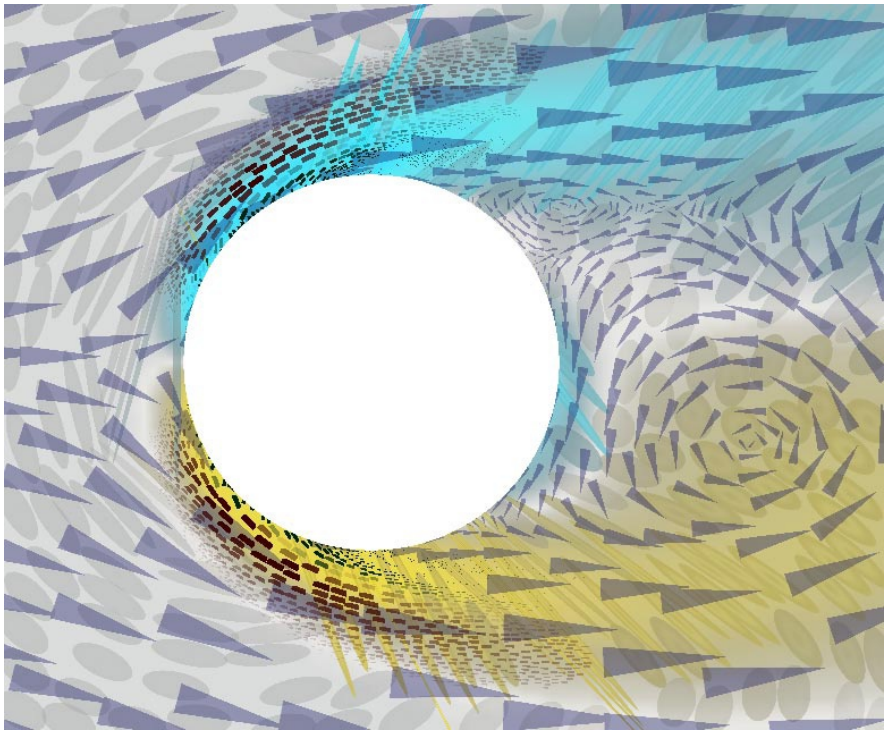
sparse & complex



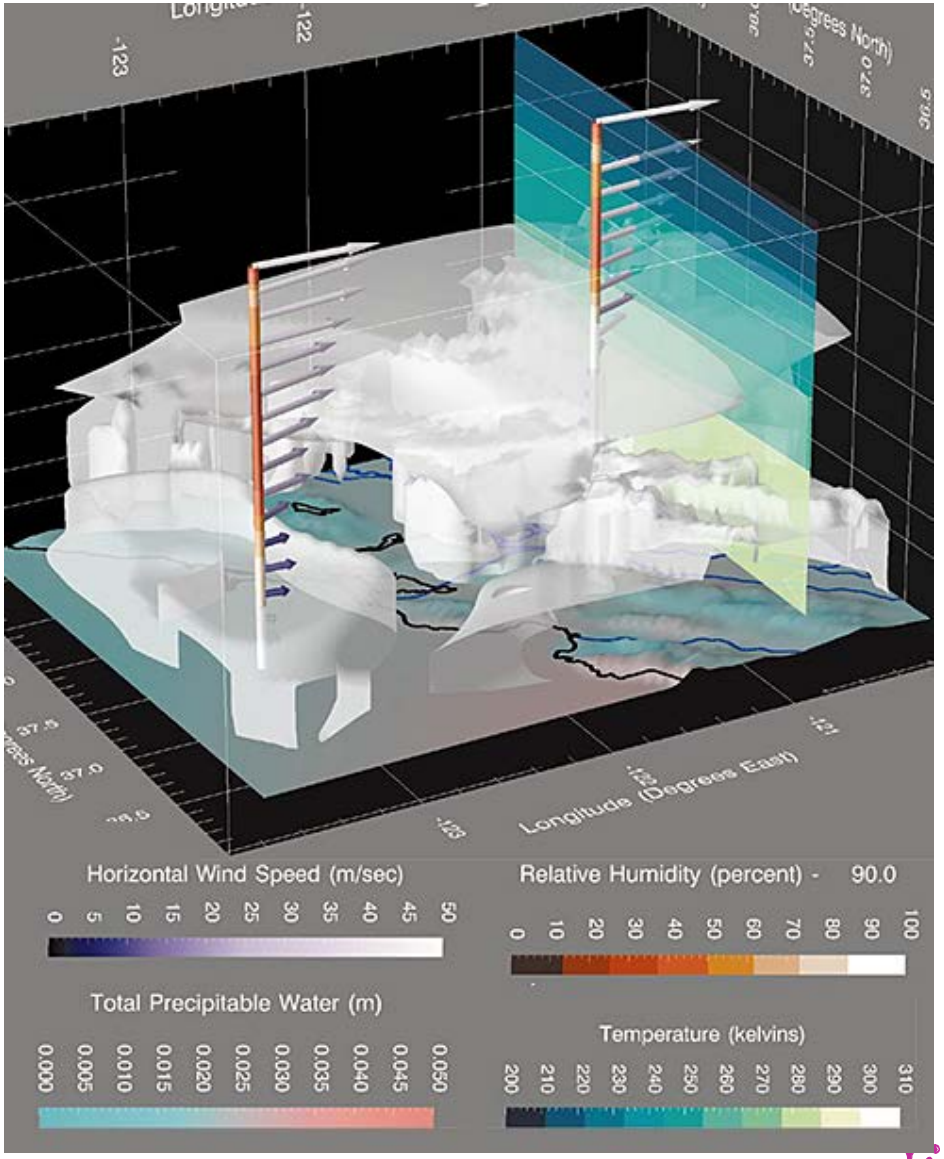
- represent multiple flow properties
- sparsely placed

