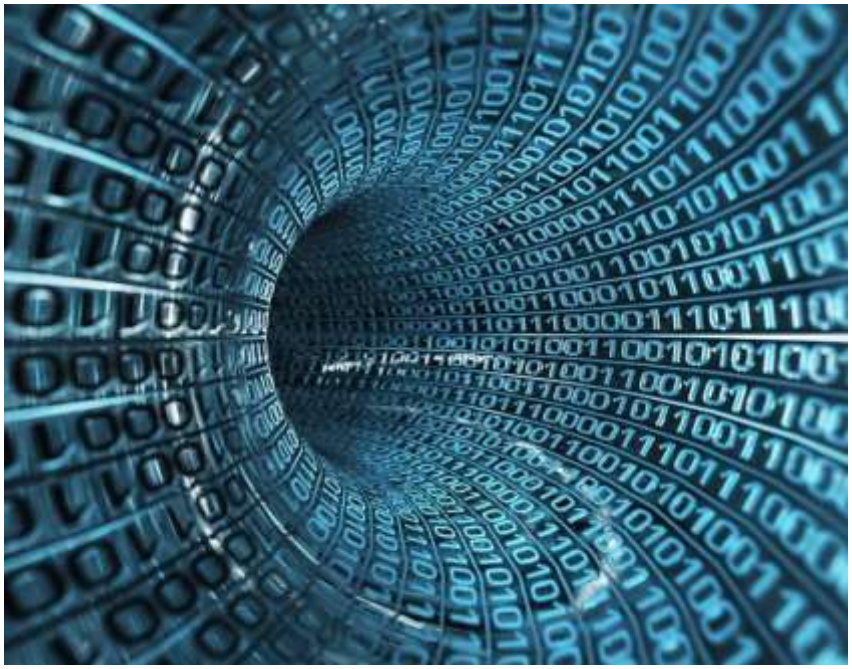
# Image based algorithm to support interactive data exploration

20th November 2014



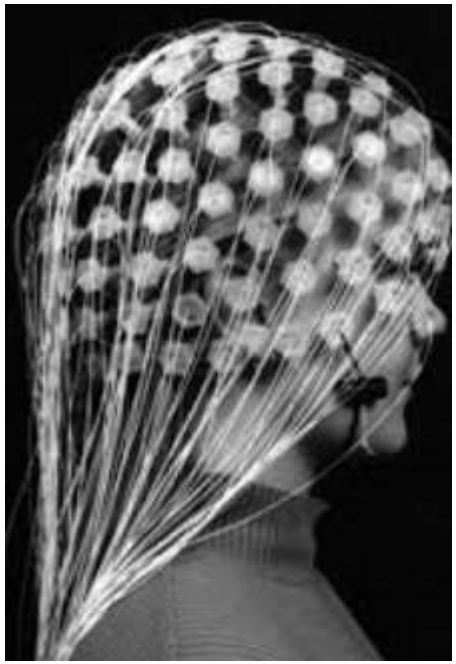
**Christophe Hurter**
*Assistant Professor - HDR*
*ENAC- Ecole Nationale de l'Aviation Civile*
Toulouse, France
Christophe.hurter@enac.fr
http://recherche.enac.fr/~hurter/

Laboratoire d'Informatique Interactive

UNIVERSITÉ TOULOUSE III PAUL SABATIER


07:30
Tuesday, March 1


12:03



# How to support data exploration?

The key to supporting this task is not only to **visualize data**, but also to allow users to **interact with them**.

I explored new computing techniques called **pixel-based algorithms** so as to support efficient interactive visualizations for the exploration of **large datasets**.

# Pixel-based algorithms

Graphic card used as:

- Fast rendering process
- Parallel processor

Pixels used as:

- Data storage (textures)
- Discrete space

# Outlines

- Brushing and linking

  FromDady

- View simplifications

  Edge Bundling techniques

- View animations

  MoleView

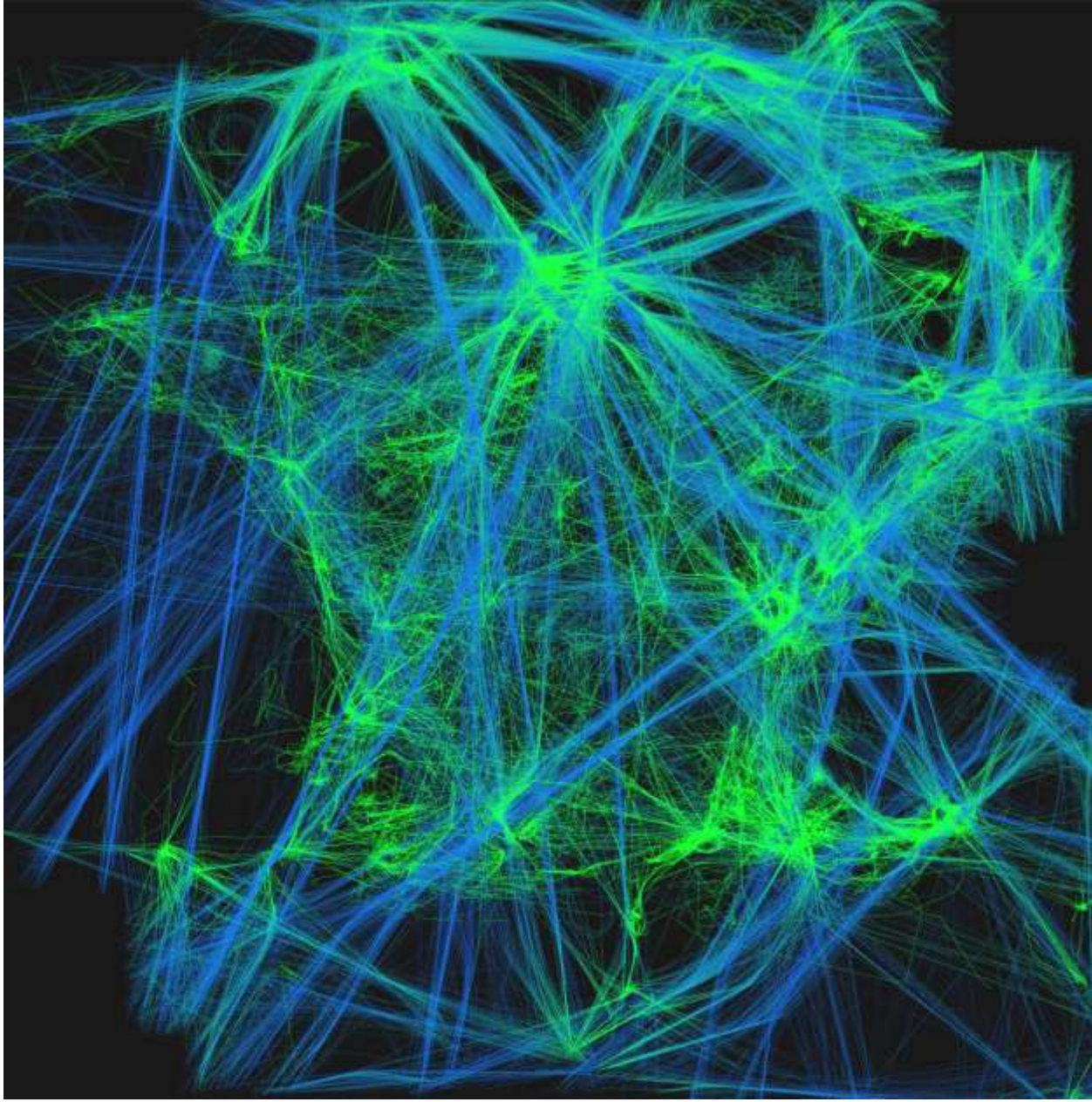
  ColorTunneling

# Brushing and linking

FromDady

from Da Dy

*from Data to Display*



Christophe Hurter, Benjamin Tissoires, Stéphane Conversy.

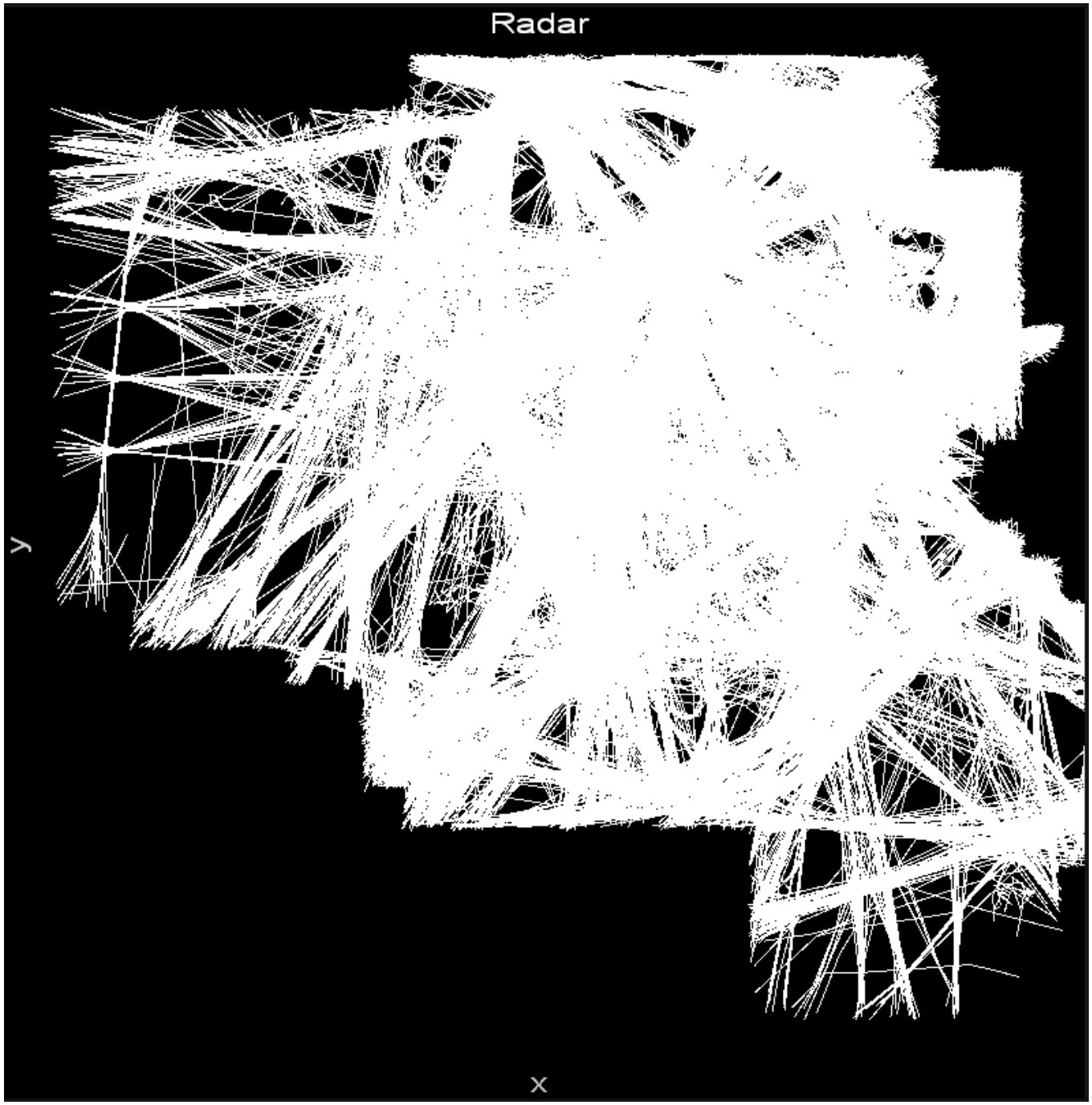
**FromDaDy: spreading data across views to support iterative exploration of aircraft trajectories.**

