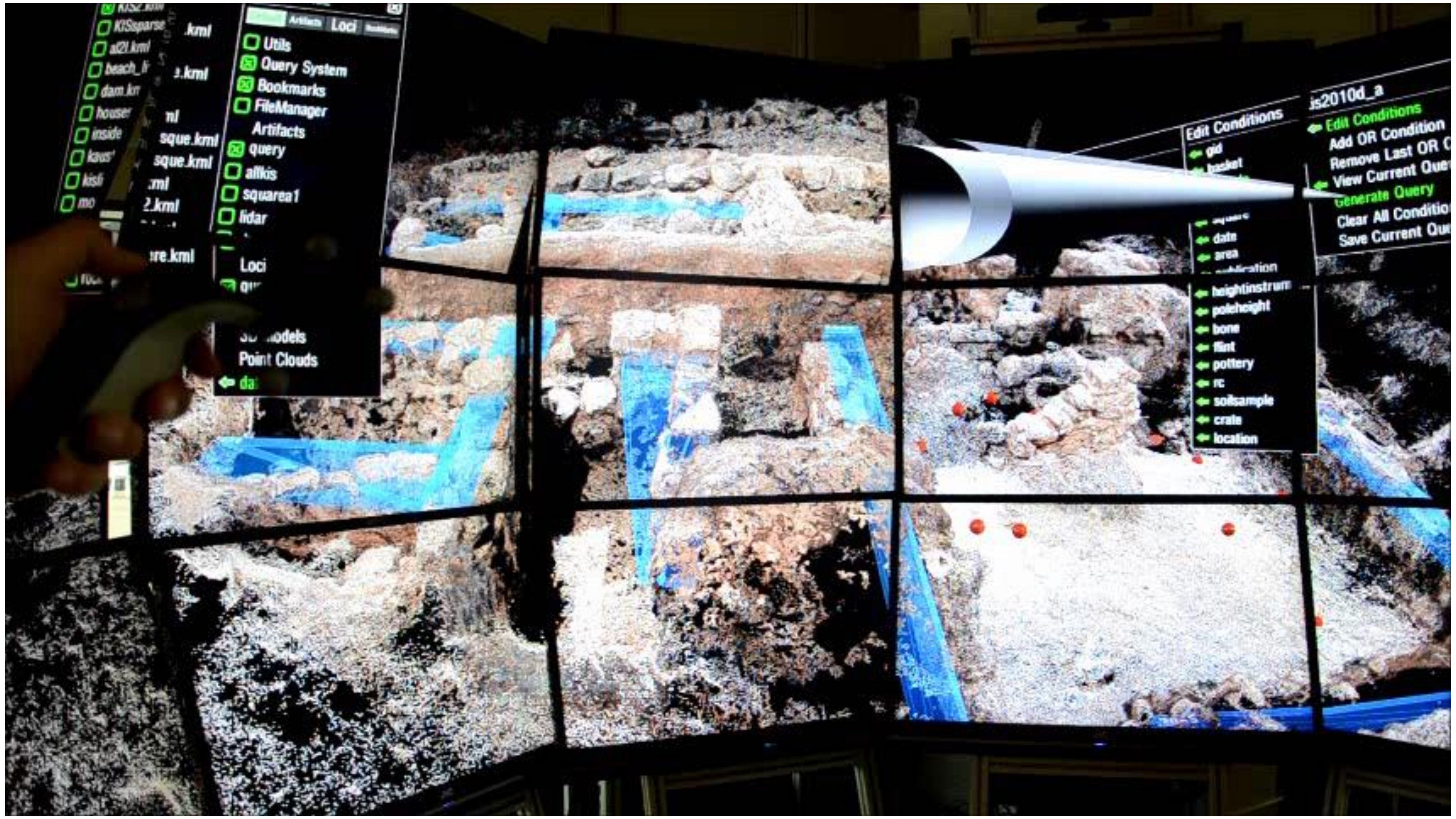
Dr. Neil Smith

4.3a Scientific Visualization for mesh based data with Unreal Engine 5

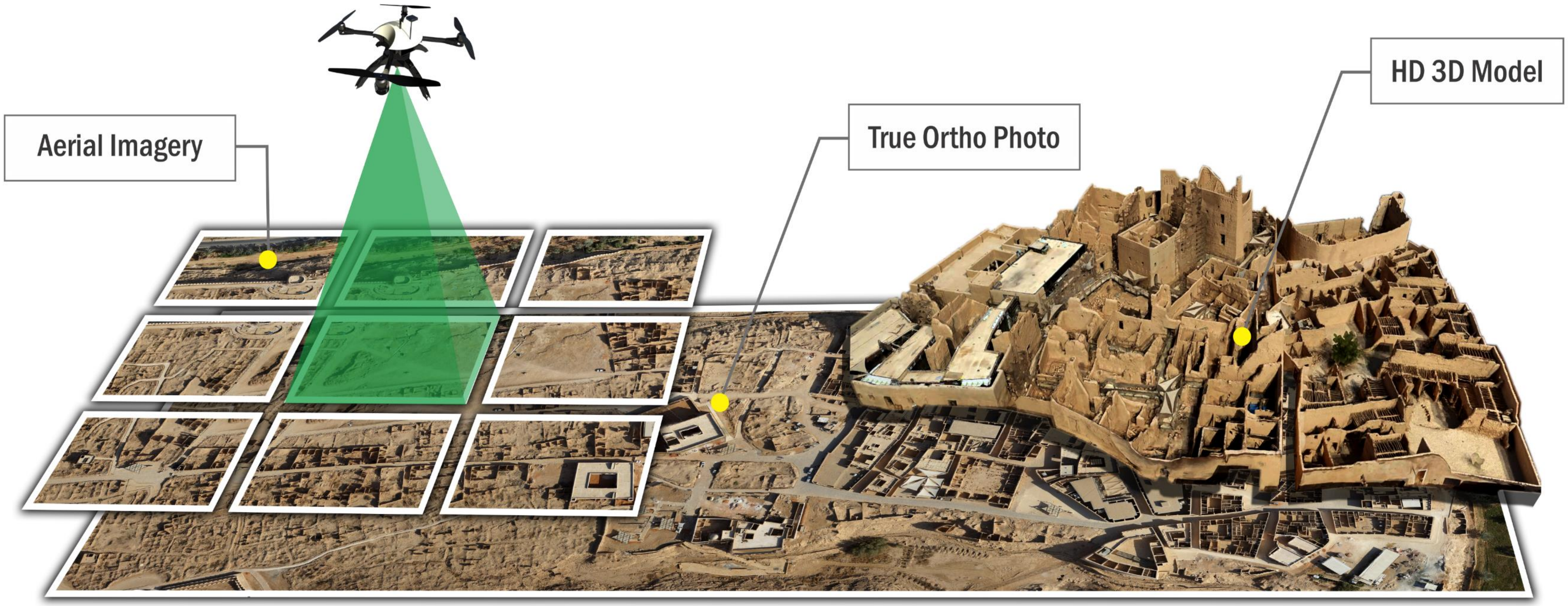

ArtifactVis (2008-2011)
Jurgen Schulze
Kyle Knabb
Connor Defanti
Thomas Levy
ArtifactVis2 (2011-)
Neil Smith
Jurgen Schulze
Connor DeFanti
Marcin Rogowski
Thomas Levy

ArtifactVis 2 (Presented in DHIC 2013

- Fully Immersive 4D GIS
- Fully Integrates all Digital Content recovered from Excavations
- Real-time Query System for conducting Multi-Variate Studies
- Scalable to Various Computer Architectures
- Part of CalVR Middle-ware allowing full exploitation of OpenGL (GLSL), CUDA, PhysX and other libraries