Local flow probe
[de Leeuw&van Wijk 93]

Hybrid Visualizations

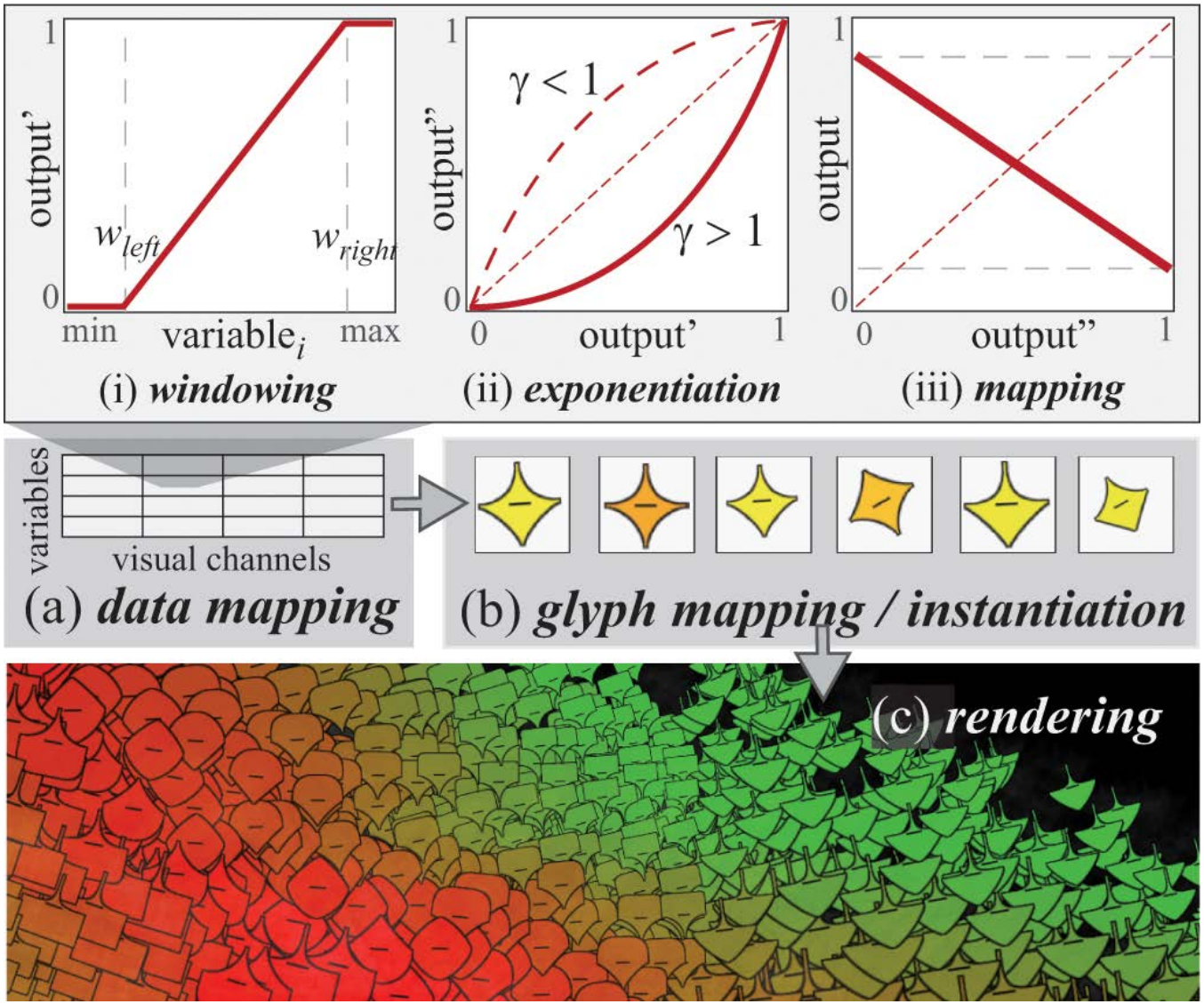


Layering [Kirby et al. 99]



Arrow glyphs [Treinish 99]