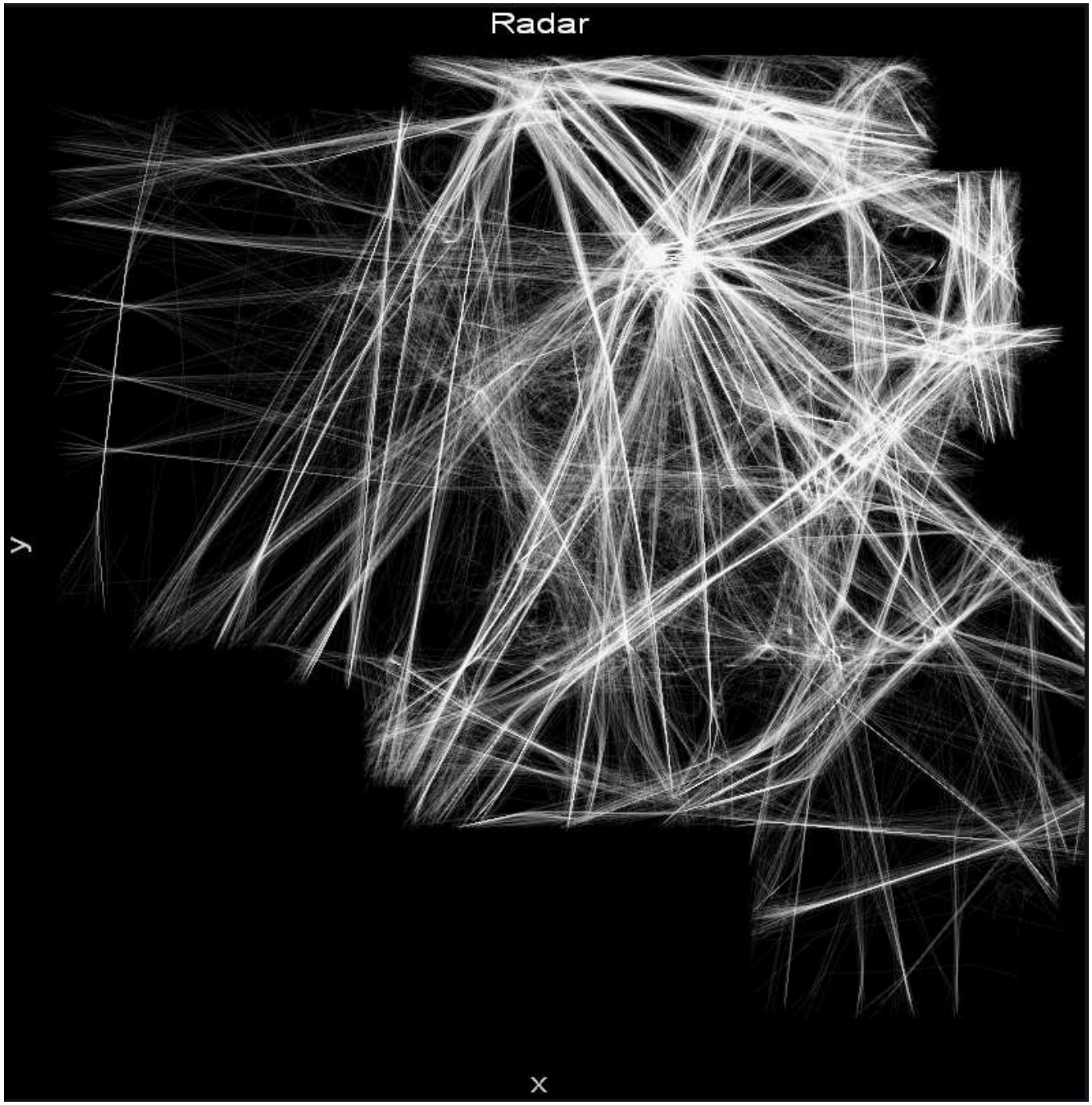
*InfoVis 2009*

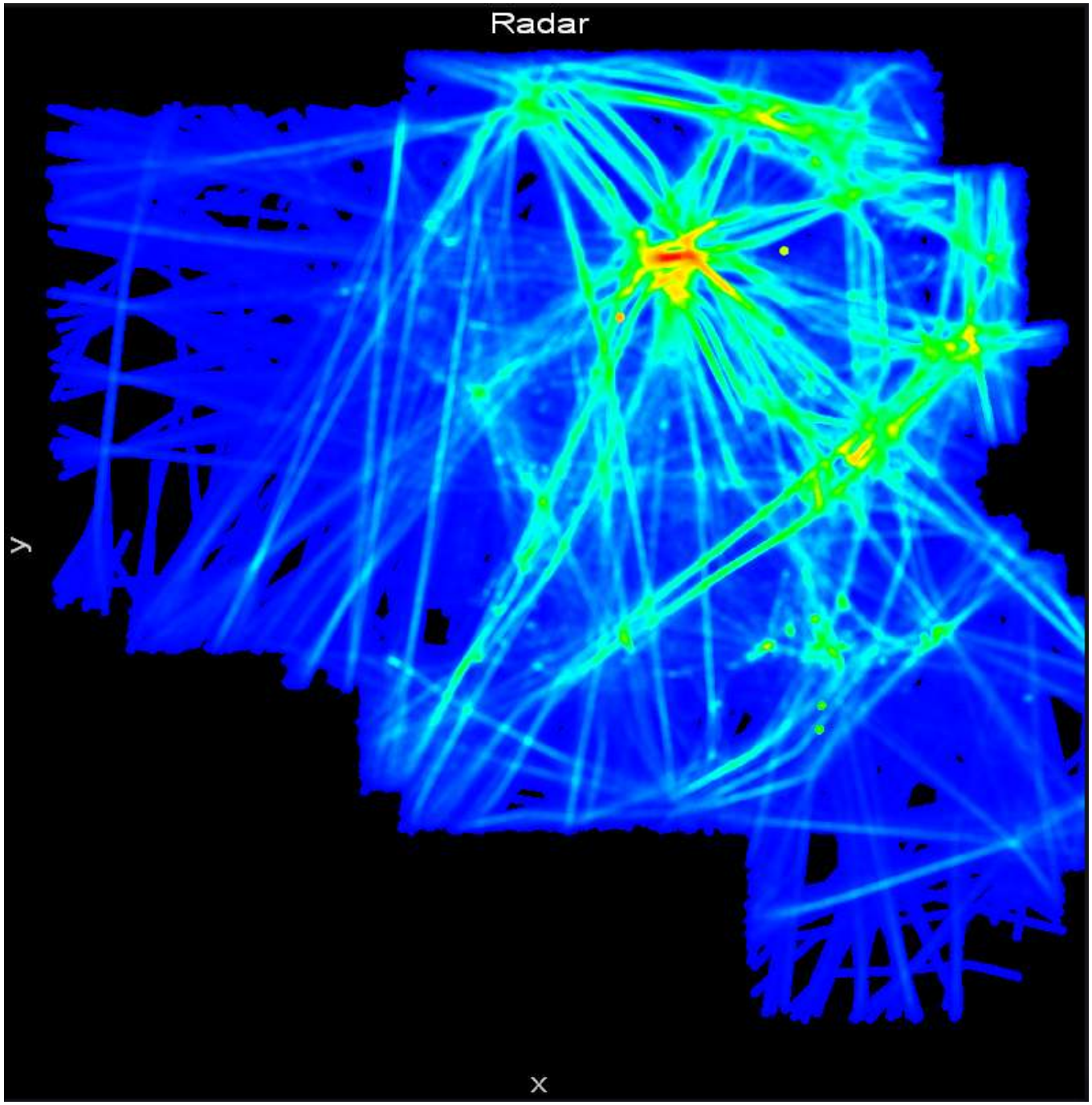
# Design rationale

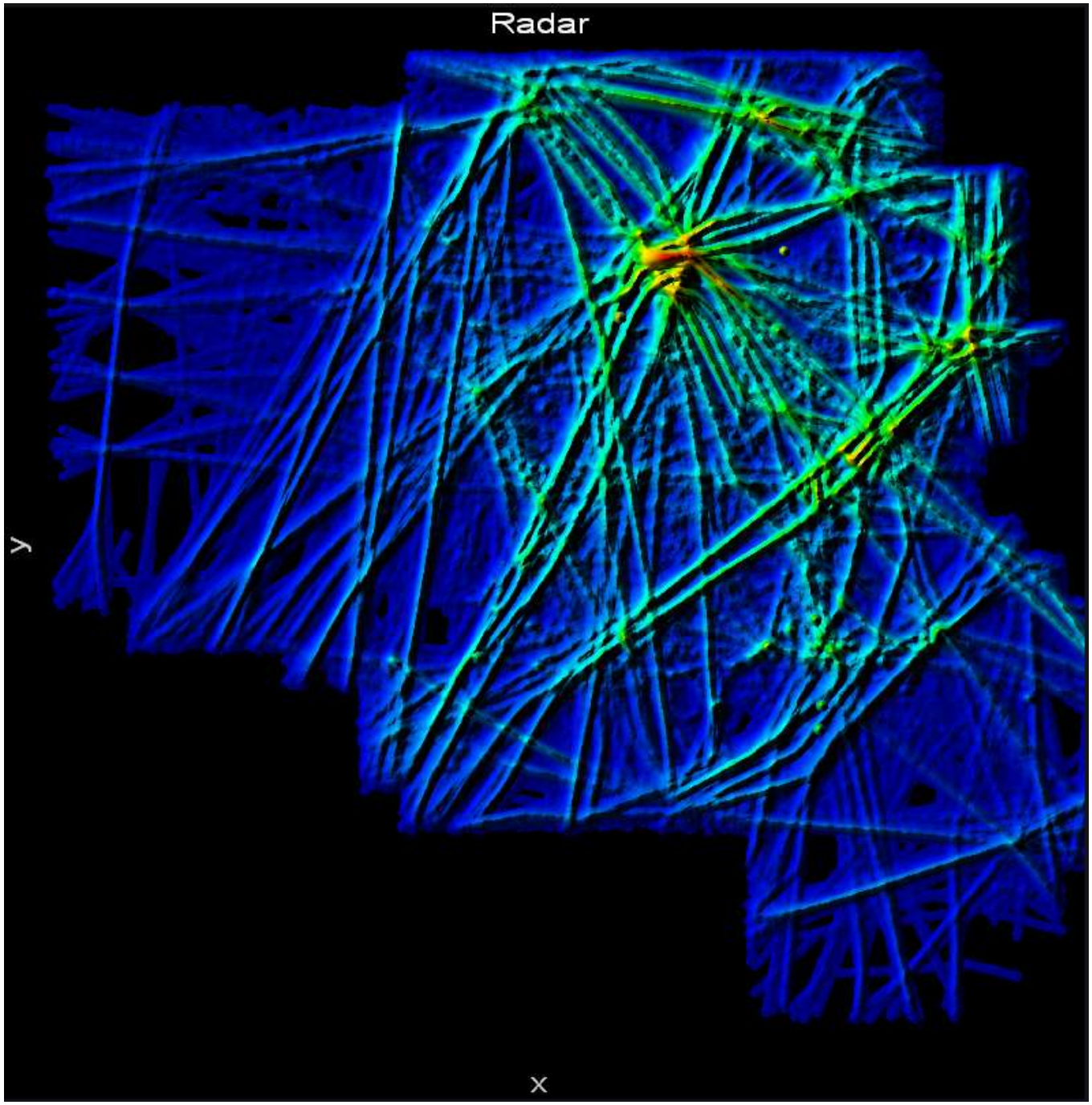
## FromDaDy

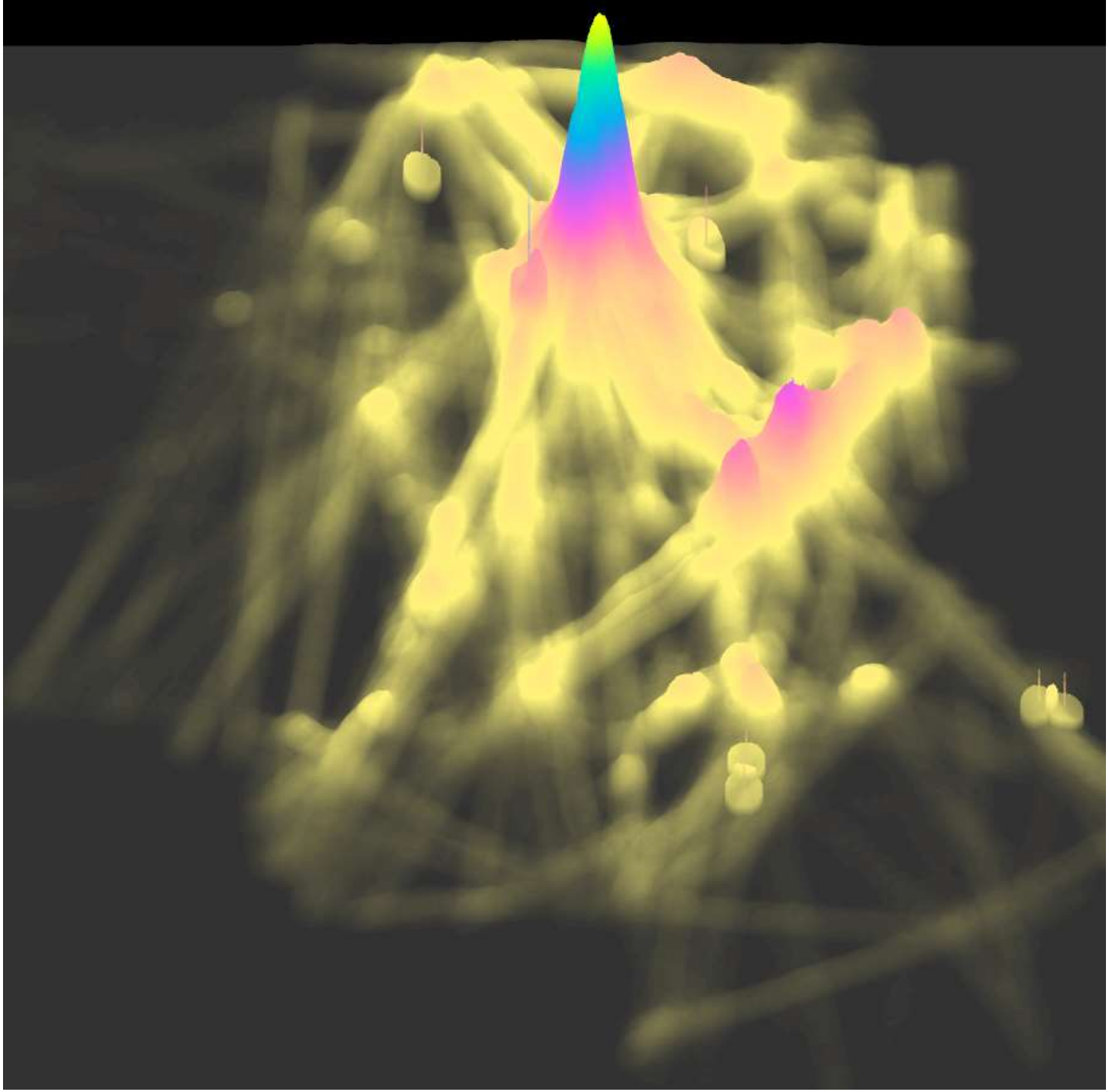
- Display large multidimensional datasets (up to 10 millions records)
- Allow direct manipulation of trajectories (spreading trajectories)
- Smooth transitions between view configurations