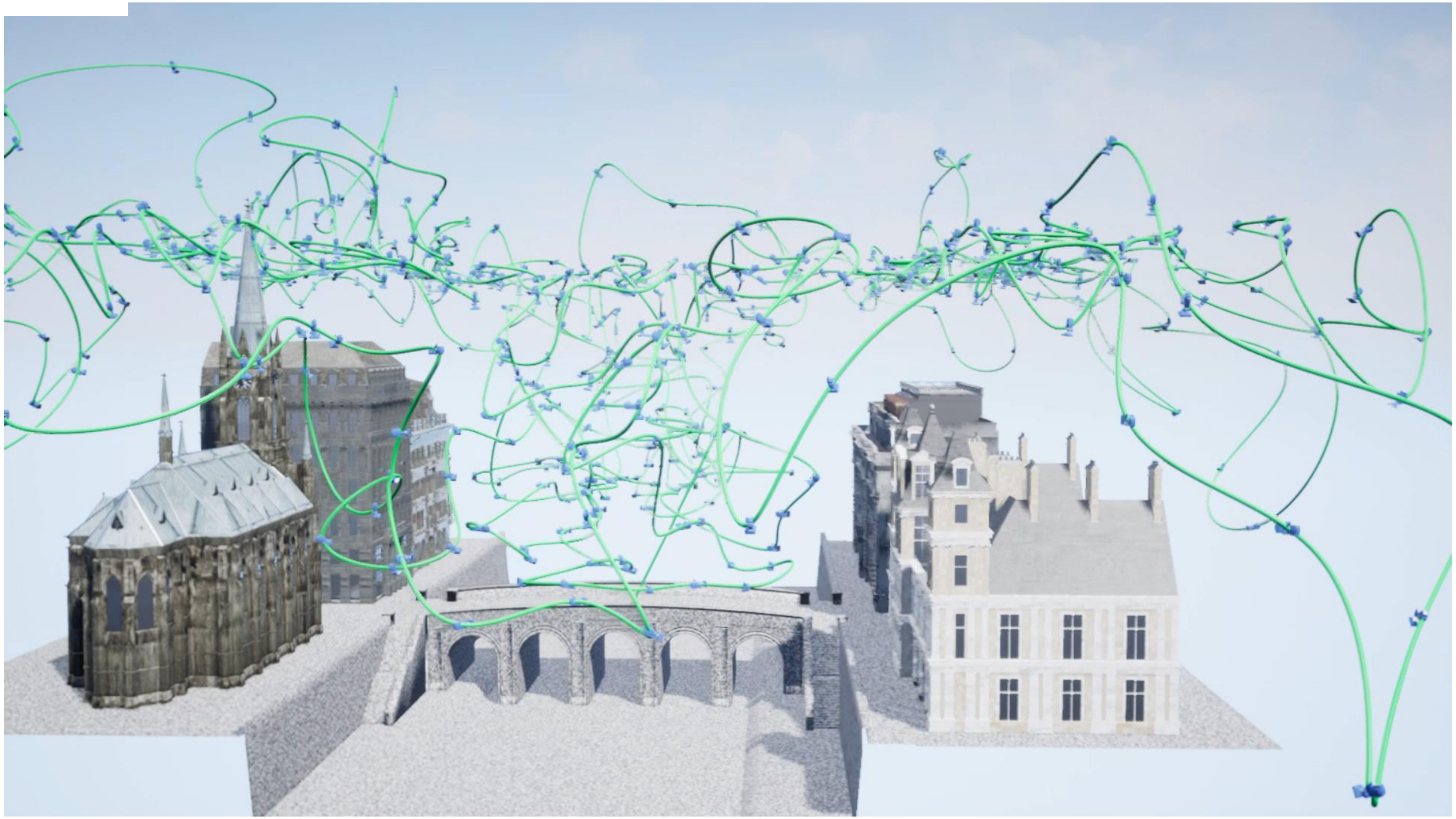
END TO END SOLUTION



From Planning --→to Visualizing


FALCONVIZ

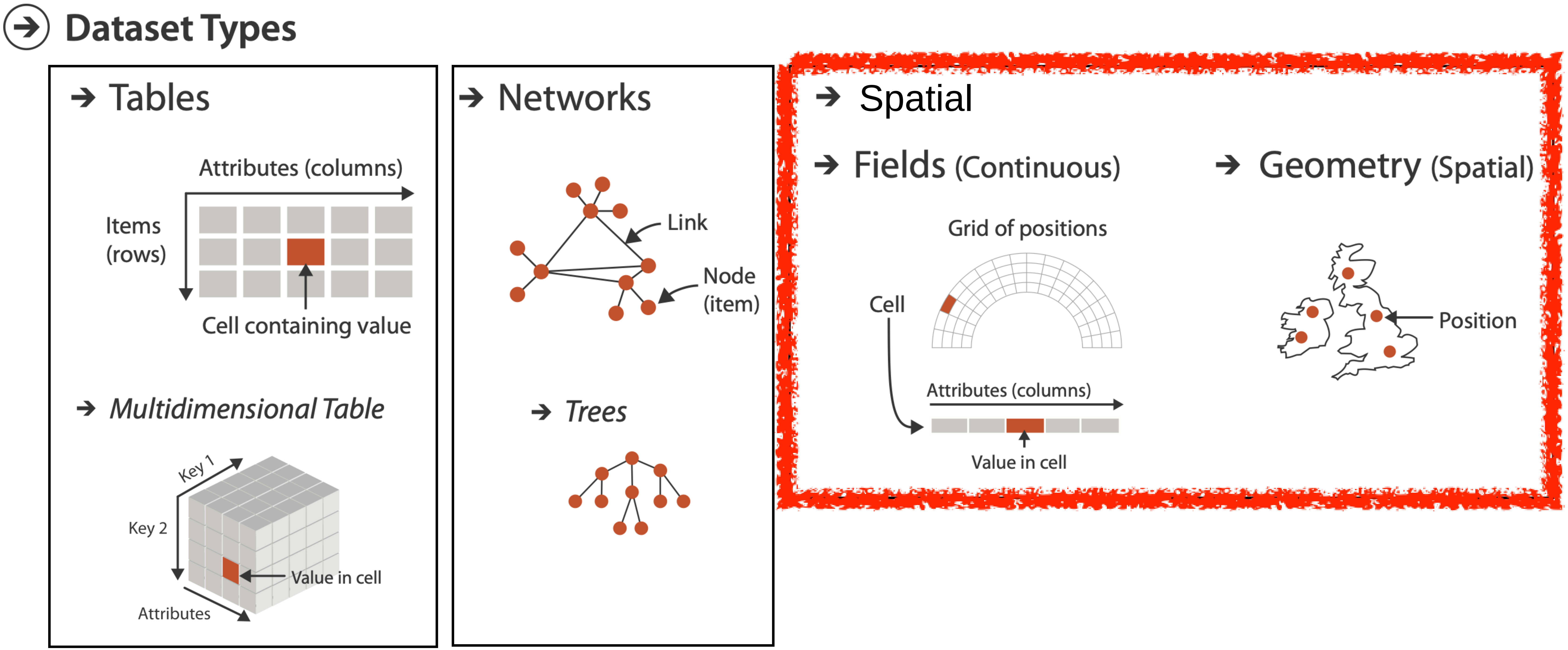
AERIAL PATH PLANNING

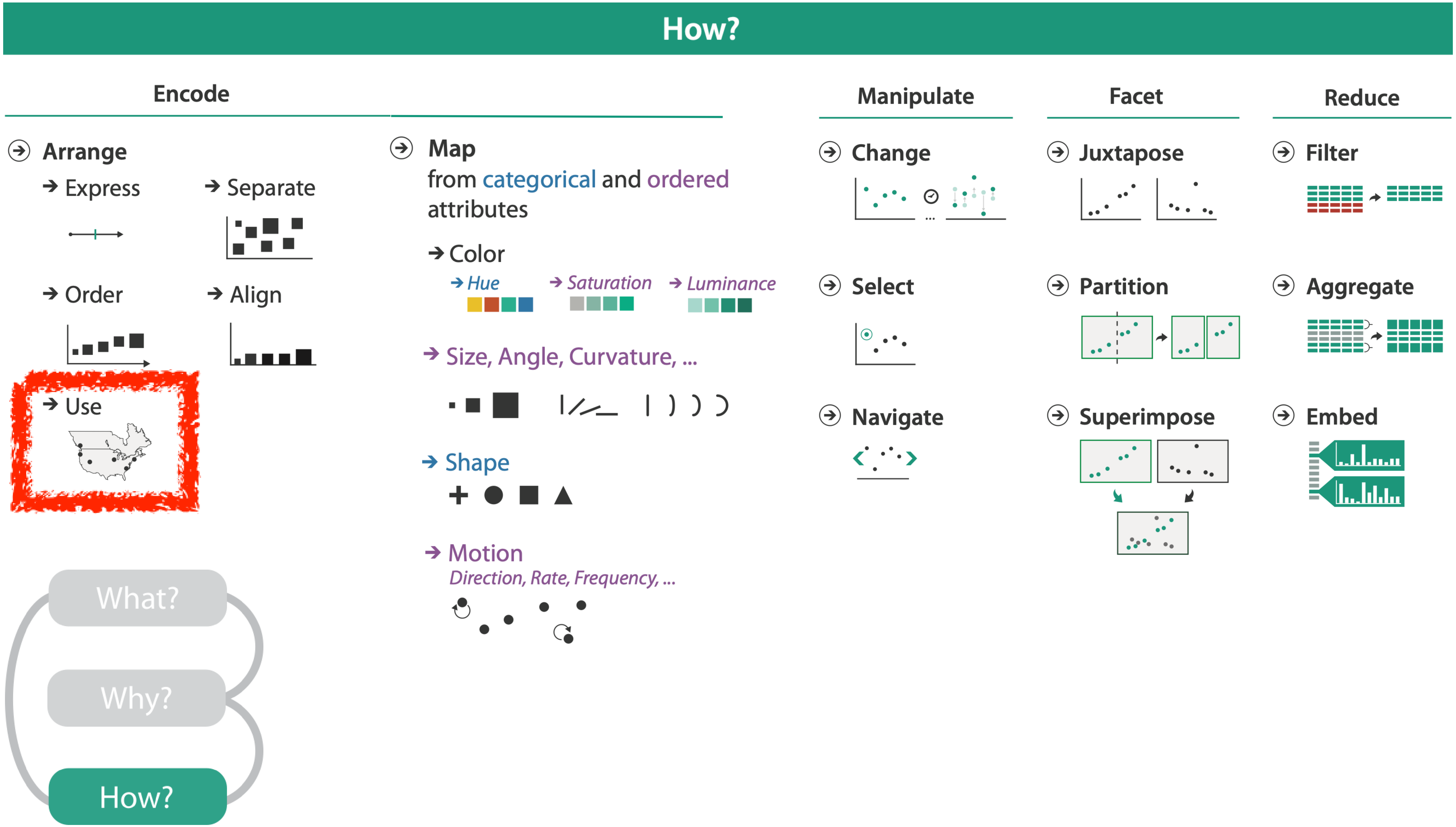


TEACHING AUTONOMOUS DRIVING AND DRONES HOW TO RACE

MetaHumans Preview [NetMode: Standalone 0] (64-bit/D3D Shader Model 5)

Focus on Spatial





How?
Encode
Arrange
Express
Separate
Order
Align
Use
Map
from categorical and ordered attributes
Color
Hue
Saturation
Luminance
Size, Angle, Curvature, ...
Shape
Motion
Direction, Rate, Frequency, ...
Manipulate
Change
Select
Navigate
Facet
Juxtapose
Partition
Superimpose
Reduce
Filter
Aggregate
Embed
What?
Why?
How?

Spatial data

- use given spatial position
- when?
  - dataset contains spatial attributes and they have **primary importance**
  - central tasks revolve around **understanding spatial** relationships

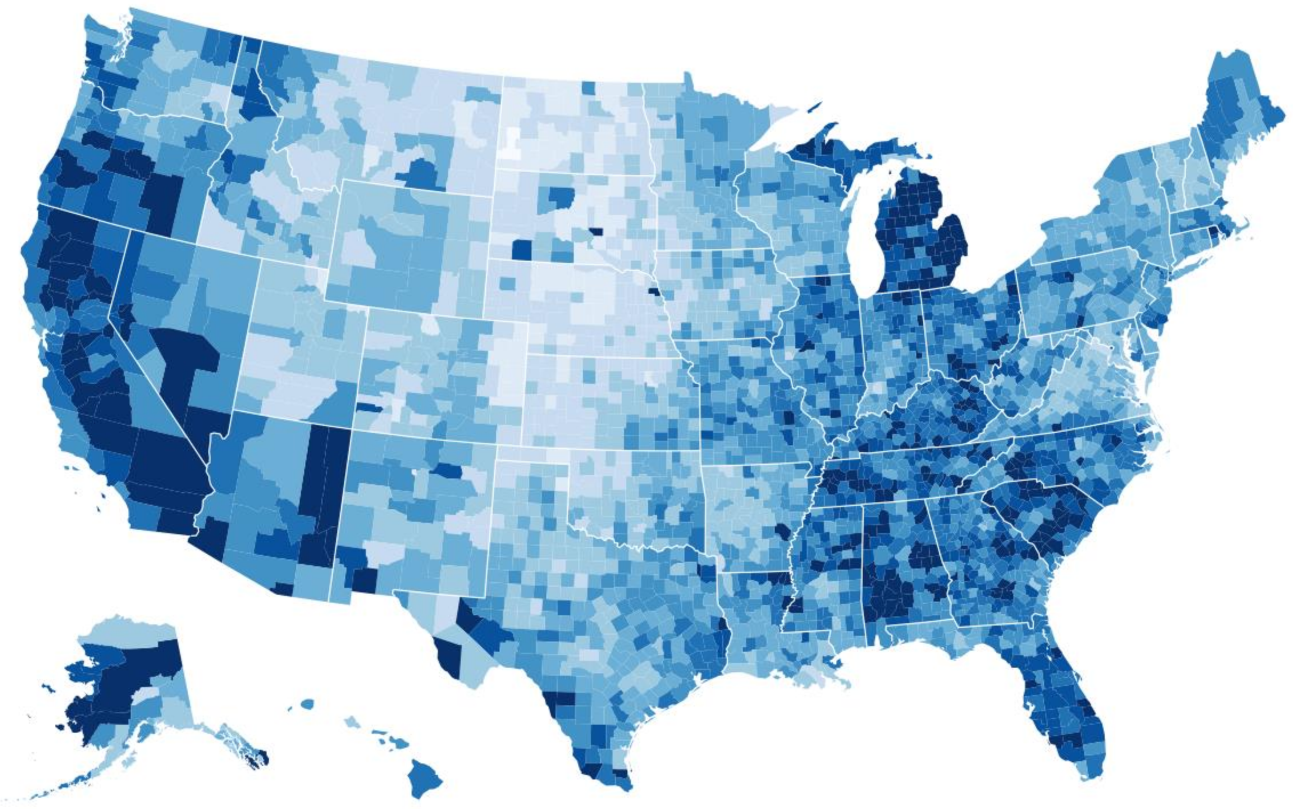
- examples
  - geographical/cartographic data
  - sensor/simulation data
  - Digital Twins