Data Enhancement

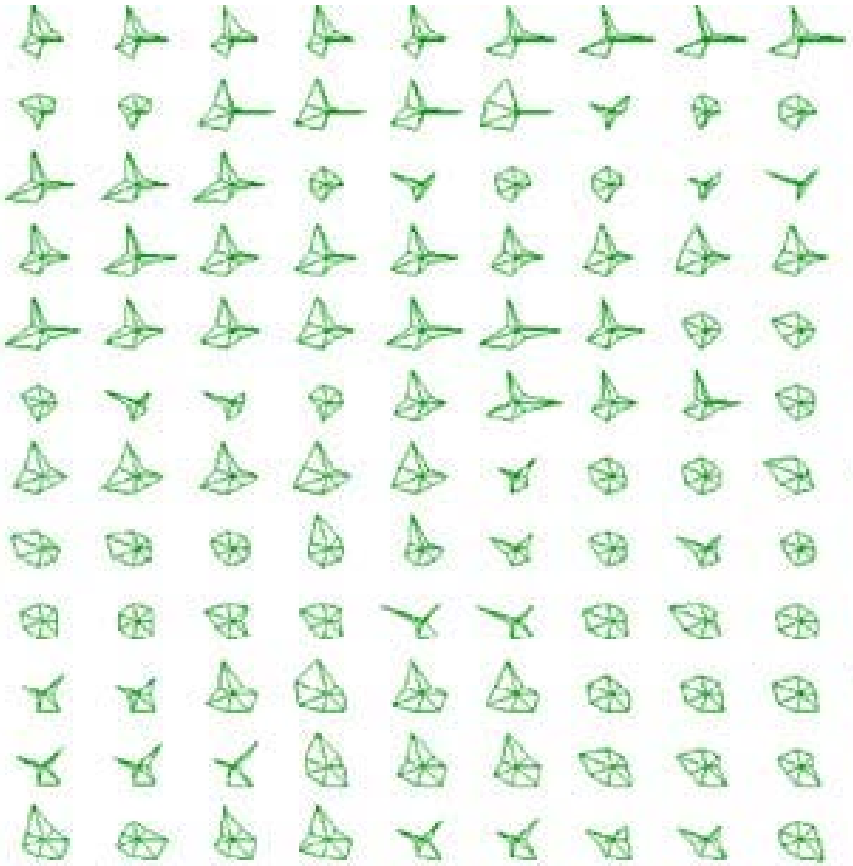


- Data range → [0, 1]
- Exponentiation
- Inverse mapping

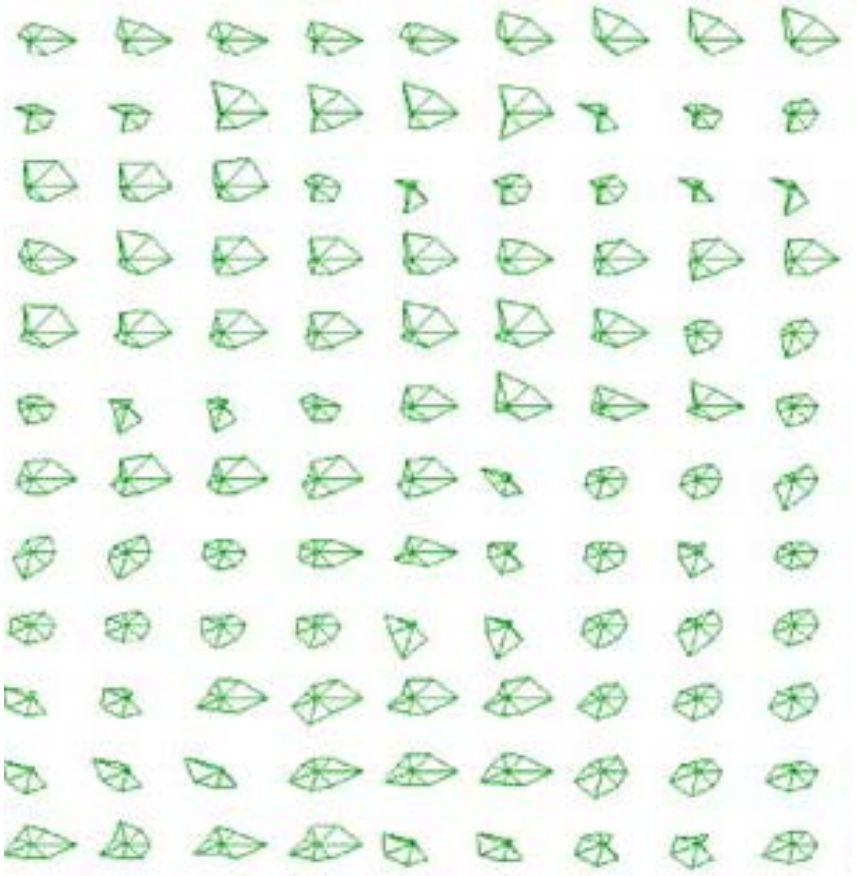
[Lie et al. 09]

Simplicity & Symmetry

Gestalt principles: Simple & symmetric shapes facilitate perception of patterns [Ward 08, Peng et al. 04]