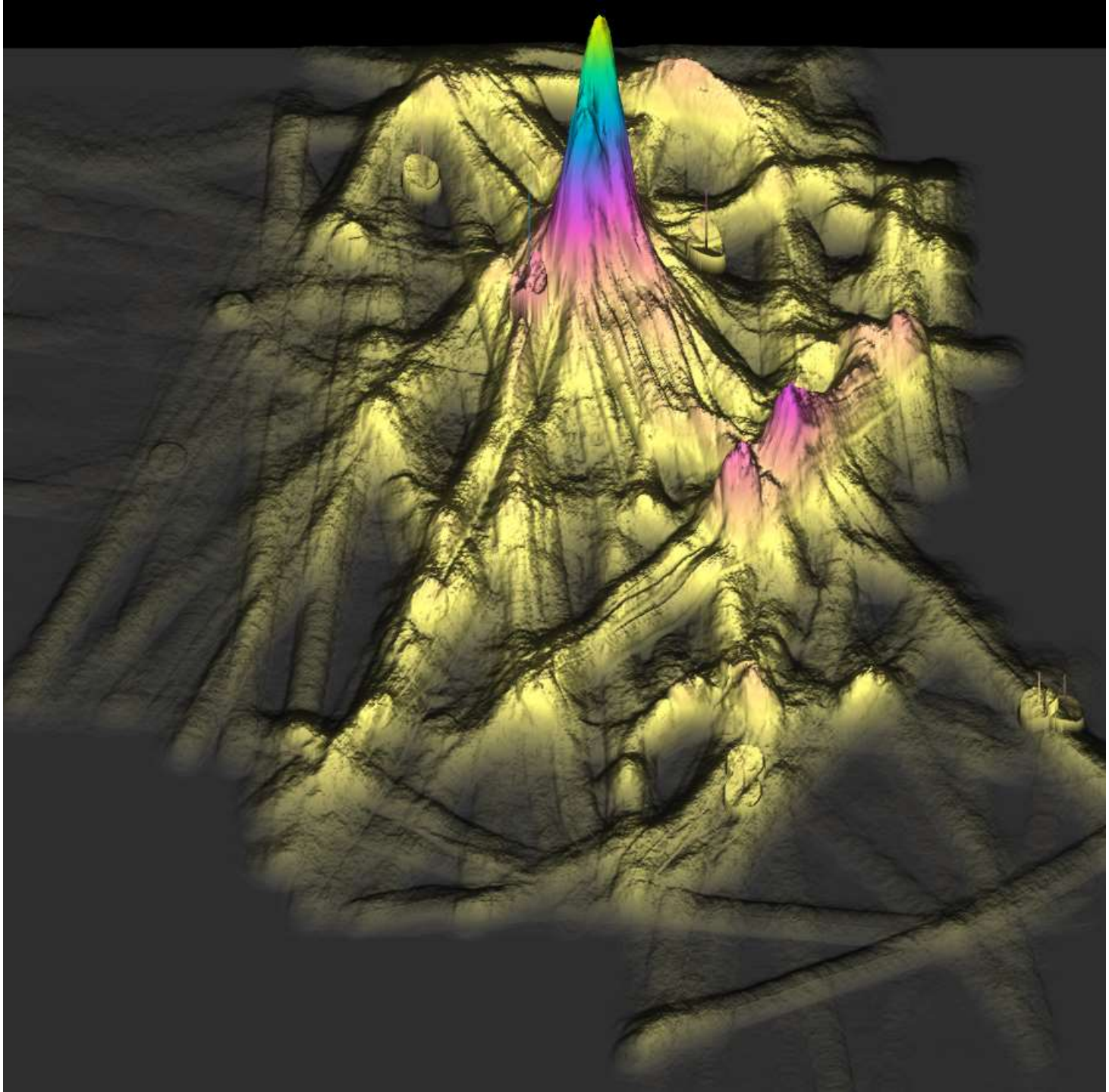

Radar
y
x


Radar
y
x


Radar
y
x


Radar
y
x

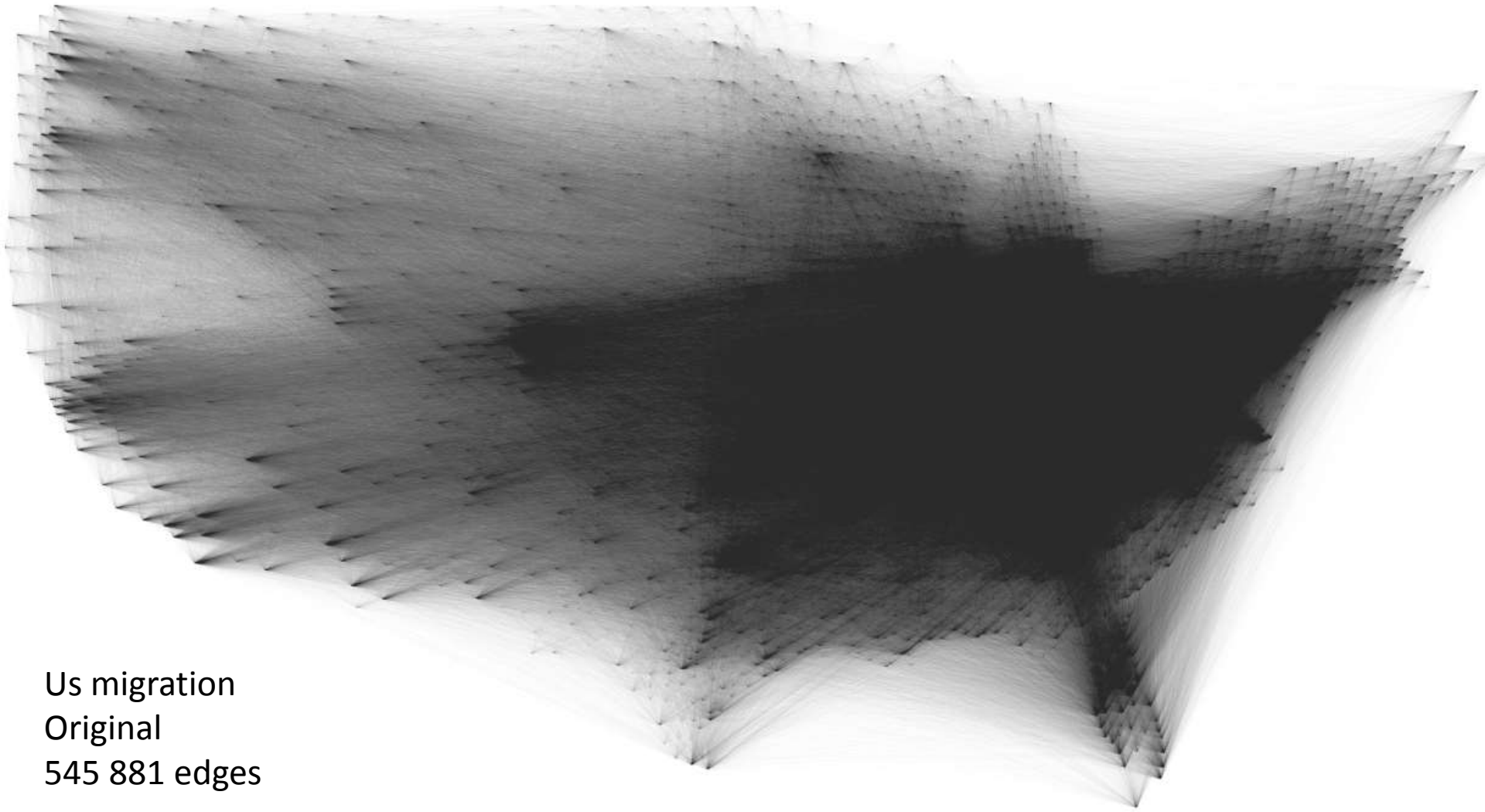




# View simplification

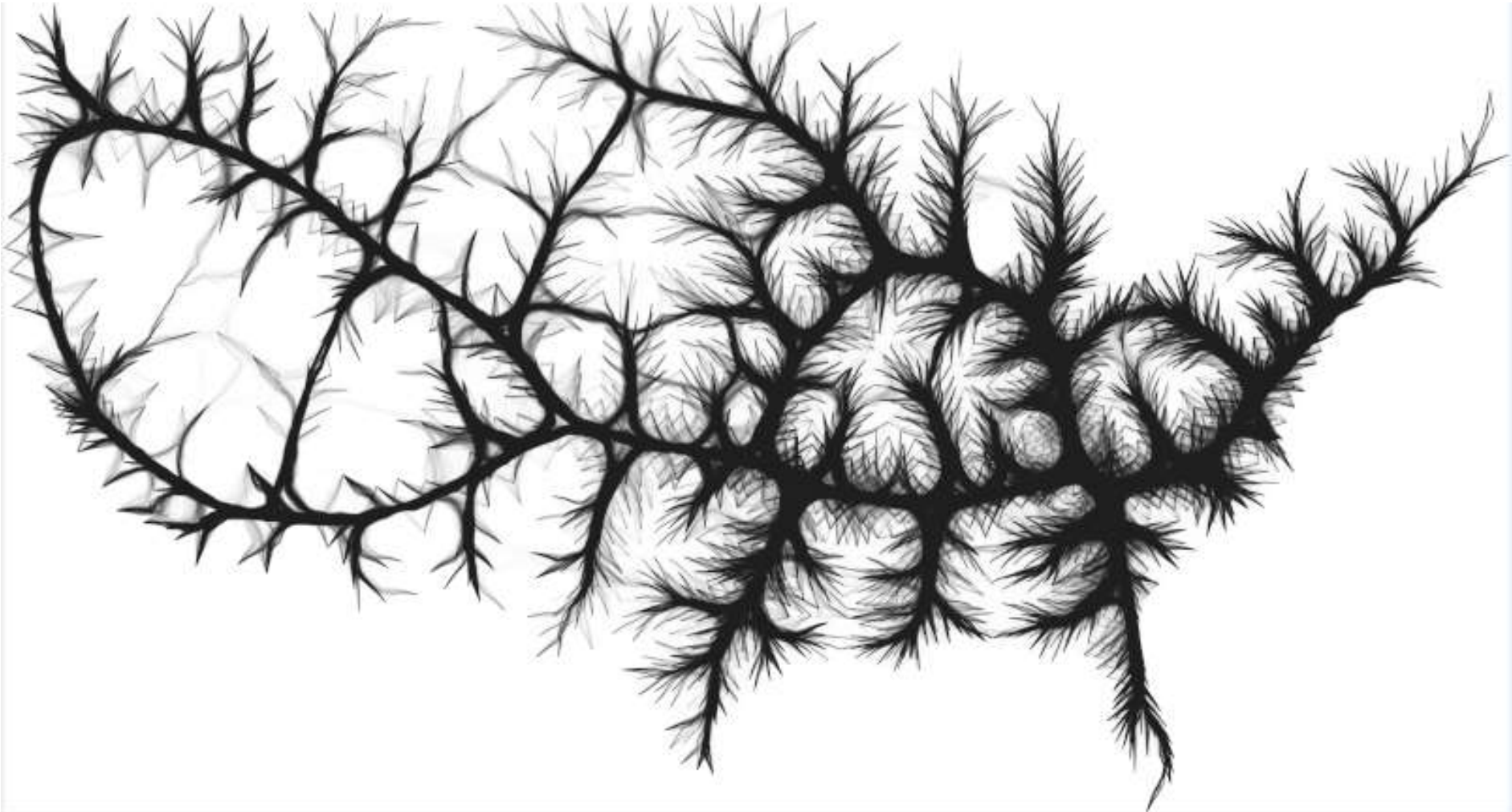
Edge Bundling techniques

County-to-county migration flow files (http://www.census.gov/population/www/cen2000/ctytoctyflow/). These data come from the Census 2000 long-form question on residence 5 years ago and contain the number of people who moved between counties.