Thematic maps (GIS)

- show spatial variability of attribute ("theme")
  - combine geographic / reference map with (simple, flat) tabular data
  - join together
    - region: interlocking area marks (provinces, countries with outline shapes)
      - also could have point marks (cities, locations with 2D lat/lon coords)
    - region: categorical key attribute in table
      - use to look up value attributes
- major idioms
  - choropleth
  - symbol maps
  - cartograms
  - dot density maps

Idiom: **choropleth map**

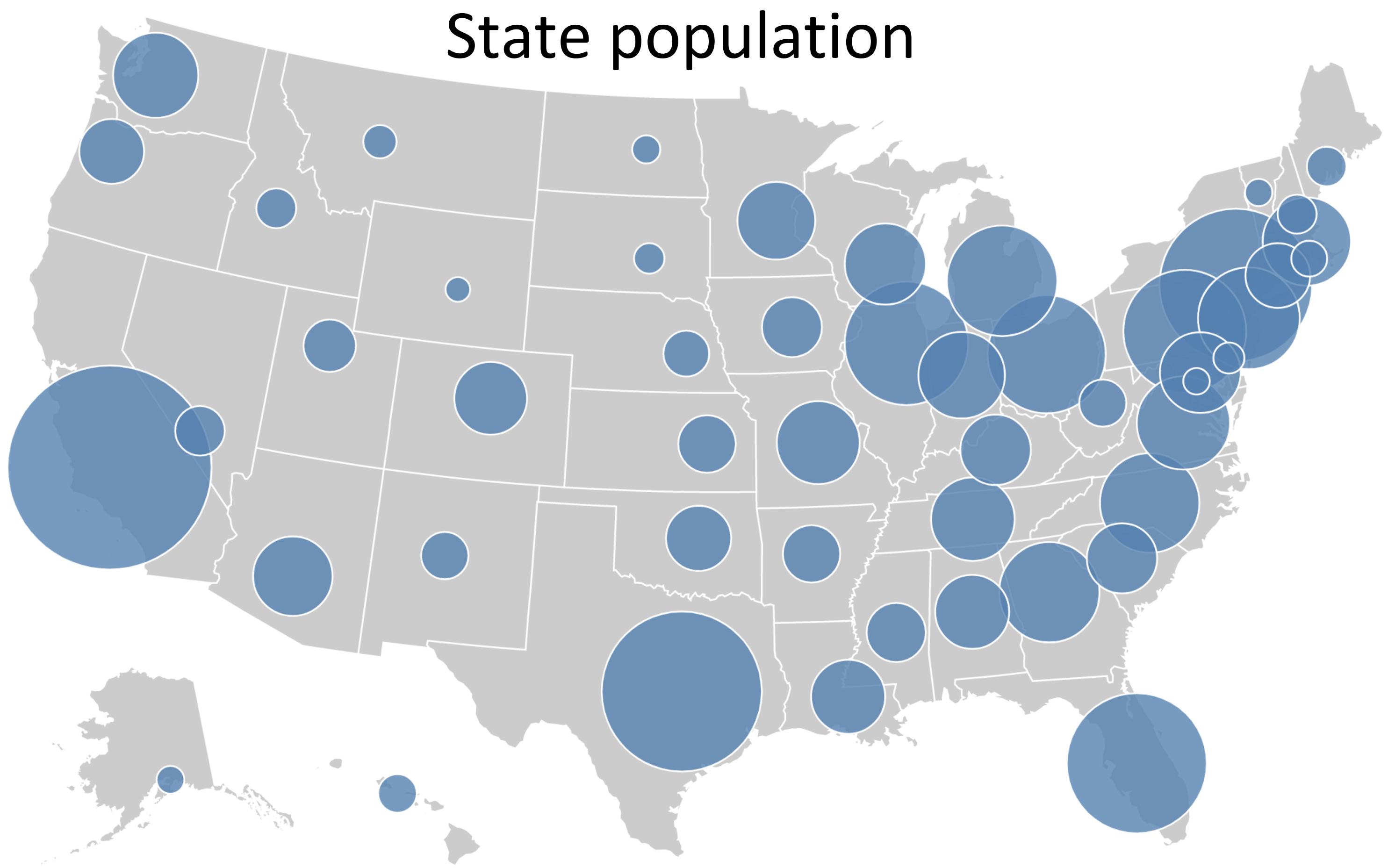
- use given spatial data
  - when central task is understanding spatial relationships
- data
  - geographic geometry
  - table with 1 quant attribute per region
- encoding
  - position:
    use given geometry for area mark boundaries
  - color:
    sequential segmented colormap