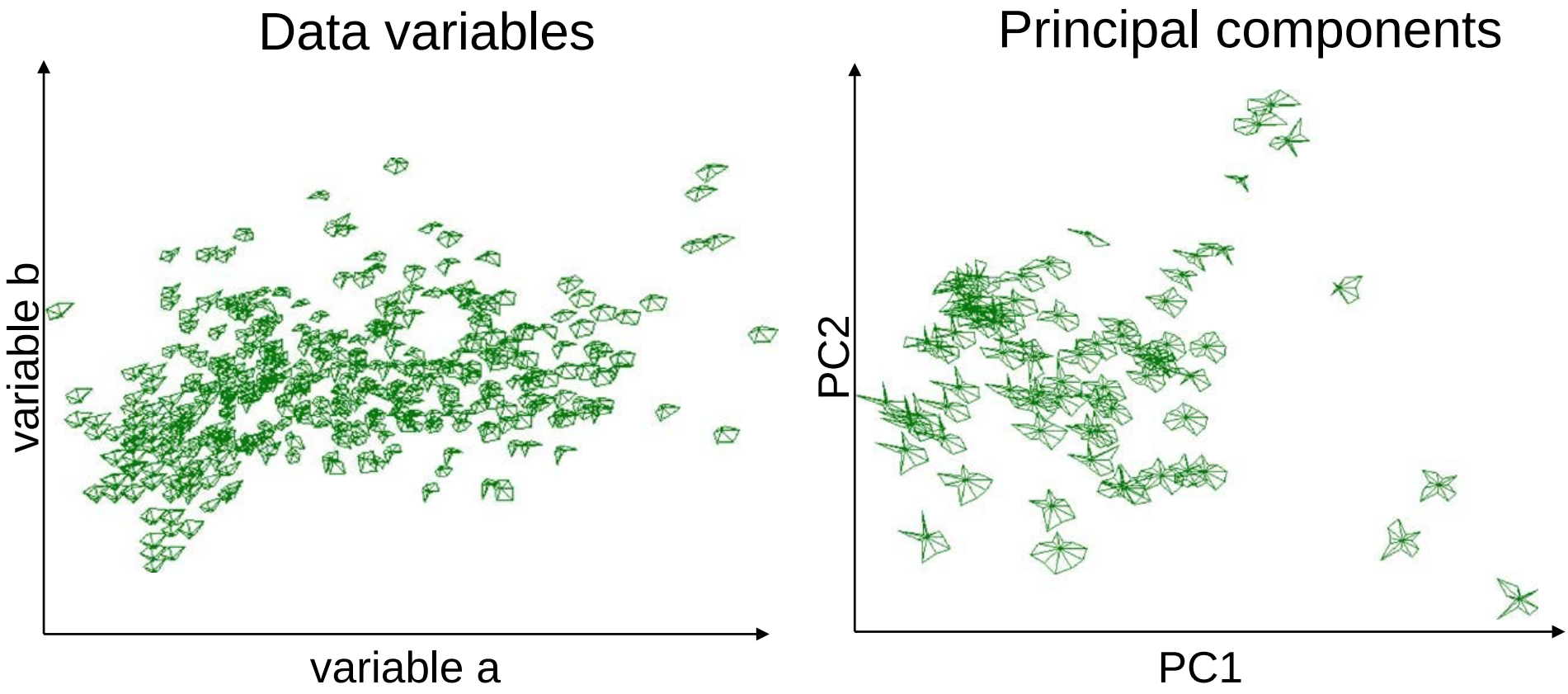


Random ordering



Complexity and symmetry-driven ordering

Glyph Placement [Ward 02]