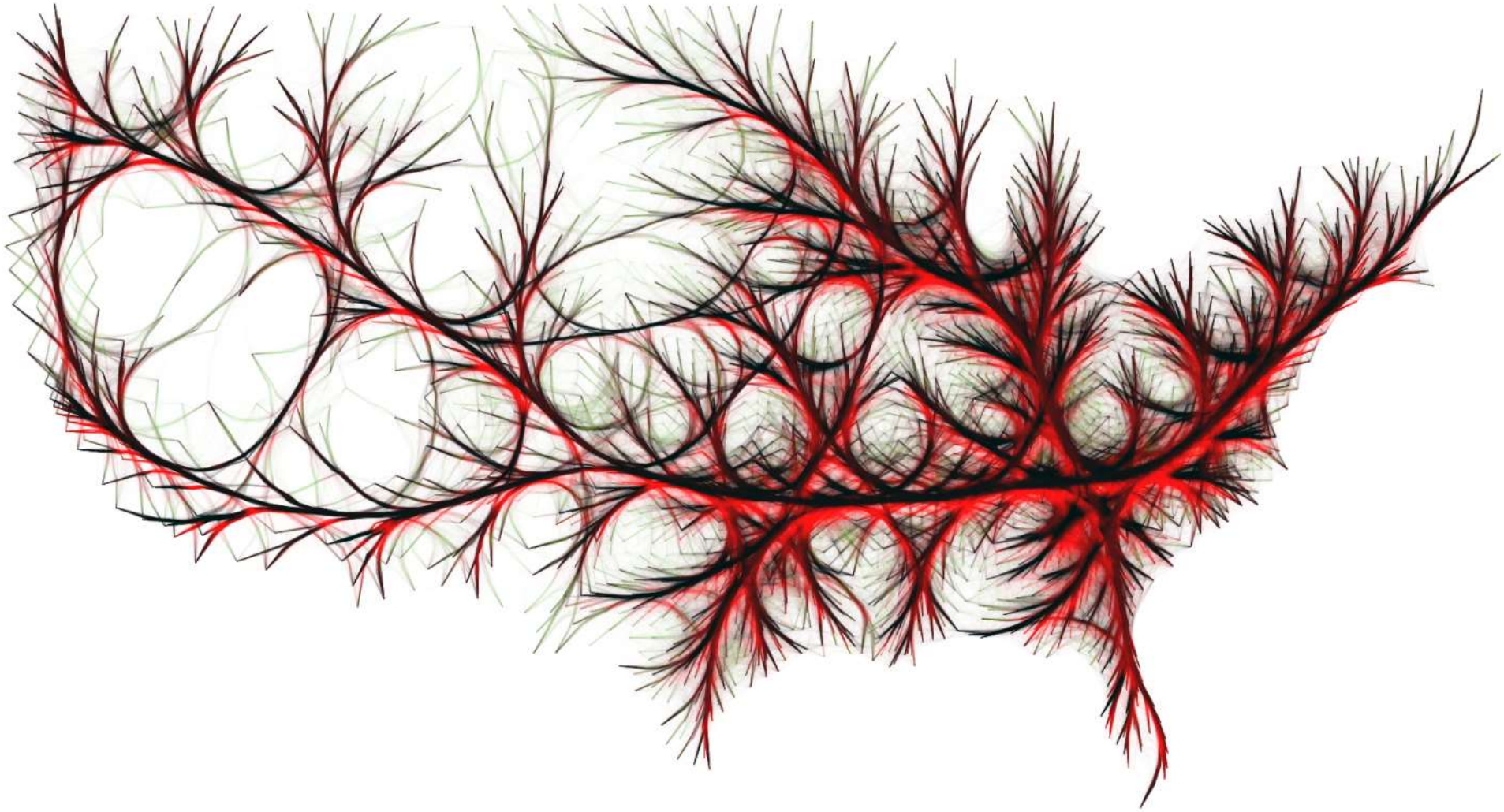
Us migration
Original
545 881 edges

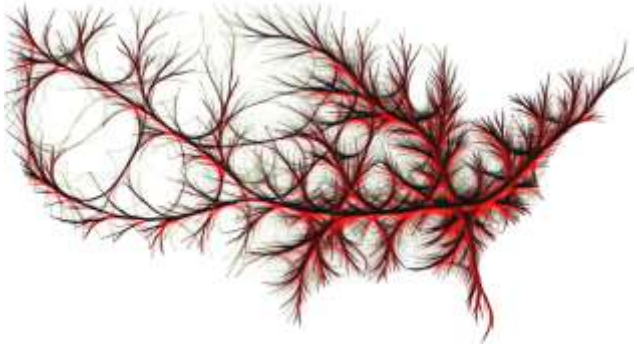
# Bundled



Us migration
Kernel Density Based Edge Bundling
22 million vertexes

# Shading





# Edge Bundling

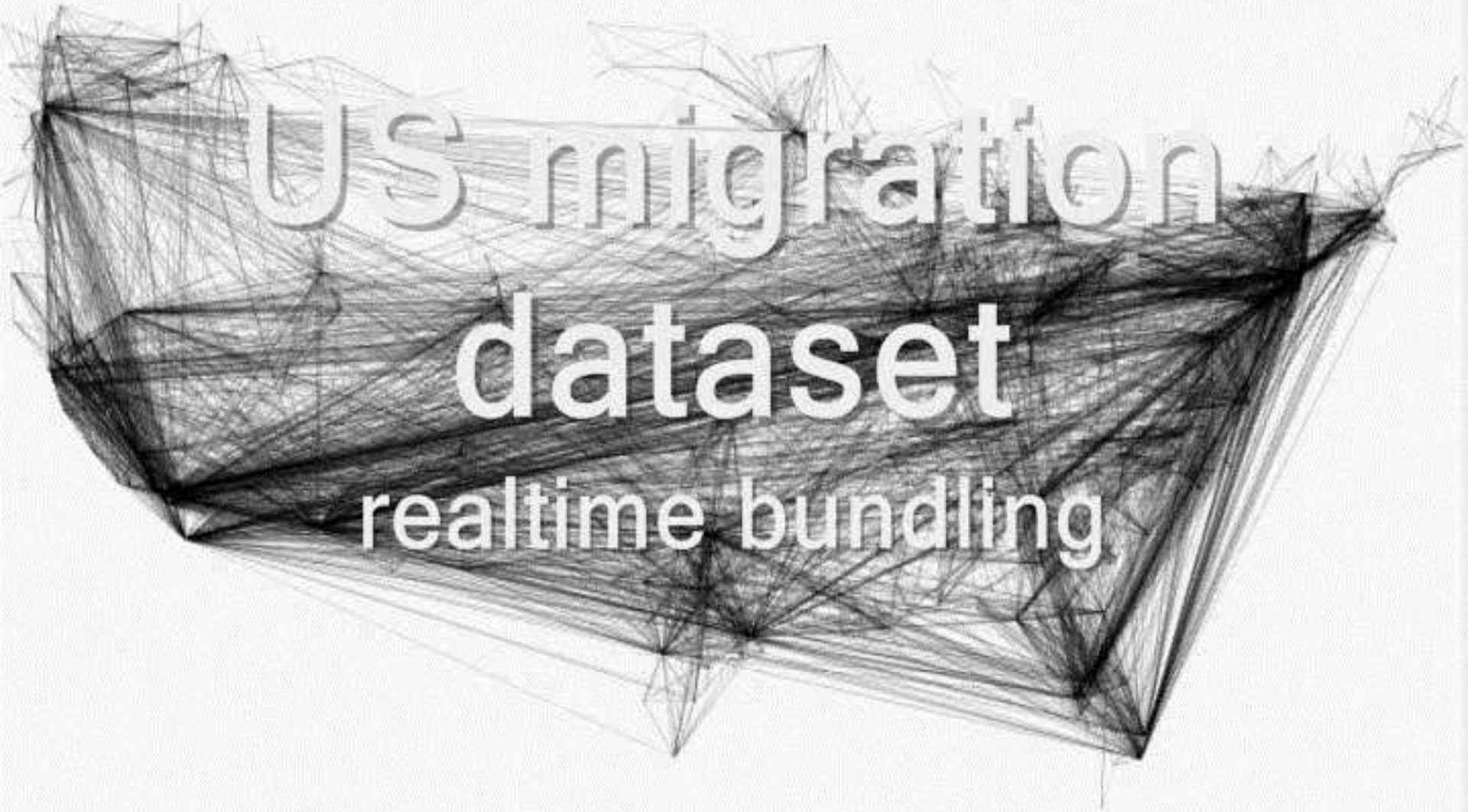
## definitions

Edge bundling techniques trade clutter for overdraw by routing related edges along similar paths.