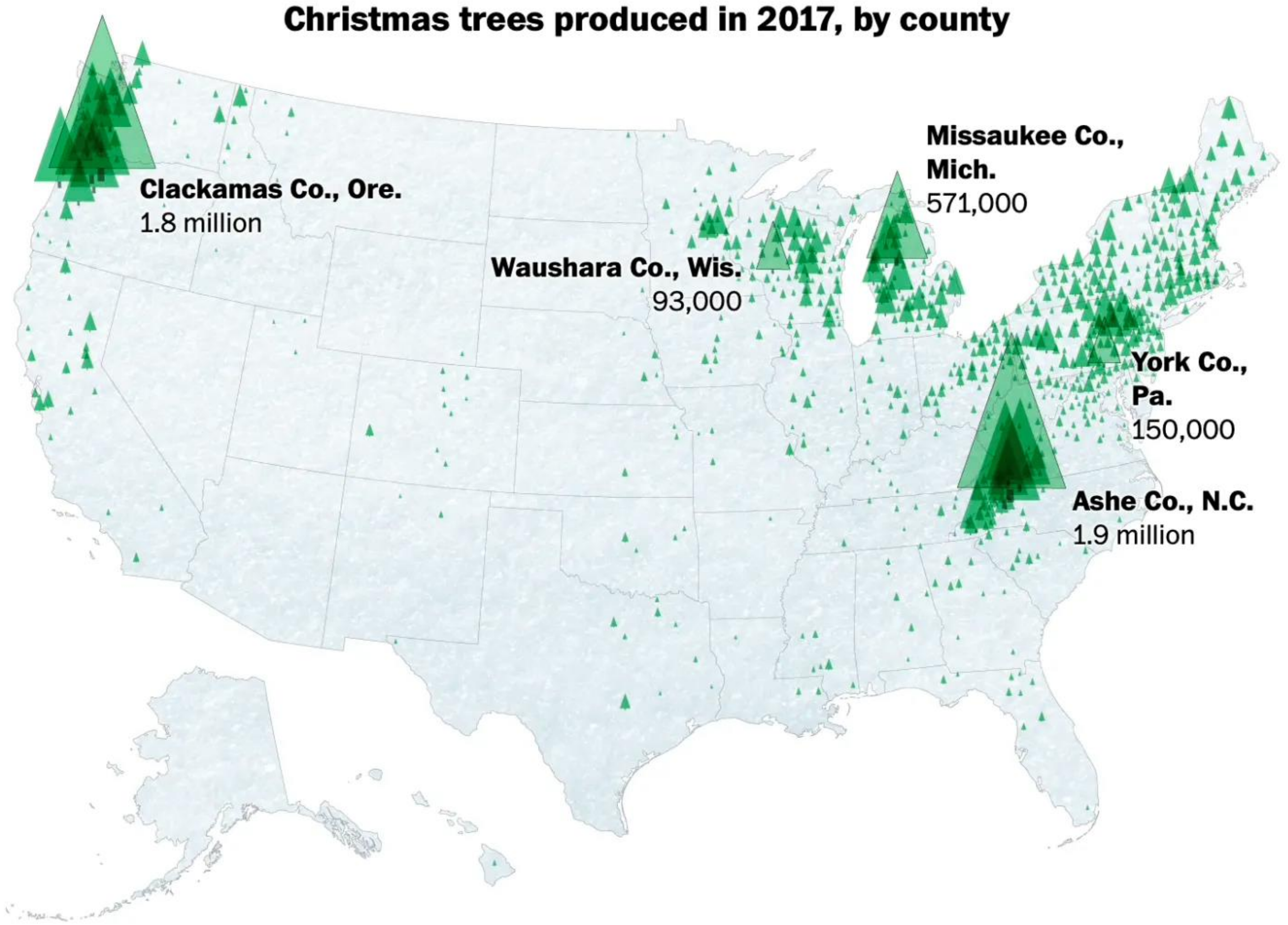


http://bl.ocks.org/mbostock/4060606

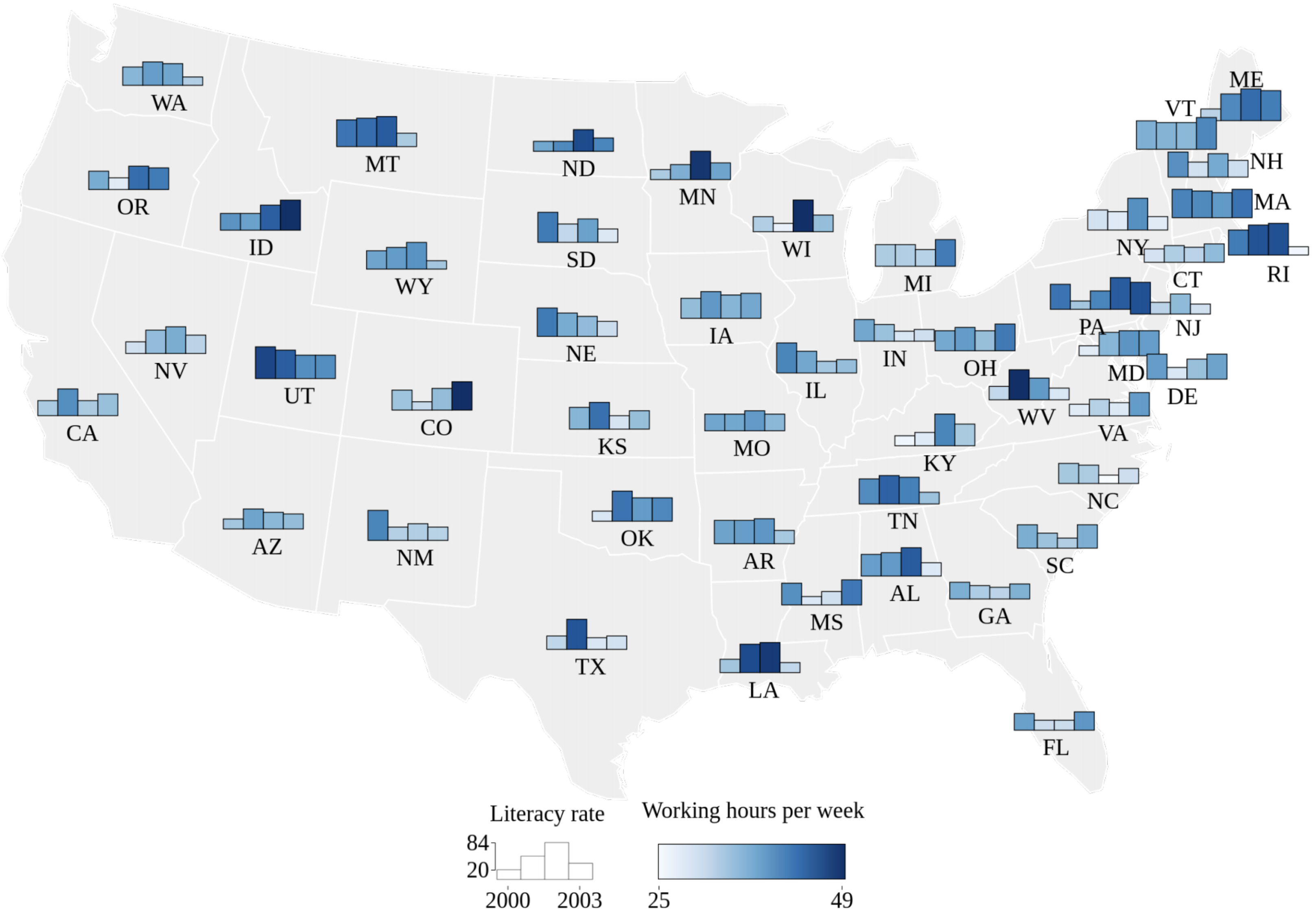
Idiom: **Symbol maps**

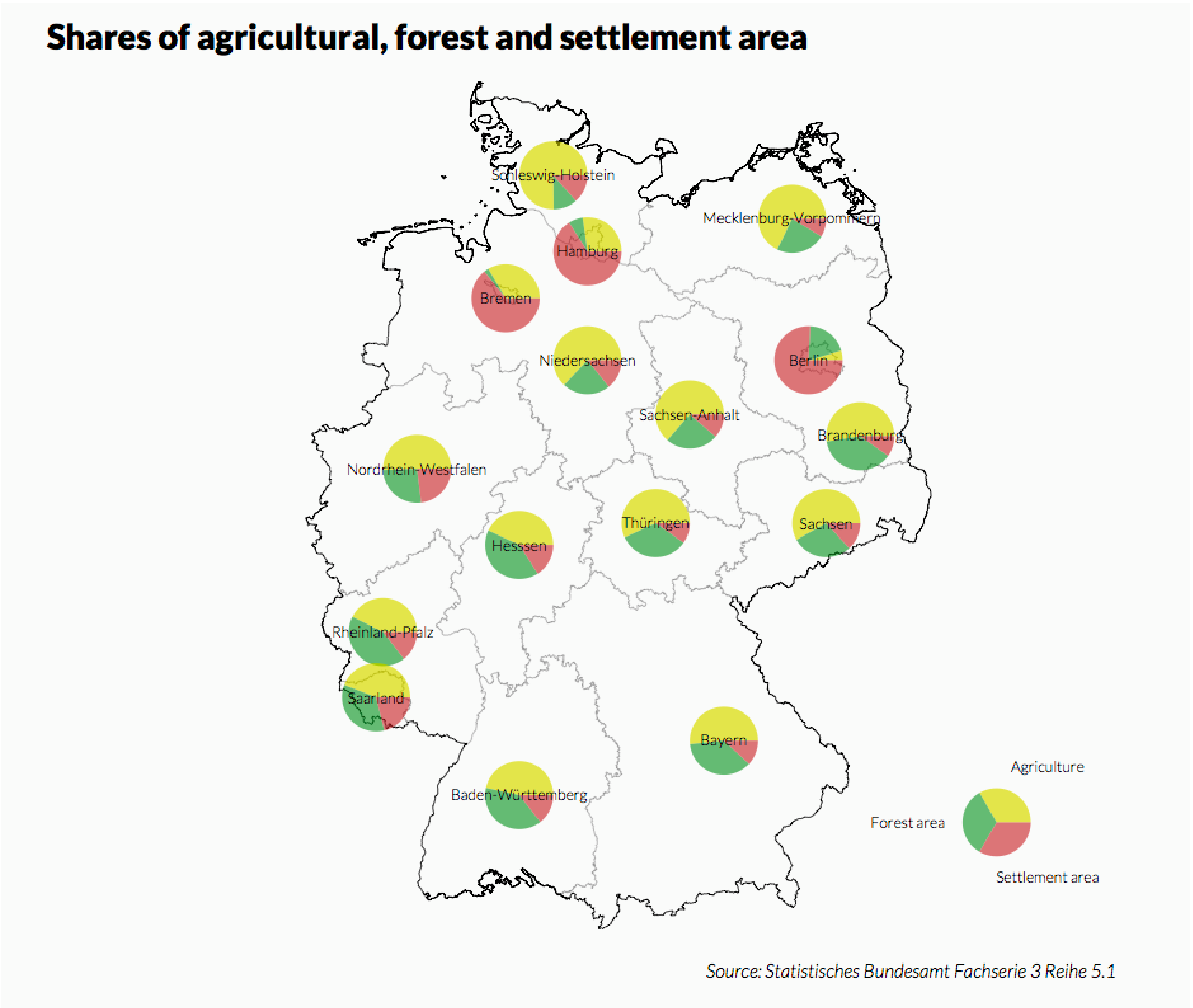
- symbol is used to represent aggregated data (mark or glyph)
  - allows use of size and shape and color channels
    - aka proportional symbol maps, graduated symbol maps
- keep original spatial geometry in the backgrounc
- often a good alternative to choropleth maps