Perceptually Uniform Channels

- Colors

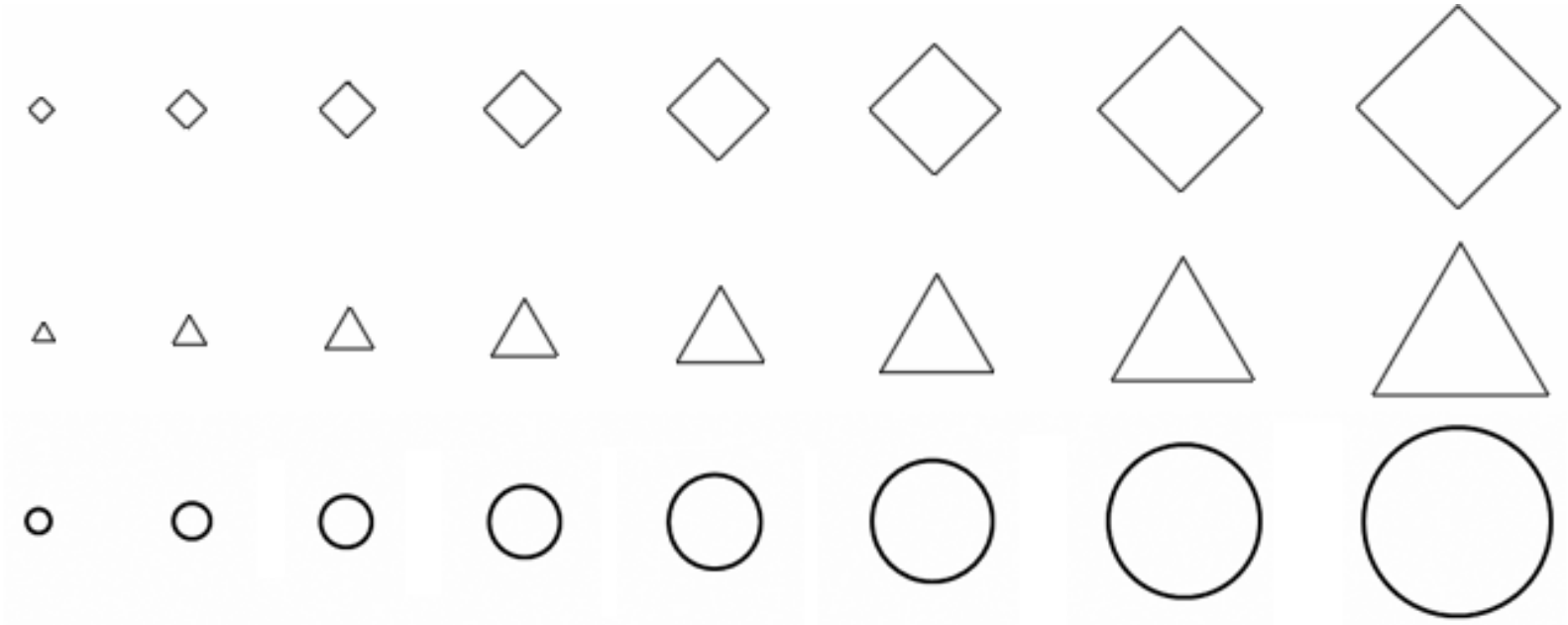
Rainbow colormap

Black-body radiation

Green-red isoluminant

[Borland&Taylor II 07]

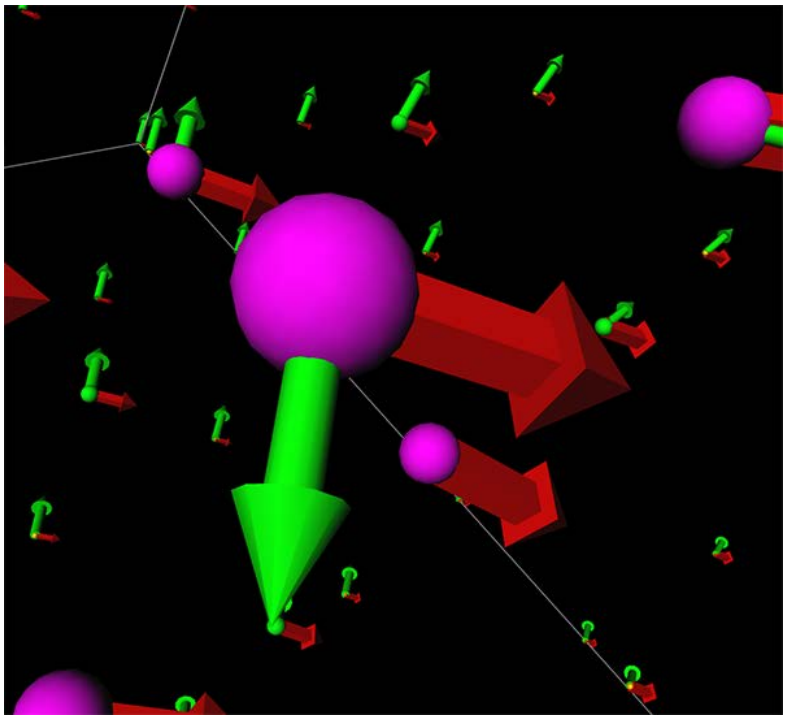
- Symbol size



power law transformation [Li et al. 10]

Glyph Shapes [Ropinski et al. 11]

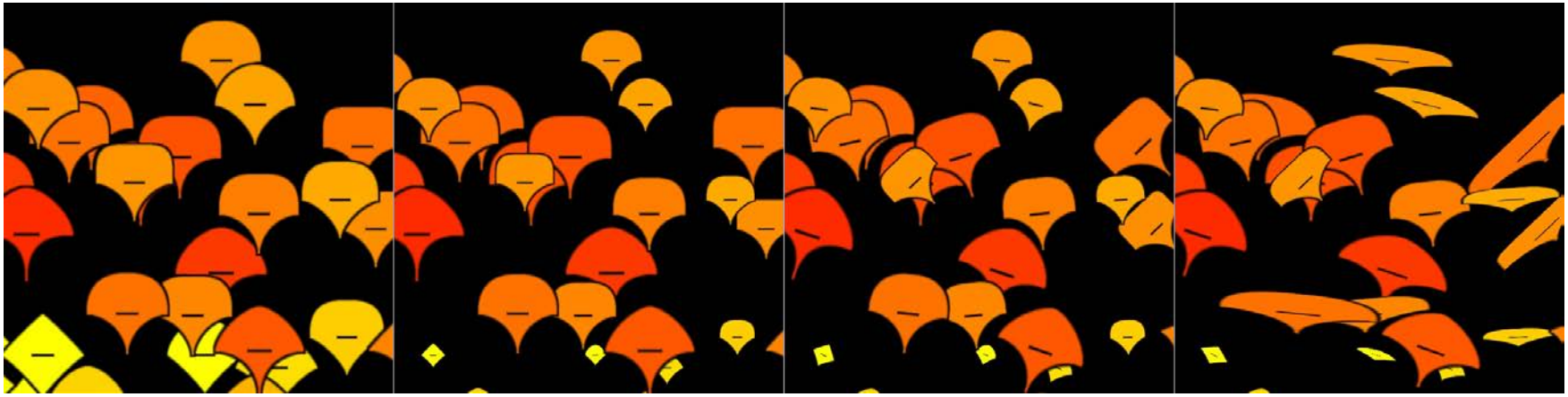
- Basic glyph shapes
  - box, spere, torus, ellipsoid, etc.
  - pre-attentive processing
- Composite shapes
  - combine basic shapes



Customized glyphs [Kraus&Ertl 01]