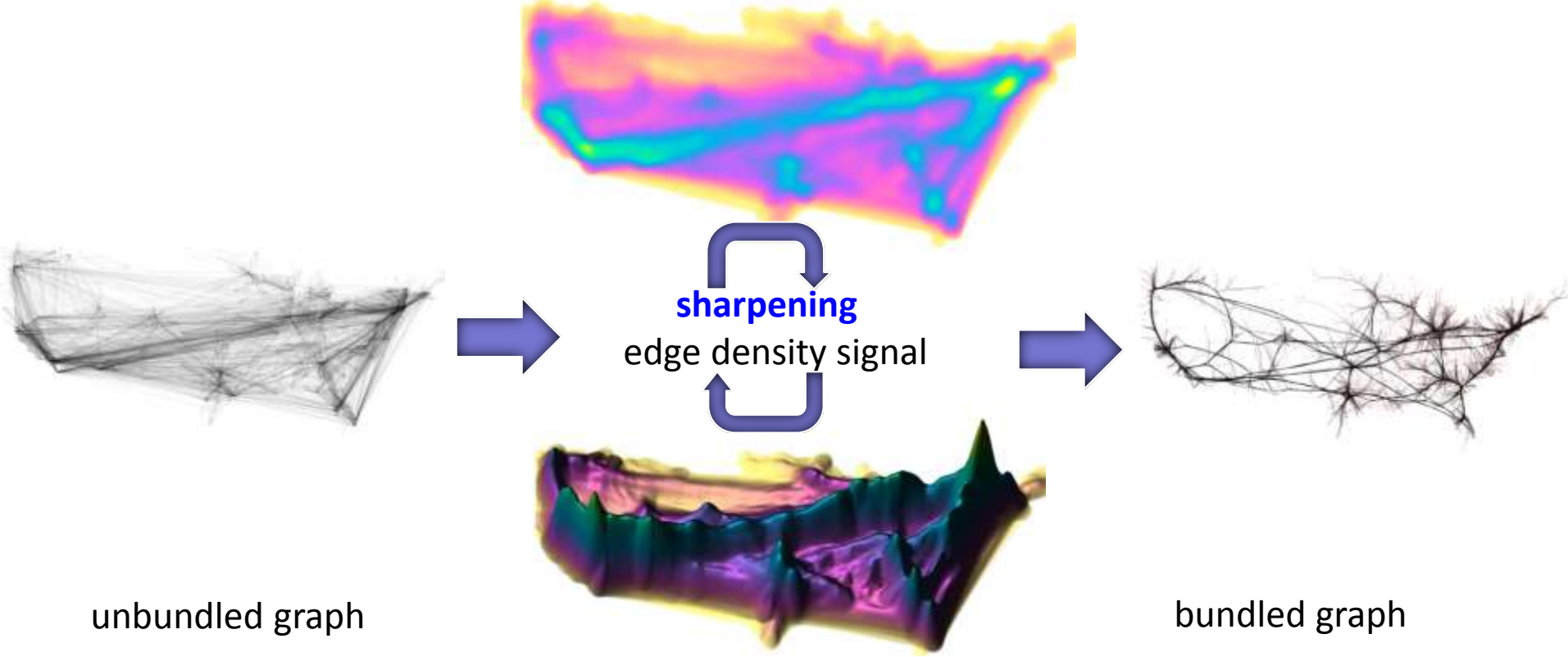
Bundling can be seen as sharpening the edge spatial density, by making it high along bundles and low elsewhere.

Bundling improves readability for finding node-groups related to each other by edge-groups (bundles) which are separated by white space.

Christophe Hurter, Ozan Ersoy, Alexandru Telea.
**Graph Bundling by Kernel Density Estimation.**
***EuroVis 2012***

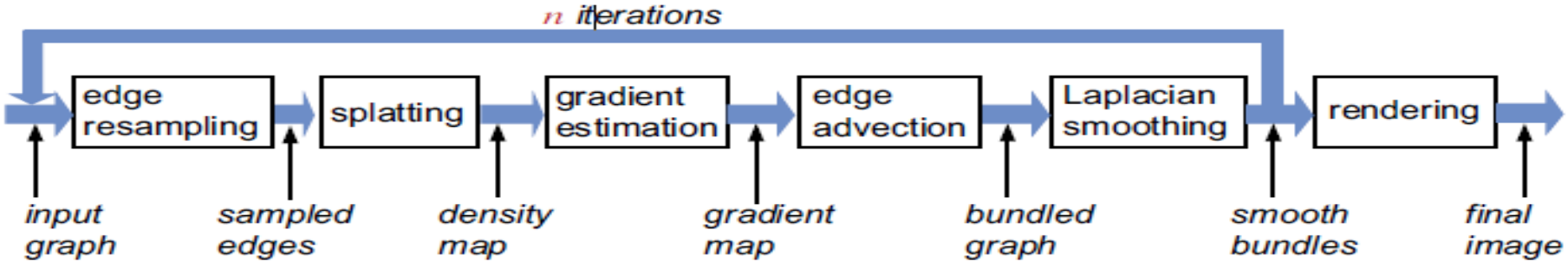

US migration
dataset
realtime bundling

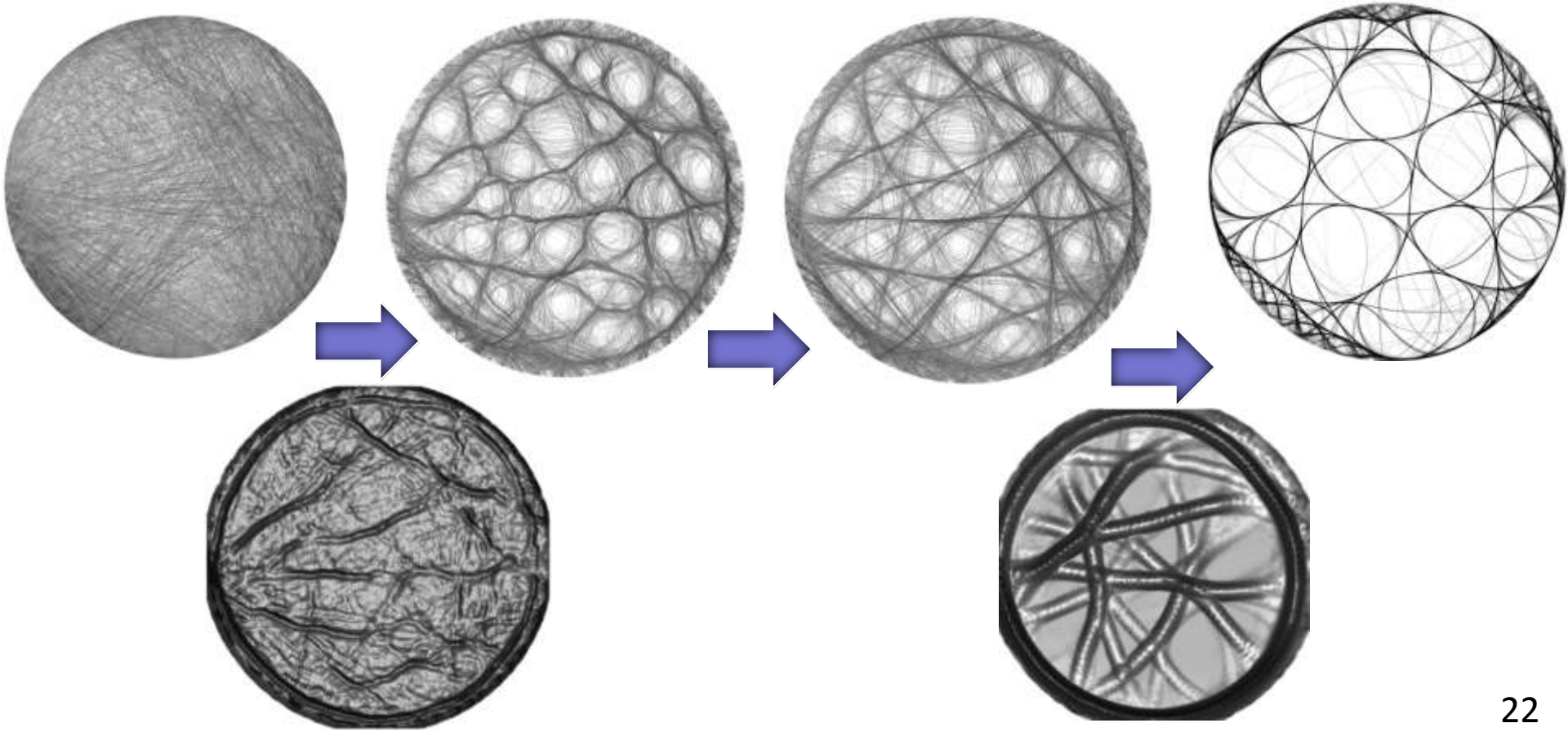
# Hence our bundling idea (mean shift algorithm)