Symbol maps with glyphs



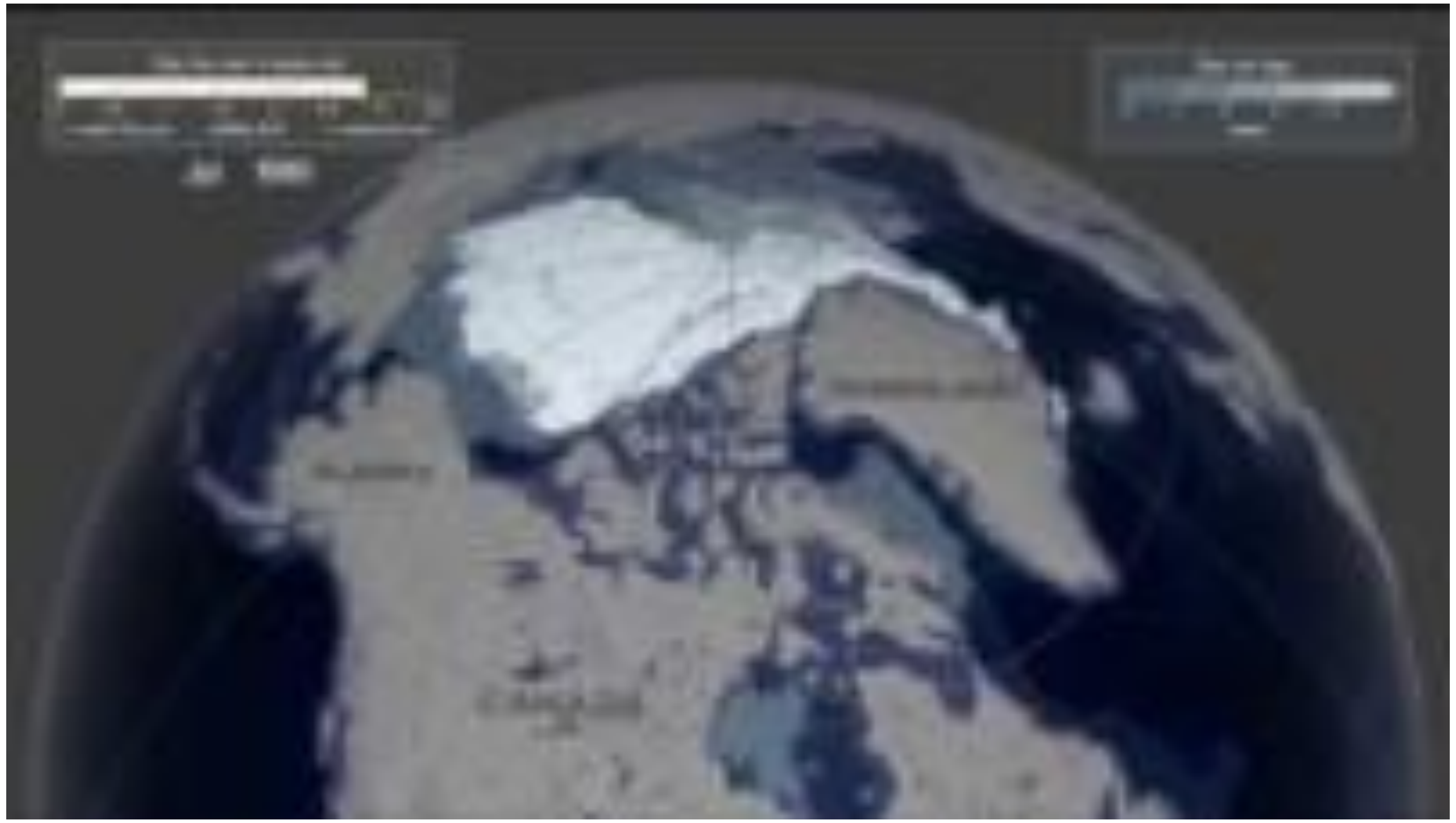


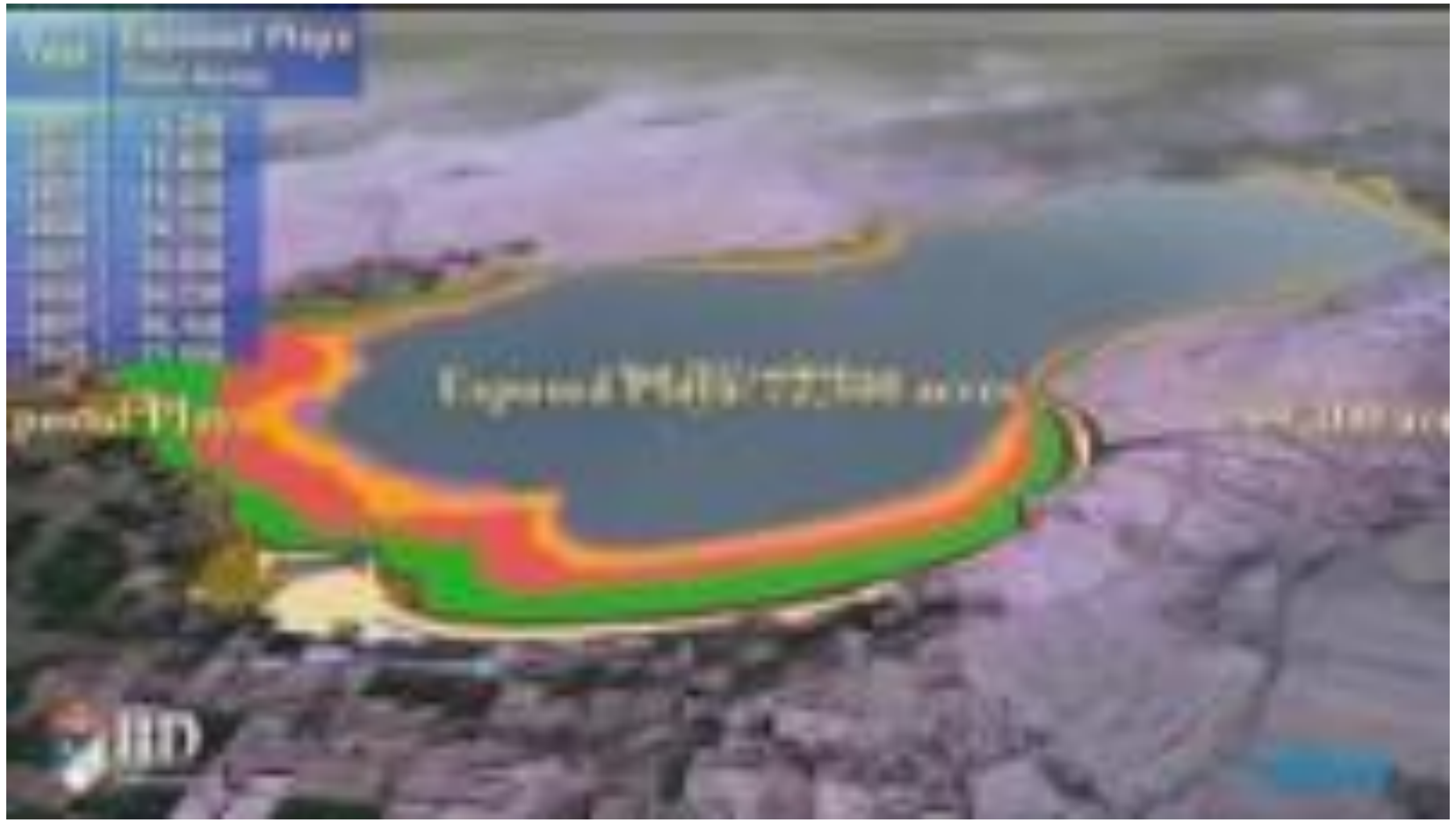
Idiom: **topographic map**

- data
  - geographic geometry
  - **scalar spatial field**
    - 1 quant attribute per grid cell
- derived data
  - isoline geometry
    - isocontours computed for specific levels of scalar values
- task
  - understanding terrain shape
    - densely lined regions = steep
- pros
  - use only 2D position, avoid 3D challenges
  - color channel available for other attributes
- cons
  - significant clutter from additional lines

[Land Information New Zealand Data Service]

3D Thematic Mapping





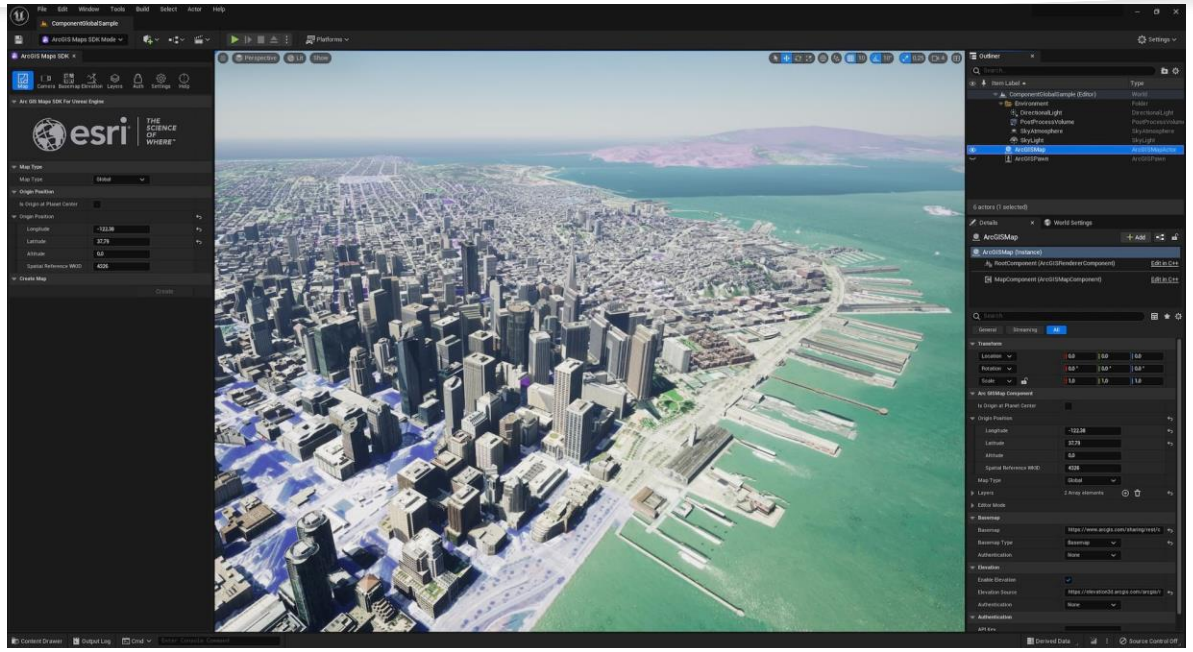
3D GIS and Thematic Mapping

Past 3D GIS Approaches:
ArcScene
CityEngine

Web 3D Mapping:
Google Earth
Cesium

Gaming Engine:
ArcGIS Maps Plugin
- Load GIS data into UE5
- Databases

Cesium Plugin
- Load GIS and 3D buildings/landmarks



From 2D to 3D to 4D GIS

Definition:

GIS is 2D mapping software with layers of spatial databases.

GIS Requirement: Not only stores spatial data but must be able to make spatial queries/measurements and conduct “Thematic Mapping”

3D GIS integrates 3D objects as spatial database layers (e.g. ArcScene)

4D GIS: multiple 3D layers changing over time (fourth dimension is time)

Integrates 3D Vector layers and DEM Rasters with Mesh or Pointcloud layers

Needs Curated Datasets to work:

- Spatial Database with QC
- Cleaned and Geo-referenced 3D Models
- Organized Storage System for Access/Retrieval

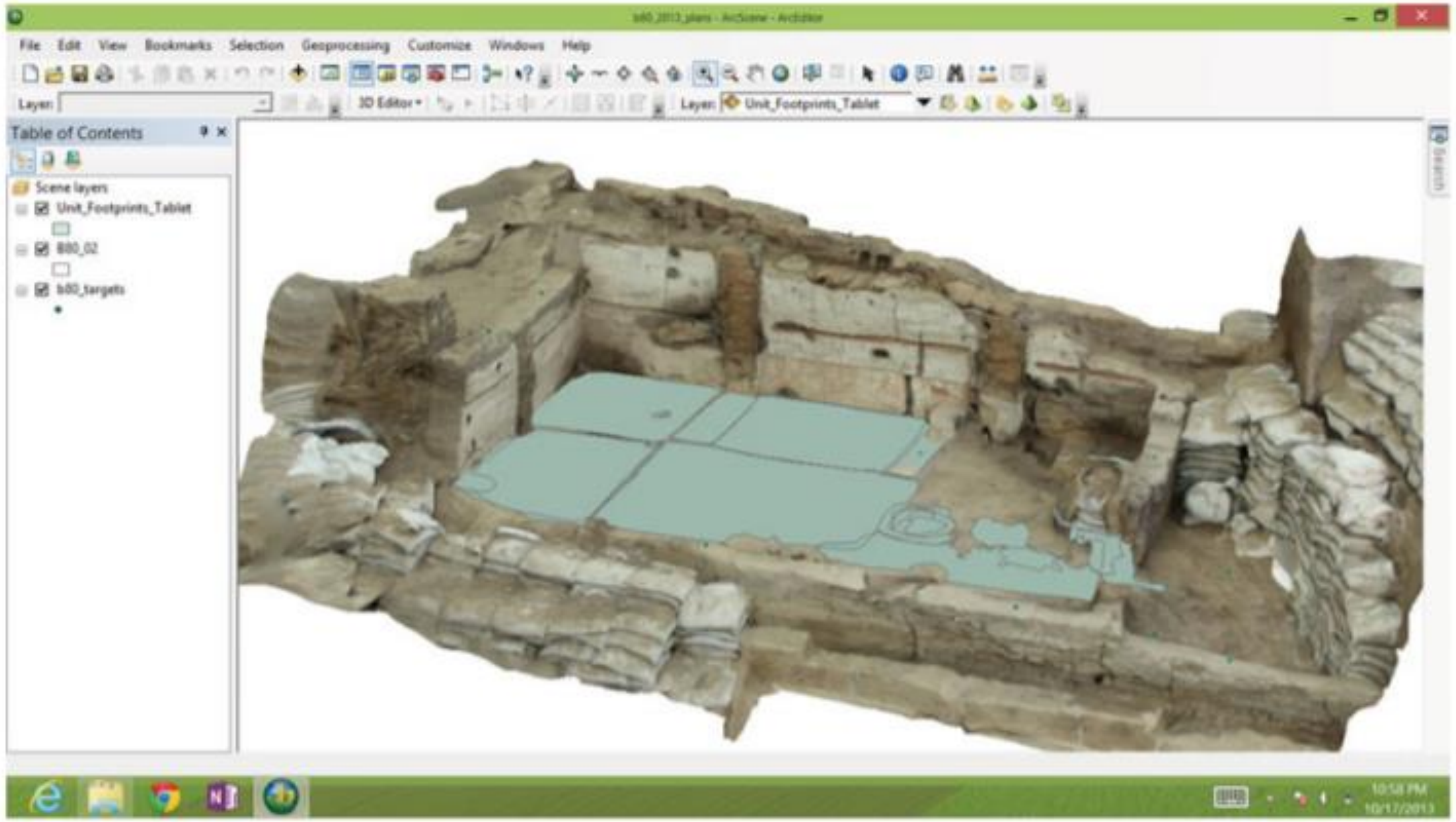


Figure 5. 3D GIS of Building 80 visualised using Arcscene. The screenshot shows the field documentation (2D polygons in green) recorded by the archaeologists working in Building 80 imported and visualised in spatial relation to the model of the building created using image based modelling. Source: Justine Issavi.