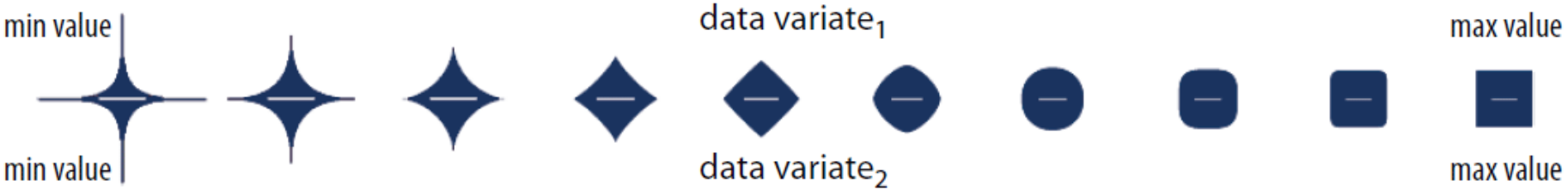
Orthogonality & Normalization

- Perceive each visual channel independently



upper/lower shape +size +rotation +aspect ratio

- Account for distortions (e.g., shape→size)



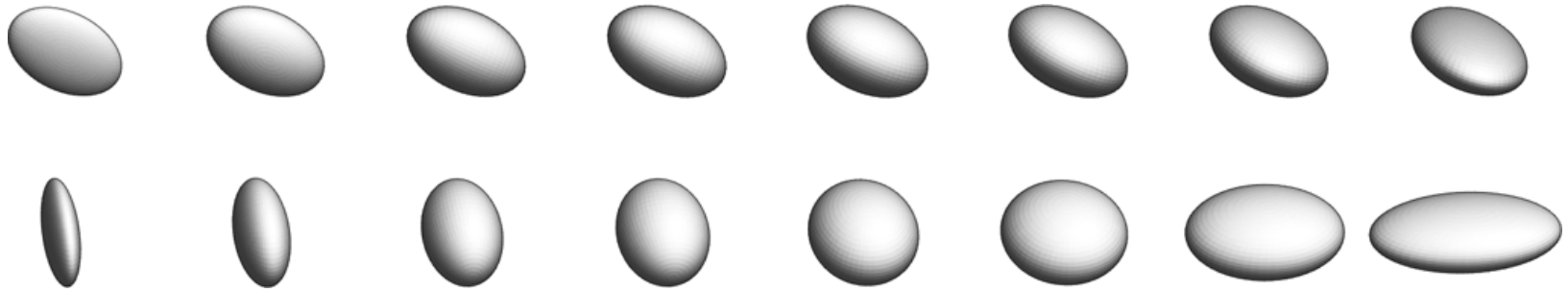
[Lie et al. 09]