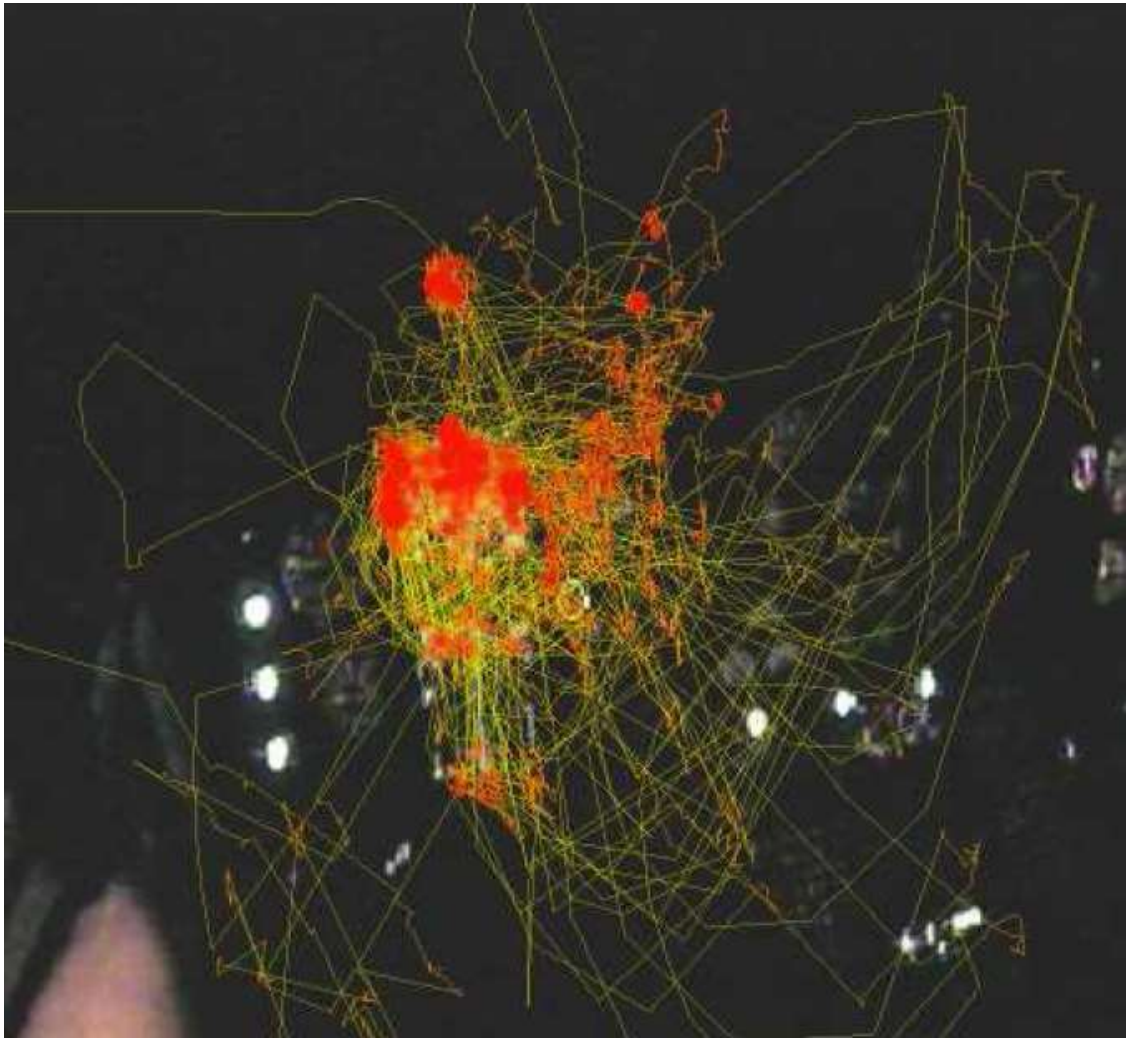


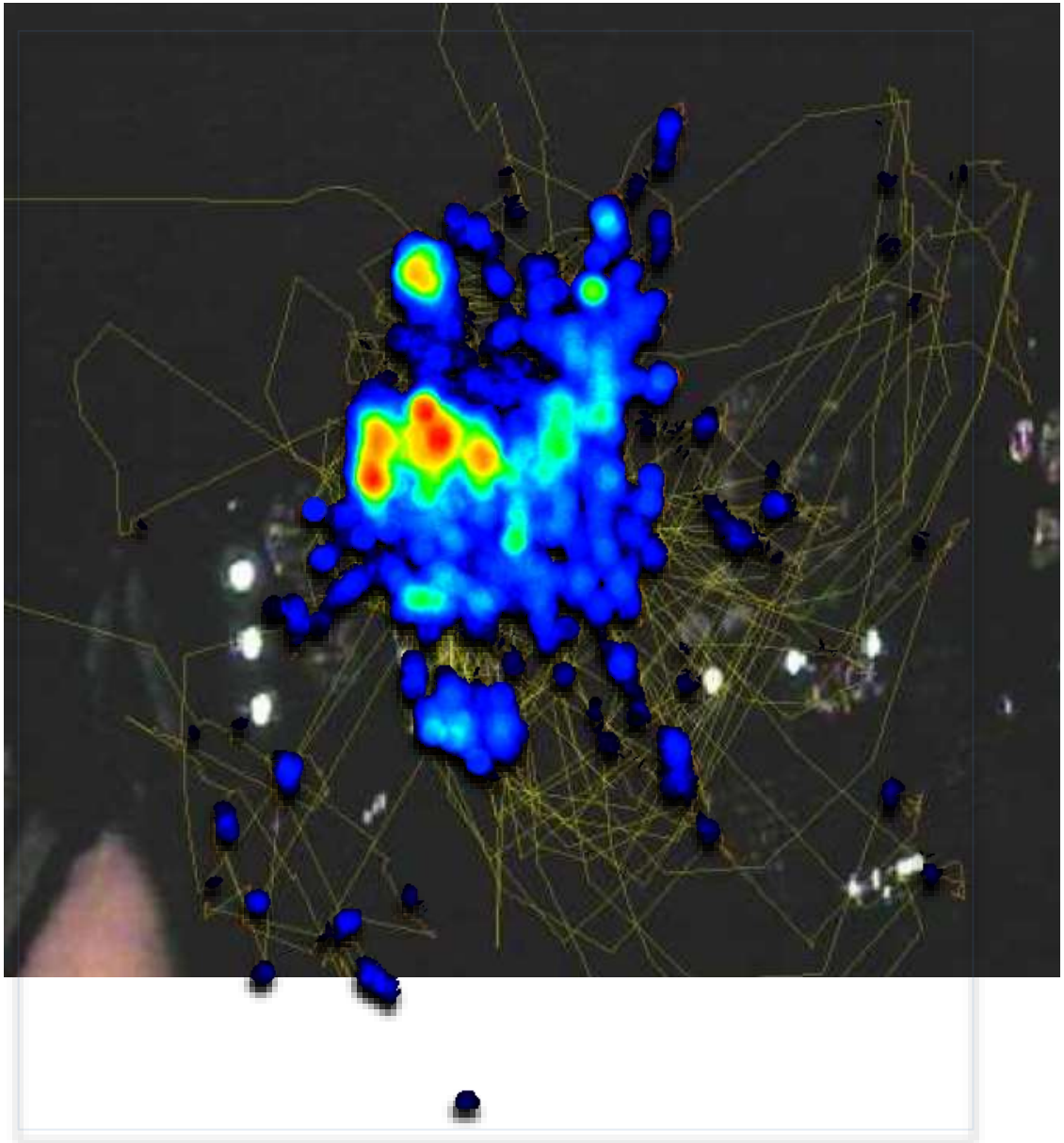

If bundling **sharpens** the **edge density**, then **sharpening** the edge density should **bundle**