Digital Twin -> Metaverse

Digital Twin: Virtual Model to accurately reflect a physical object

A Digital Twin is constantly updated, is living!-Streaming in data, IOT, sensors
It's 4 dimensional (time attribute)

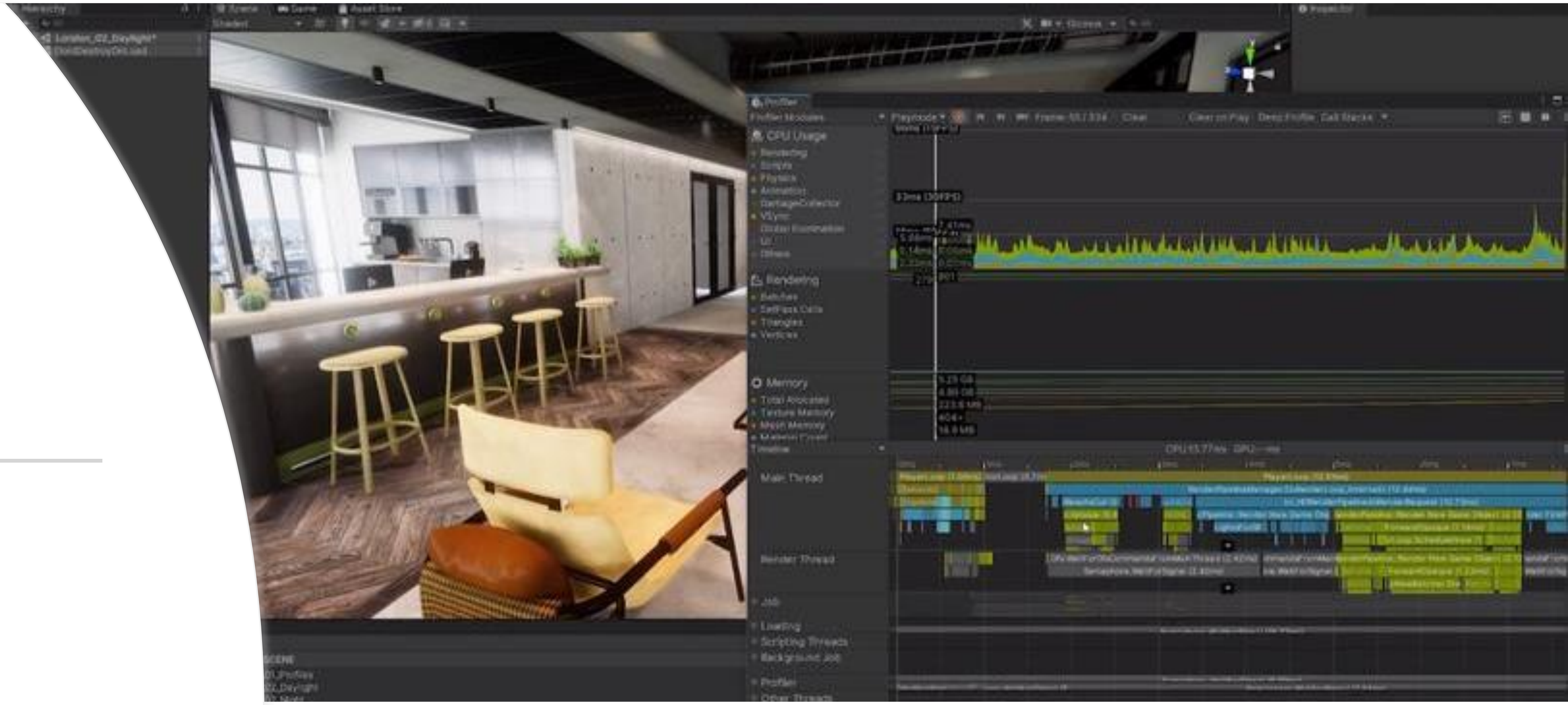
CCAS Goal: To Create a "Digital Twin" of the Archaeological Record

Game Engines for Data Visualization

- Unity
- Unreal Engine 4

Advantages:

Cross-platform (Win,Mac,Linux,IOS,Android)
Multiplayer Networking built-in
VR/AR support (CAVE, HMD)
AAA Graphics and Rendering
VR Editors
Documentation & Tutorials
Support for CAD/3D model/Pointclouds




THE MATRIX
AWAKENS
AN UNREAL ENGINE 5
EXPERIENCE

https://www.youtube.com/watch?v=xLVJP-o0g28

REALTIME FX WITH NIAGARA | UE4

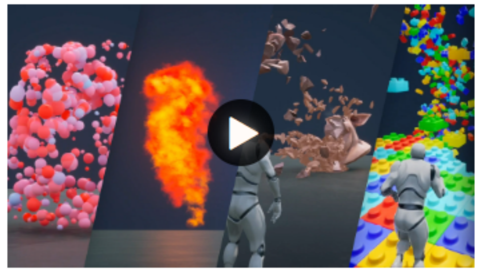
made in HOUDINI 18 for INTERMEDIATE by SIMON VERSTRAETE at SIDEFX

Category: Unreal, VFX

Posted: Nov. 16, 2020

Learn how to use the Houdini Niagara Plug-in to bring point cache data saved out as a JSON file into UE4's Niagara system along with attributes such as age, life, id and color. These point caches can be static or animated point clouds created using procedural modeling techniques or using Particle, FLIP Fluid or Rigid Body simulation tools. Here are four lessons that explore different kinds of FX.

PROJECT FILES

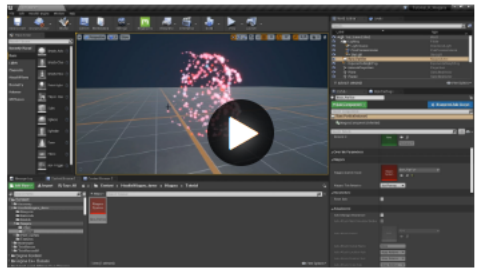


OVERVIEW

Take a quick look at the different projects being covered in these lessons. Learn what the Niagara plug-in does and how you can install it.

HOW TO INSTALL NIAGARA

Length: 04:11



1 | Houdini Particles to Niagara

Learn how to take a particle system from Houdini into UE4 using the Niagara plug-in. Learn what Niagara nodes are available in UE4 and how to get attributes from Houdini into the Niagara system for processing.

Length: 14:51

2 | Volumes to Niagara

Learn how to derive a particle cloud from a volume in Houdini then transfer that into UE4 using Niagara. You can then use sprites to bring back the smokey nature of the sim and achieve a 3 dimensional smoke effect.

Length: 11:54

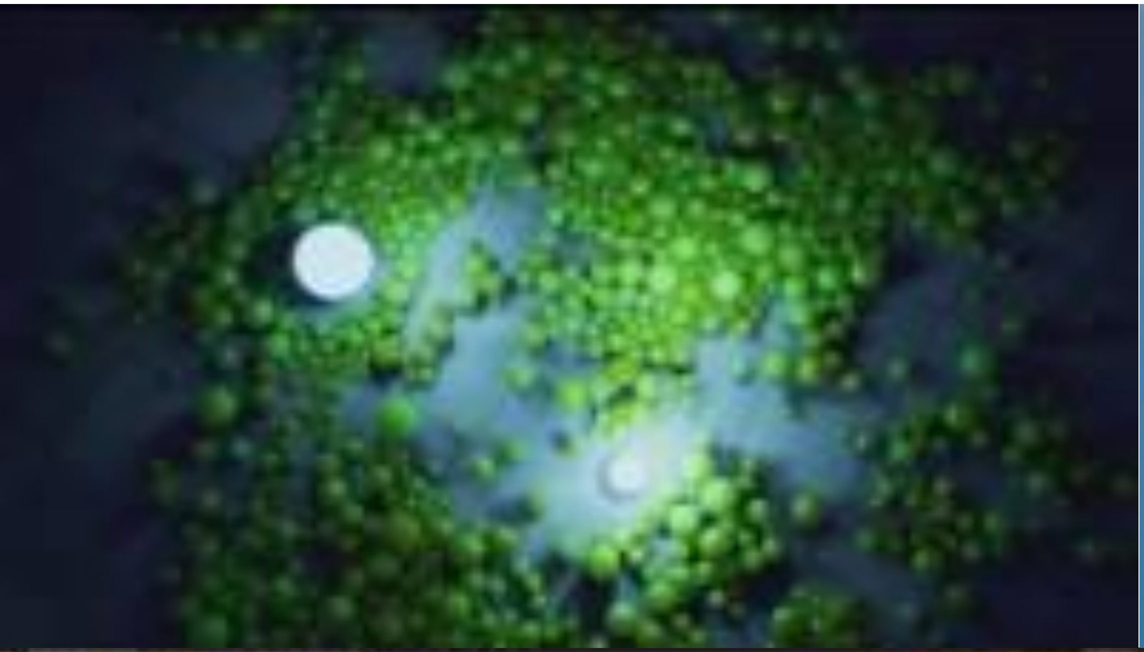
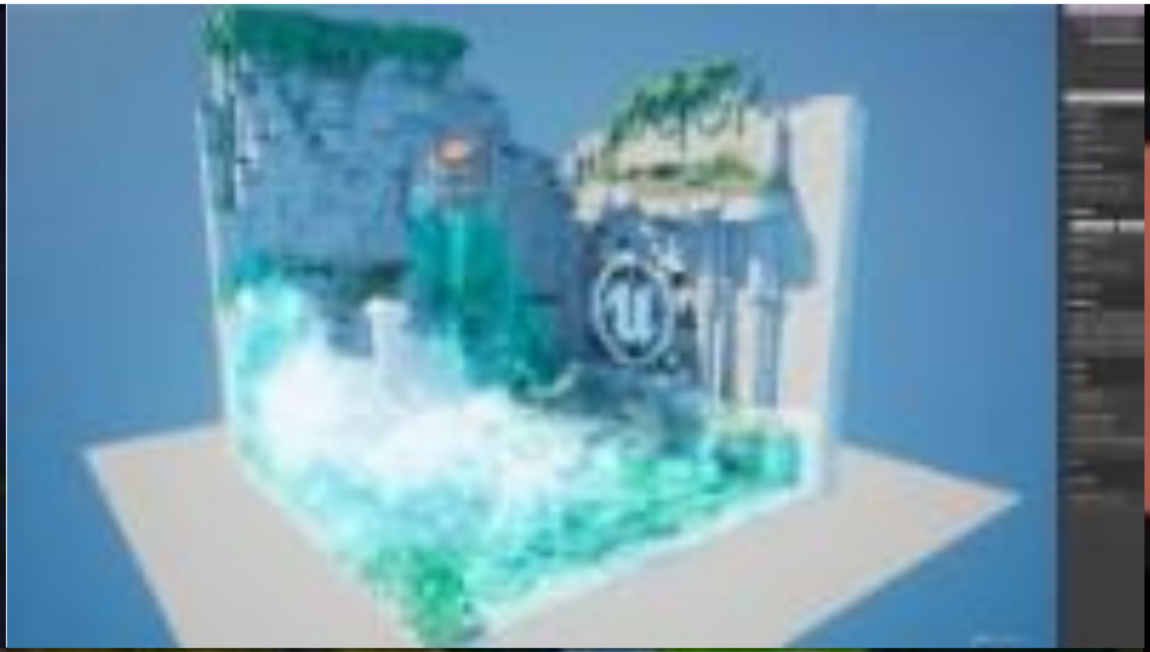
3 | Impact Data to Niagara

Learn how to use impact data generated from an RBD sim to spawn particle sims to add smoke and debris to the destruction effect.