View-point Independence

- Ellipsoid glyphs

8 tensors

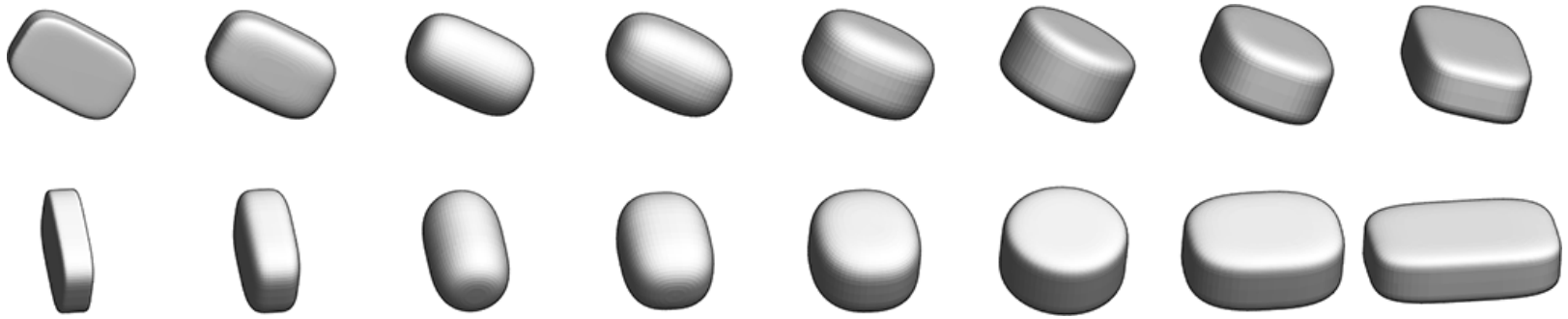
different viewpoint



- Superquadric glyphs

8 tensors

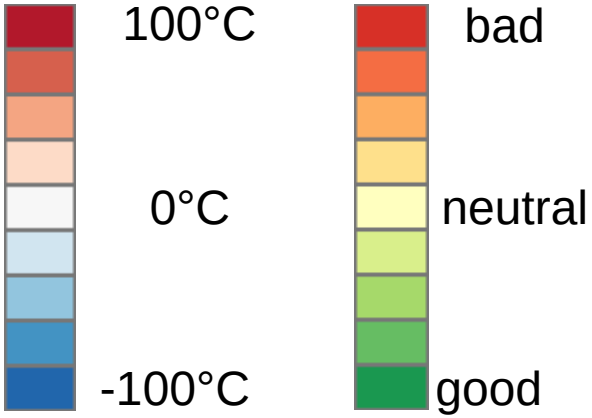
different viewpoint



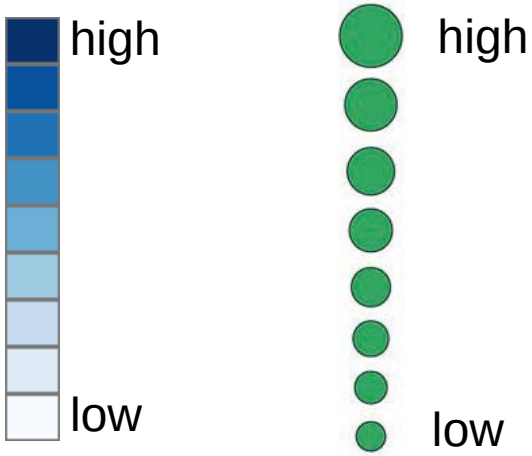
[Kindlmann 04]