Length: 18:43


UNREAL 5.1
SKELETAL MESH EFFECTS
(NIAGARA TUTORIAL)

Houdini and Niagara Simulations




Idioms: **isosurfaces, direct volume rendering**

- data
  - scalar spatial field (3D volume)
    - 1 quant attribute per grid cell
- task
  - shape understanding, spatial relationships

[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]

[Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

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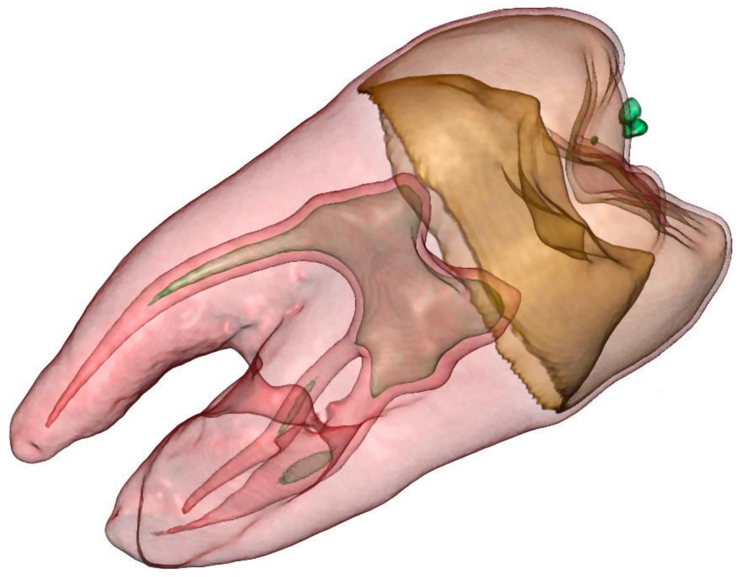

- data
  - scalar spatial field (3D volume)
    - 1 quant attribute per grid cell
- task
  - shape understanding, spatial relationships
- isosurface
  - derived data: isocontours computed for specific levels of scalar values

[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]

[Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

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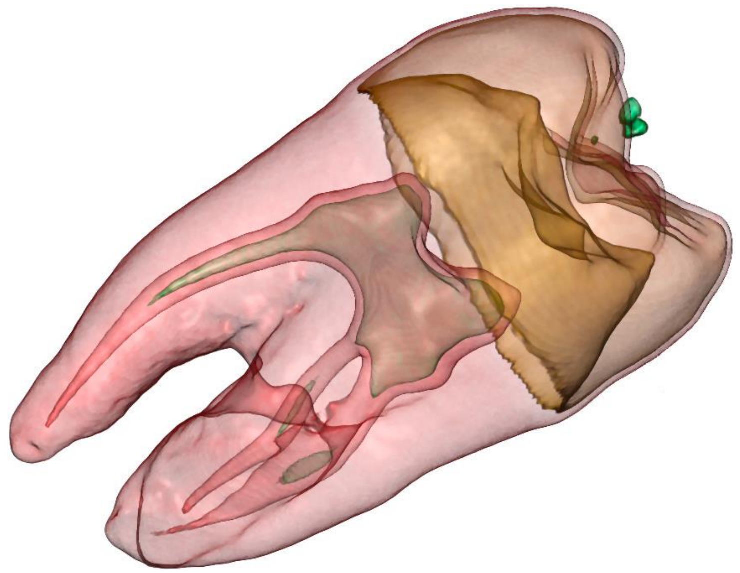
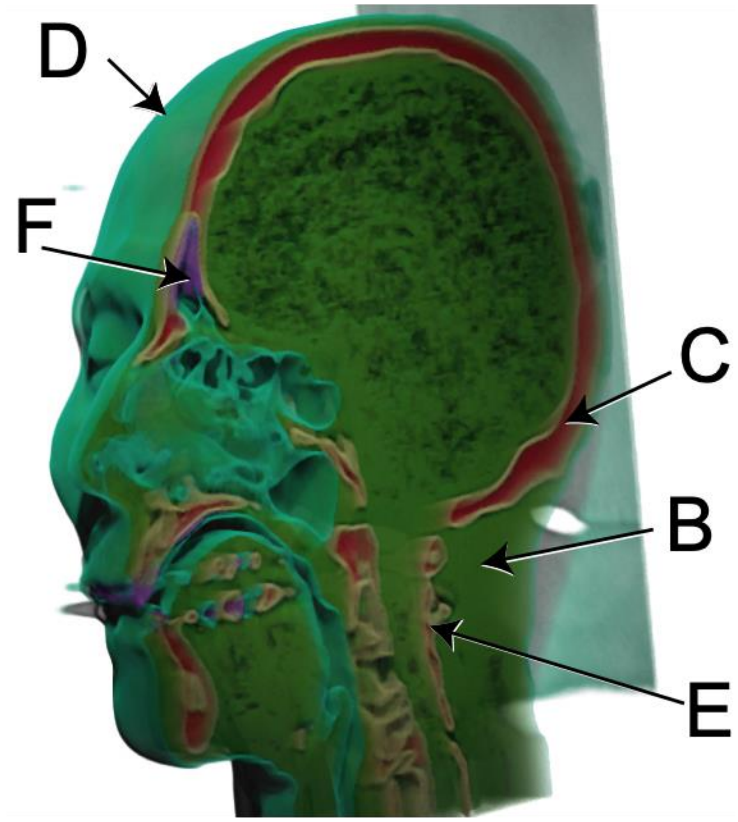


- data
  - scalar spatial field (3D volume)
    - 1 quant attribute per grid cell
- task
  - shape understanding, spatial relationships
- isosurface
  - derived data: isocontours computed for specific levels of scalar values
- direct volume rendering
  - transfer function maps scalar values to color, opacity
    - no derived geometry

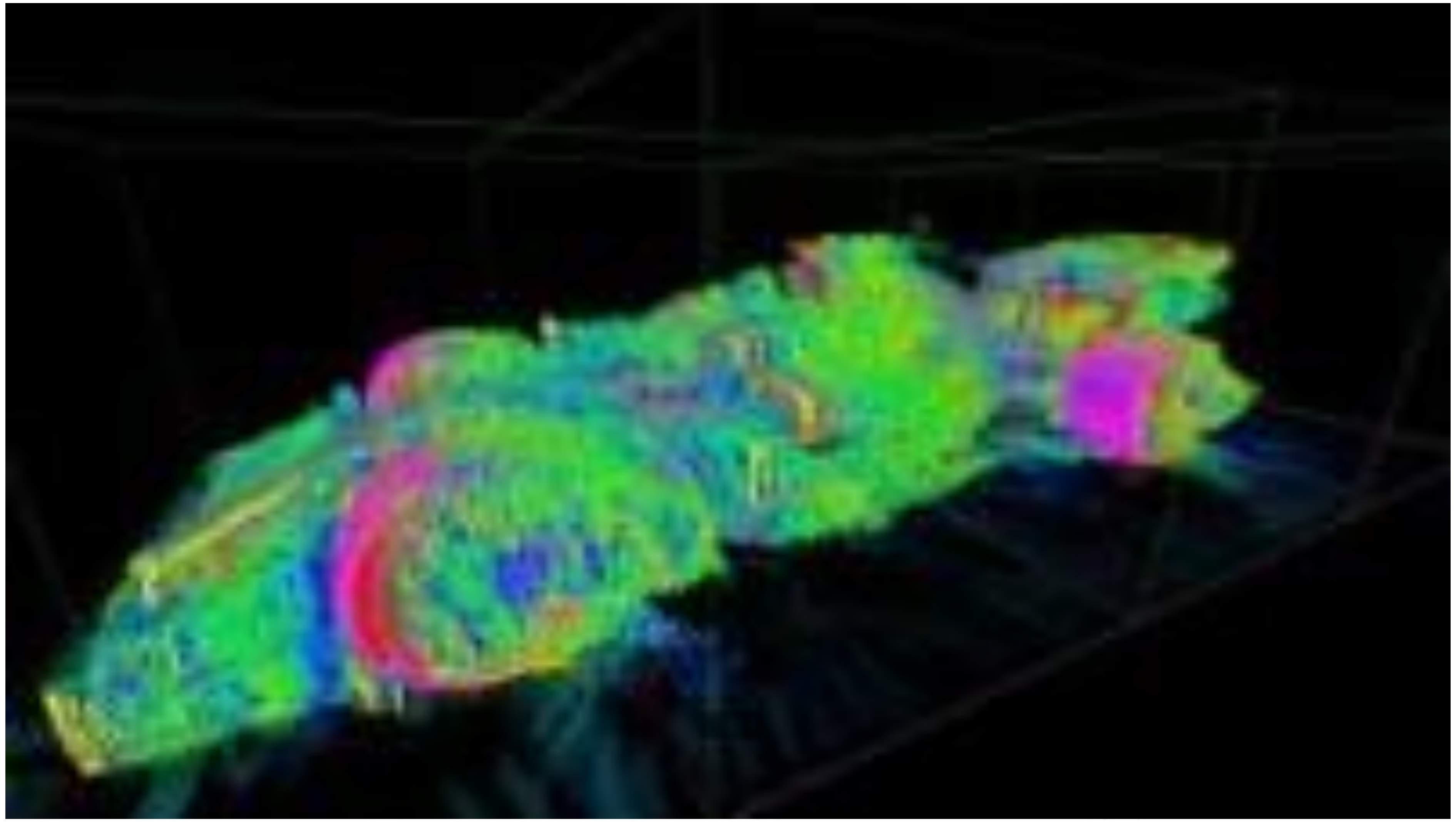


[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]

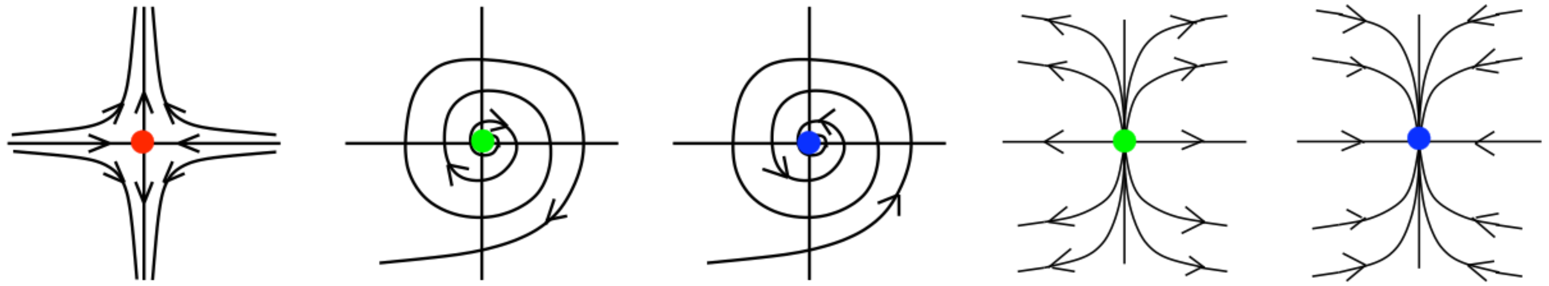
[Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

Vector and tensor fields

- data
  - multiple attribs per cell (vector: 2)
- idiom families
  - flow *glyphs*
    - purely local
  - *geometric* flow
    - derived data from tracing particle trajectories
    - sparse set of seed points
  - *texture* flow
    - derived data, dense seeds
  - *feature* flow
    - global computation to detect features



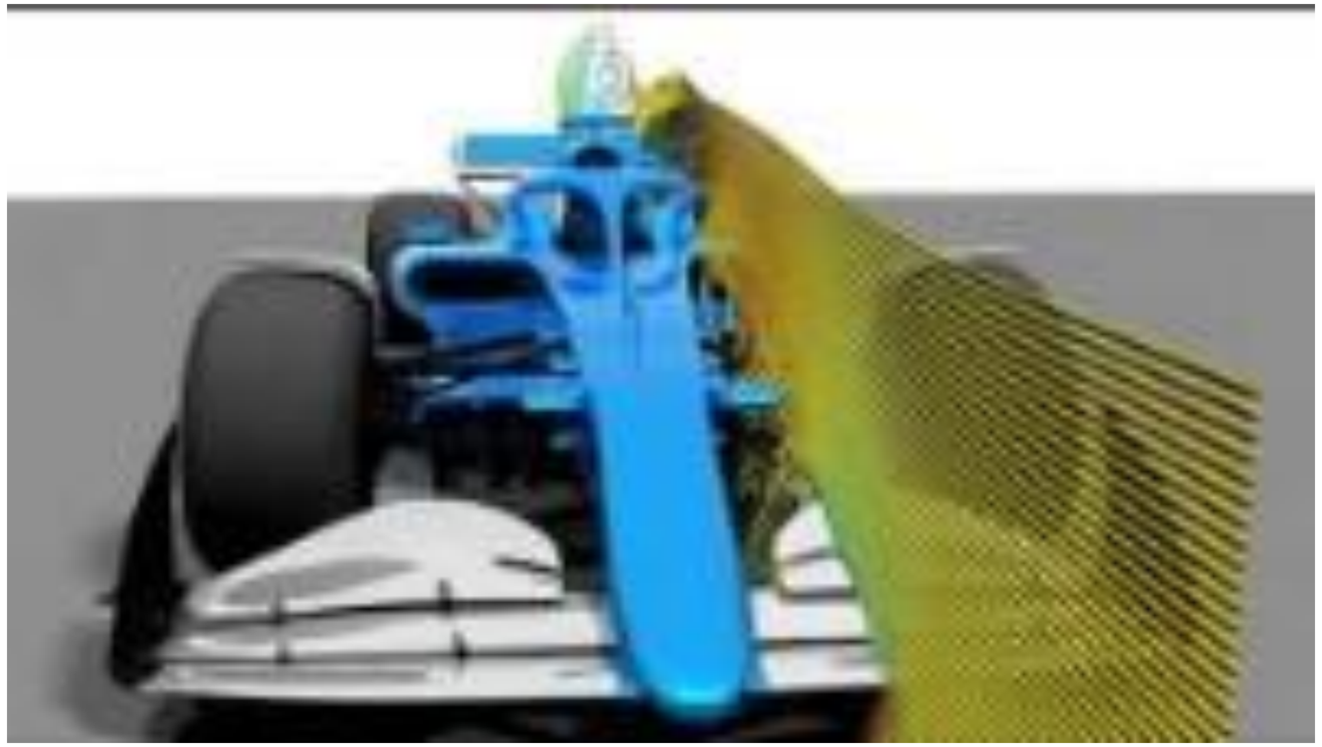
[Comparing 2D vector field visualization methods: A user study. Laidlaw et al. IEEE Trans. Visualization and Computer Graphics (TVCG) 11:1 (2005), 59–70.]



[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

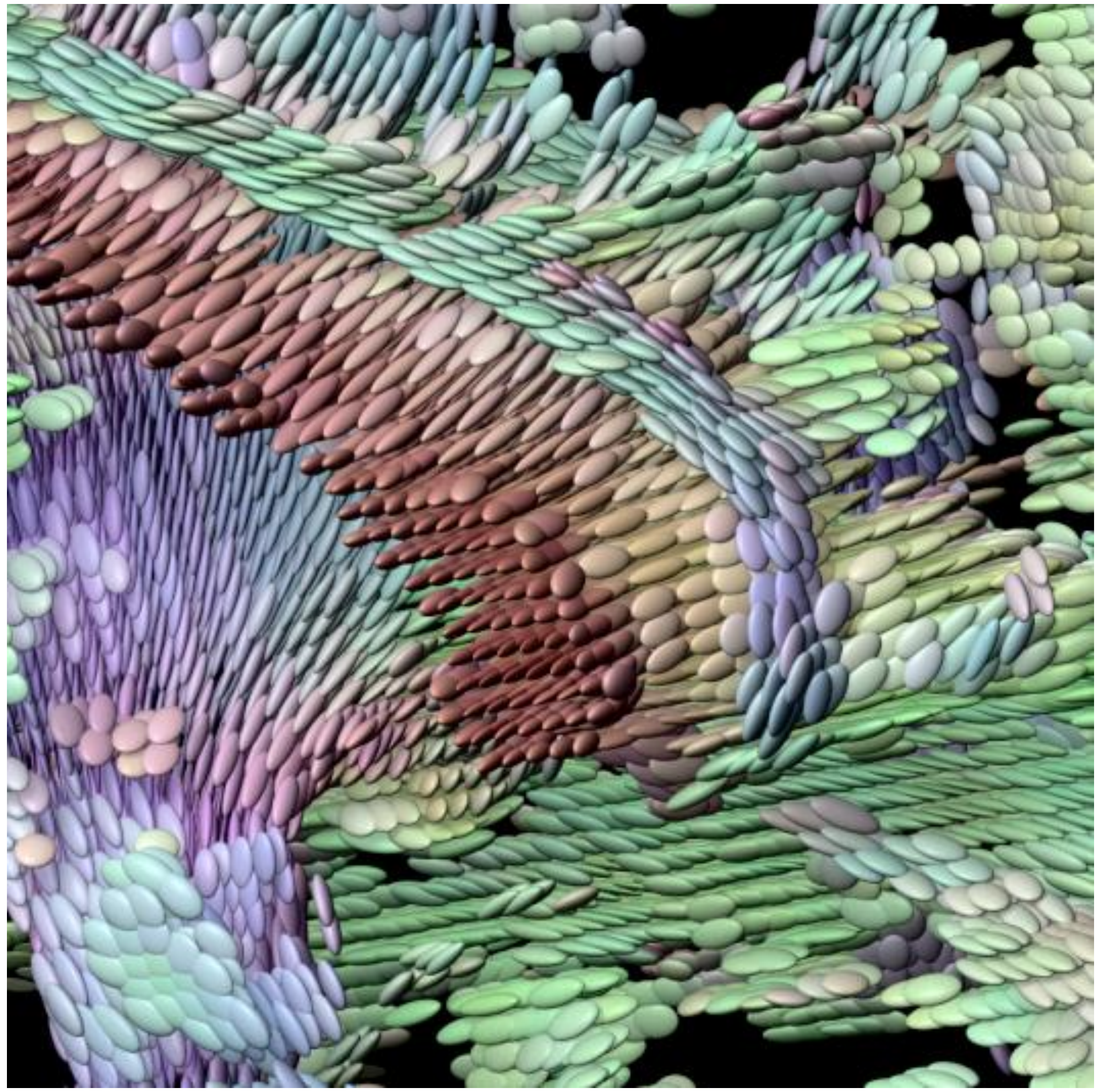
Idiom: **similarity-clustered streamlines**

- data
  - 3D vector field
- derived data (from field)
  - streamlines: trajectory particle will follow
- derived data (per streamline)
  - curvature, torsion, tortuosity
  - signature: complex weighted combination
  - compute cluster hierarchy across all signatures
  - encode: color and opacity by cluster
- tasks
  - find features, query shape
- scalability
  - millions of samples, hundreds of streamlines



[Similarity Measures for Enhancing Interactive Streamline Seeding. McLoughlin,. Jones, Laramee, Malki, Masters, and. Hansen. IEEE Trans. Visualization and Computer Graphics 19:8

Idiom: Ellipsoid Tensor Glyphs



- data
  - tensor field: multiple attributes at each cell (entire matrix)
    - stress, conductivity, curvature, diffusivity...
  - derived data:
    - shape (eigenvalues)
    - orientation (eigenvectors)
- visual encoding
  - glyph: 3D ellipsoid

[Superquadric Tensor Glyphs. Kindlmann. Proc. VisSym04, p147-154, 2004.]

What might data visualization look like in the Future?

Spatial Augmentation: Expansion of screen real-estate to see more details or provide better focus+context than is possible on a single screen (Solution for Display Limits)

Interaction Augmentation: Augmenting 2D visual encodings with new interaction techniques that take advantage of 3D space (Solve tasks more effectively)

Natural Interactions: Natural Verbal, Tactile and Gesture controlled filtering, aggregation, navigating, selecting, juxtaposing, etc… (More effective human/ai exploration/memory)

Split Rendering: Reduce manipulation latency below human perception for massive datasets (node graphs) with photorealistic rendering (Solution for Computational limits)

Collaborative Analysis: Multiple users conducting shared analysis and interaction of same visual encodings (Parallelize human-in-the-loop)

Computer-based visualization systems provide visual representations of datasets designed to help people <u>carry out tasks more effectively</u>.

Vis designers must take into account three very different kinds of resource limitations: those of <u>computers, of humans, and of displays</u>.

Towards In-situ Authoring of AR Visualizations with Mobile Devices

ISMAR 2021


Egocentric globe.