Intuitive Mapping based on Semantics

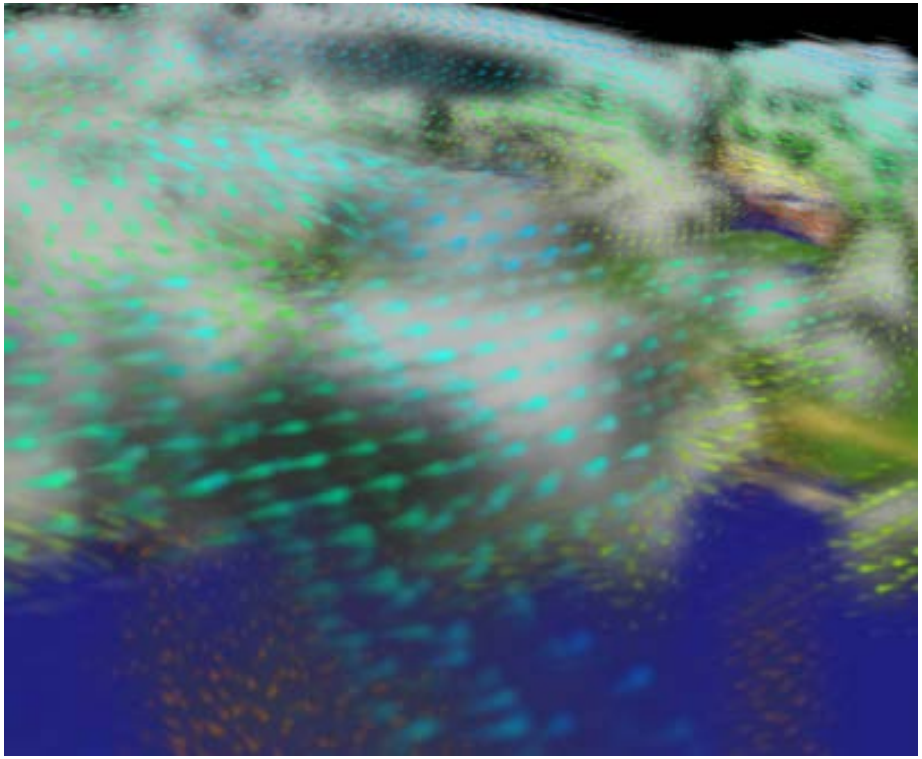
- Diverging data



- Sequential data



- Direction

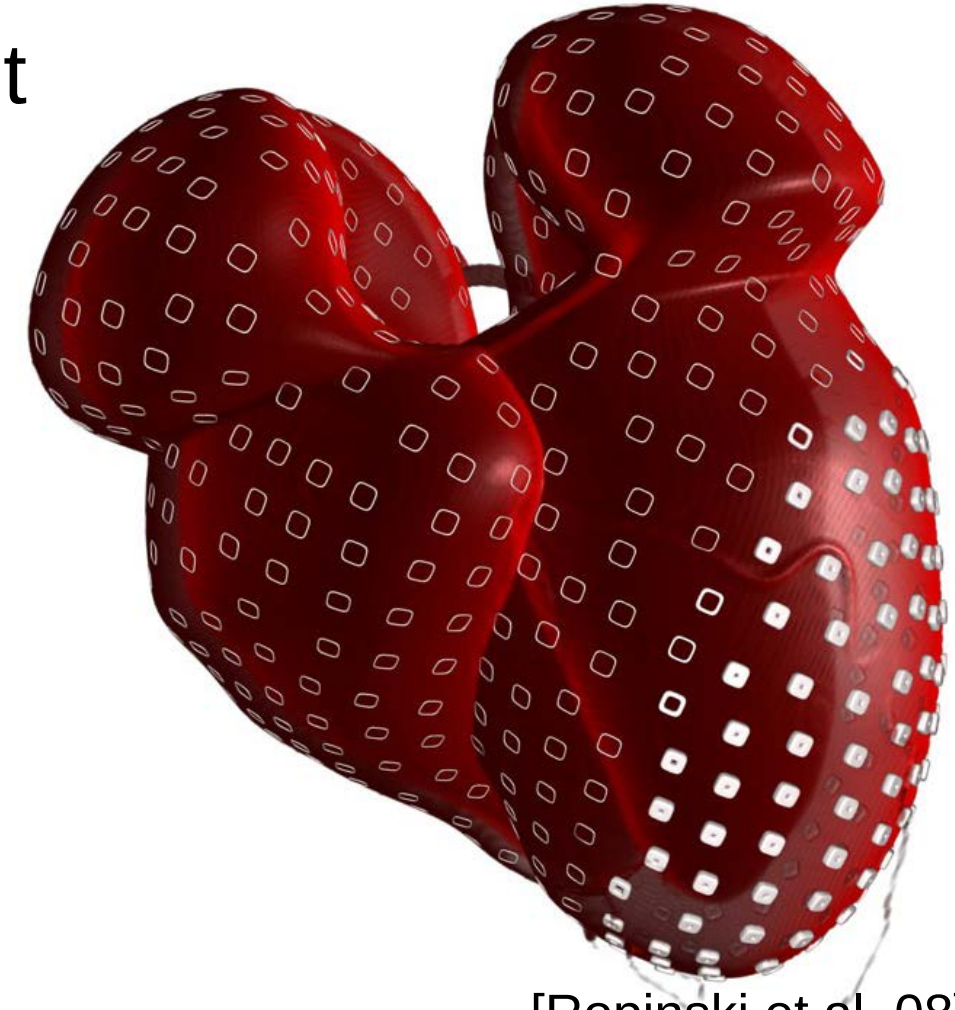


Arrow glyphs [Crawfis&Max 93]

[Brewer 99, Stolte et al. 02]

Importance-based Mapping

- Emphasize important variables
- Guide the user‘s focus of attention (e.g., color, size)

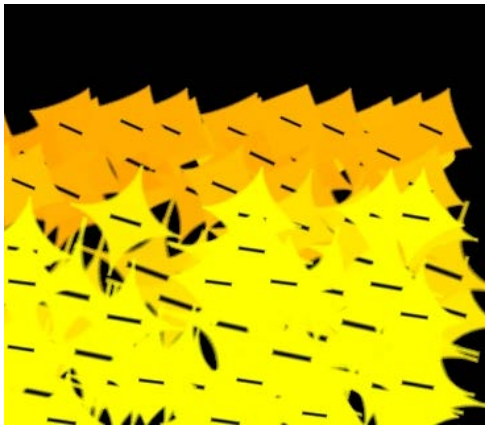


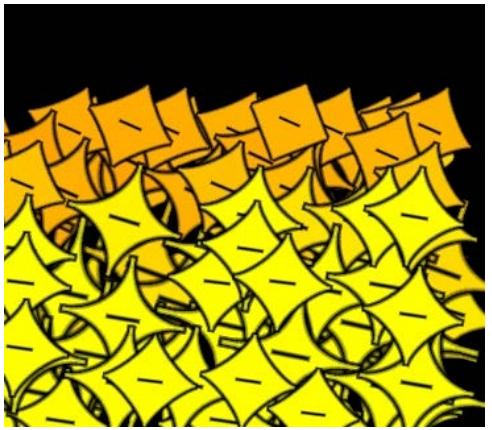
[Ropinski et al. 08]

PET activity → thickness

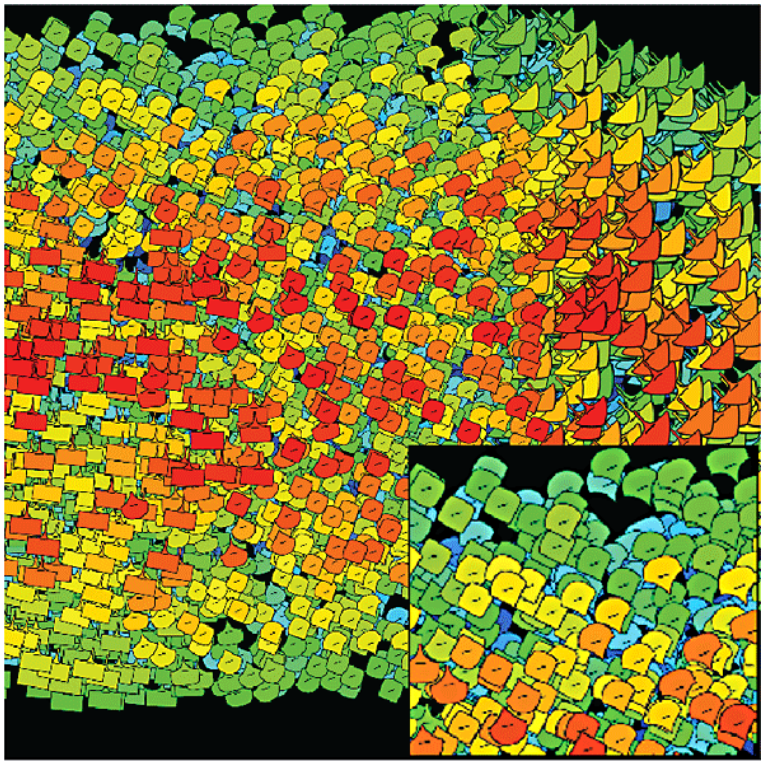
Enhance Depth Perception

- Halos/contours
  [Lie et al. 09]





- Chroma depth
  [Toutin 97]



Summary

- Just combining visual channels is not enough
- Design considerations (e.g., orthogonality, perceptually uniform channels, semantics)
- Glyph design restricted by perceptual limits