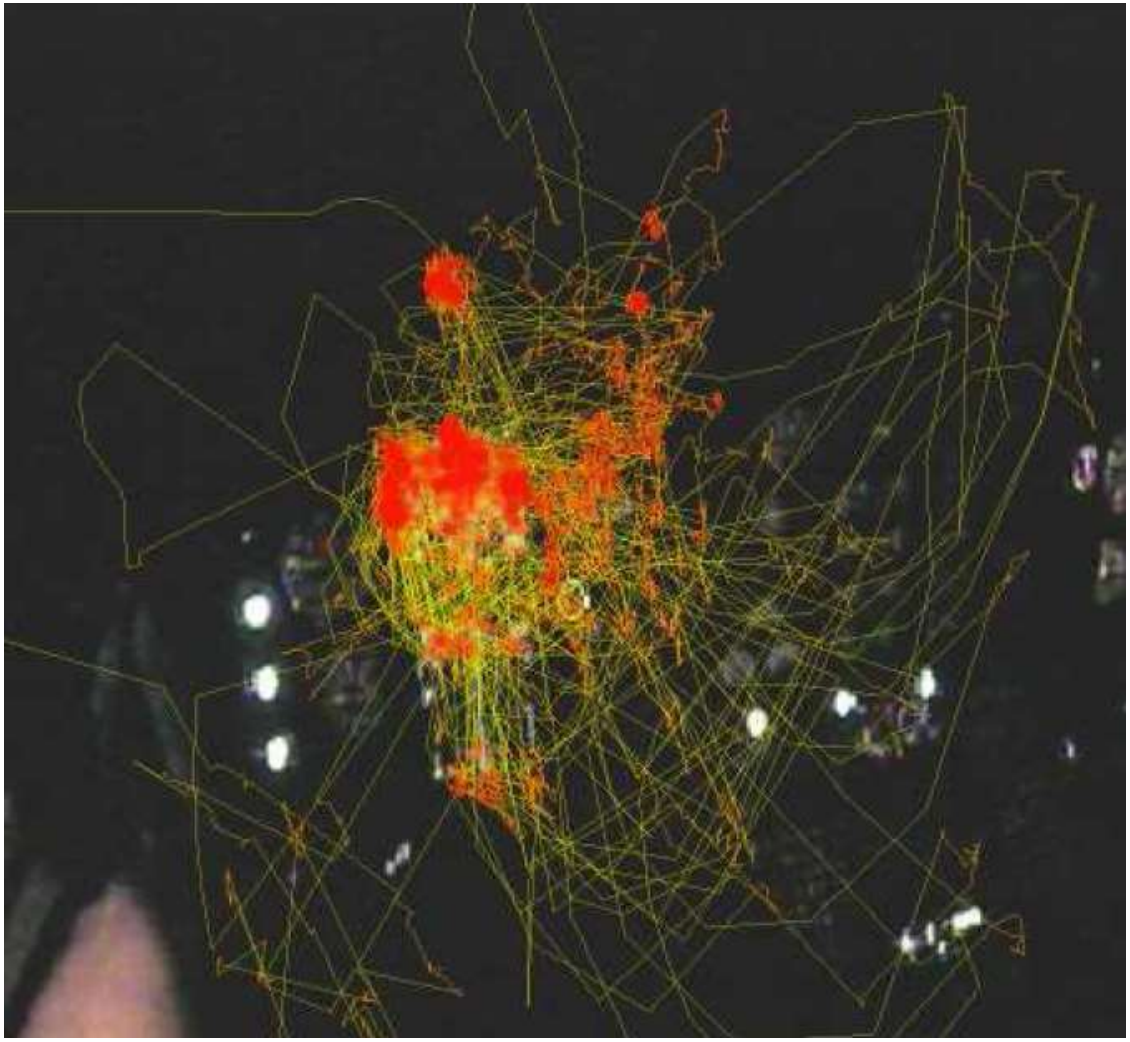
# KDEEB pipeline

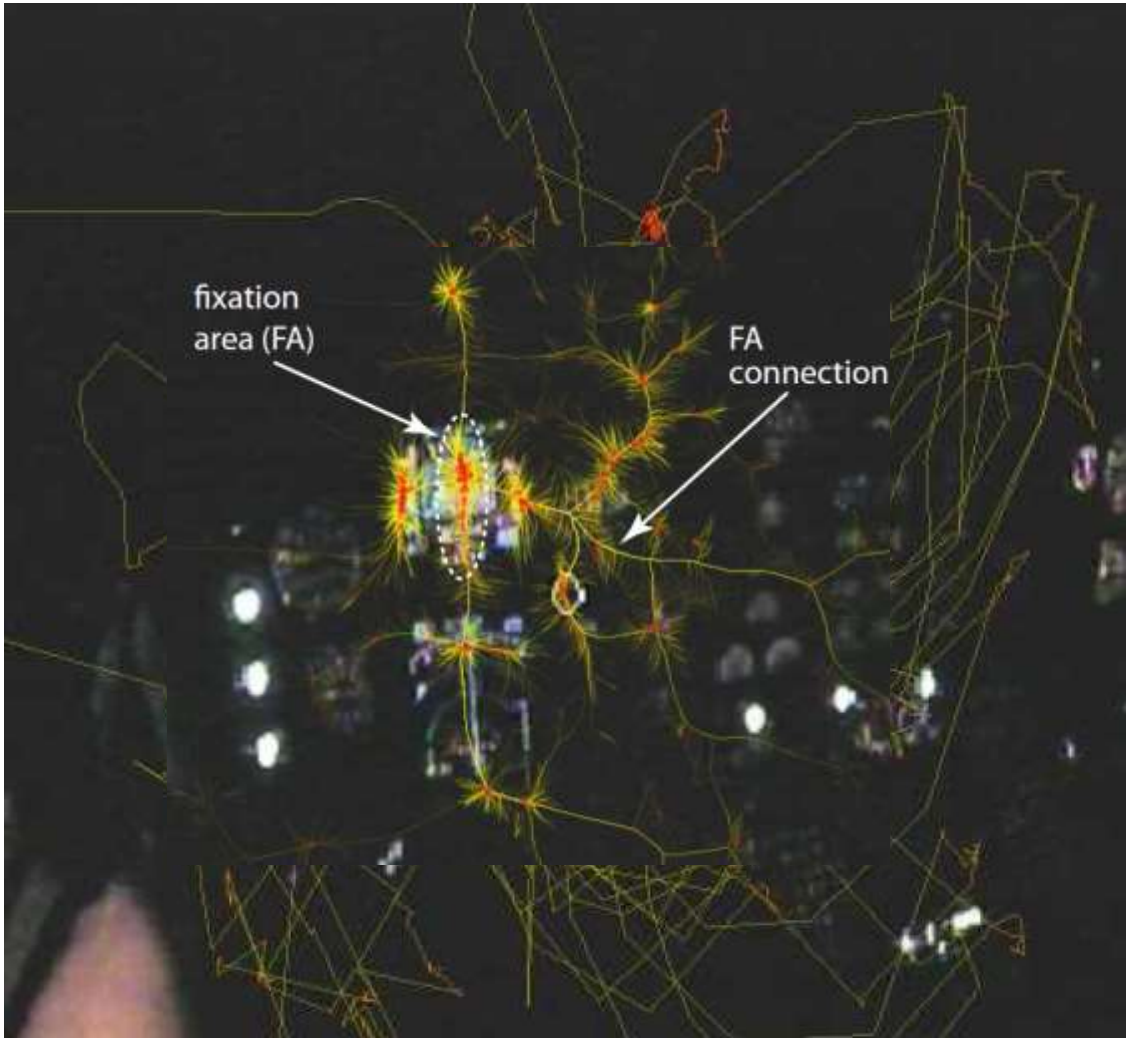




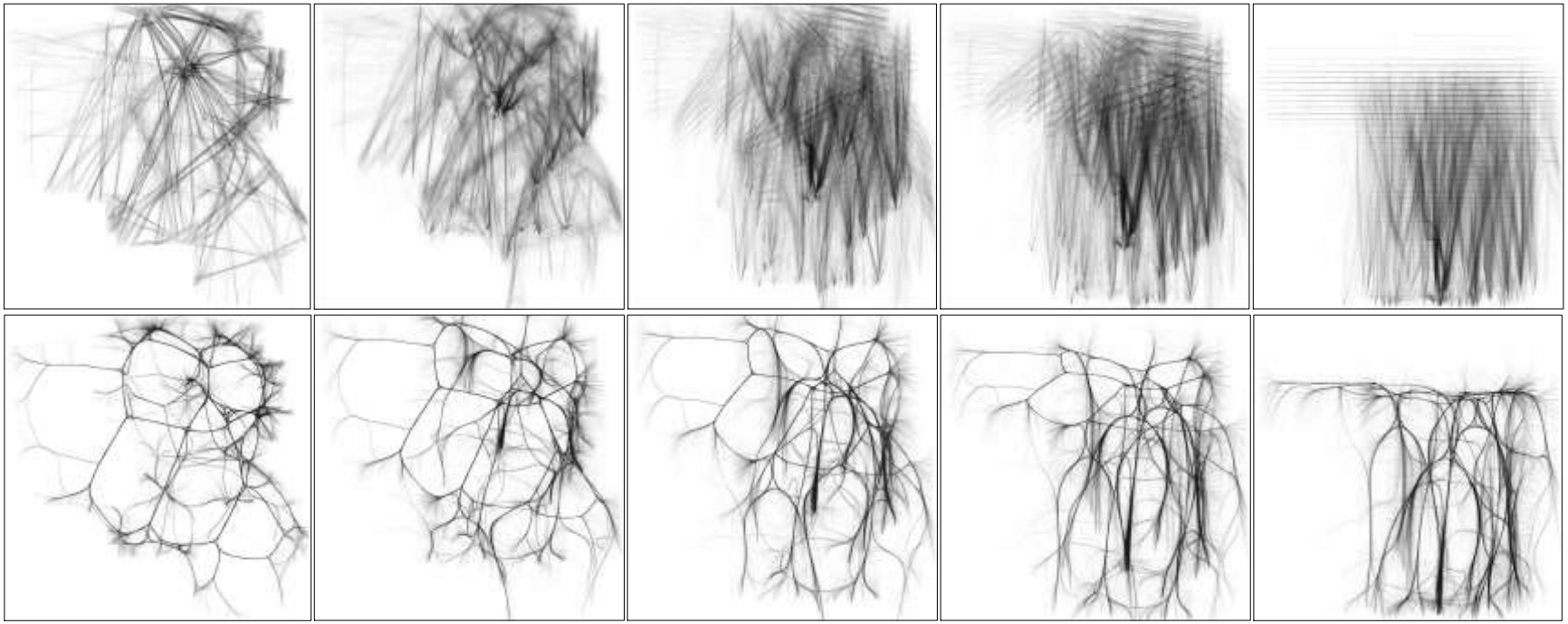




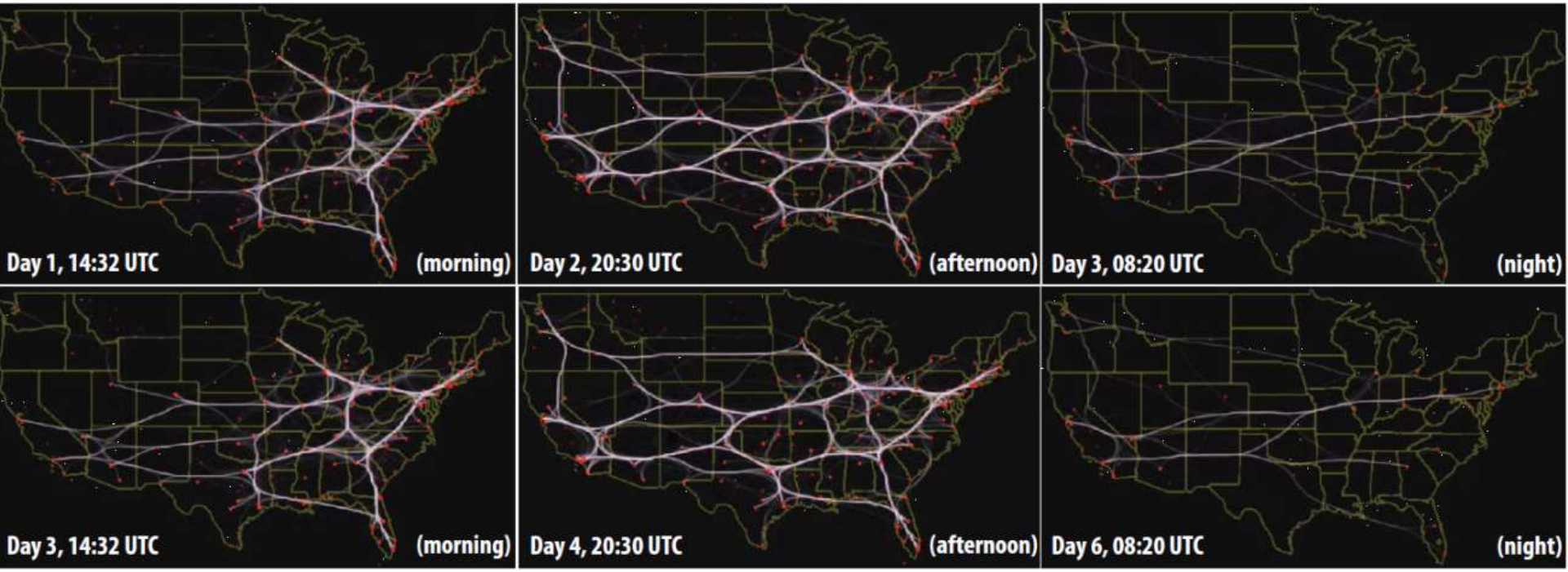



Hurter, C.; Ersoy, O.; Fabrikant, S.; Klein, T.; Telea, A.,
**Bundled Visualization of Dynamic Graph and Trail Data.**
(TVCG) *Visualization and Computer Graphics, IEEE Transactions on* , vol.PP, no.99, pp.1,1
doi= 10.1109/TVCG.2013.246

# 3D Bundling



# Bundled Visualization of Dynamic Graph and Trail Data.




Christophe Hurter, Ozan Ersoy, Alexandru Telea
**Smooth Bundling of Large Streaming and Sequence Graphs.**
(PacificVis 2013) *Visualization Symposium (PacificVis), 2013 IEEE Pacific* , vol., no., pp.41,48, Feb. 27 2013-March 1 2013. ***honorable mention PacificVis 2013***

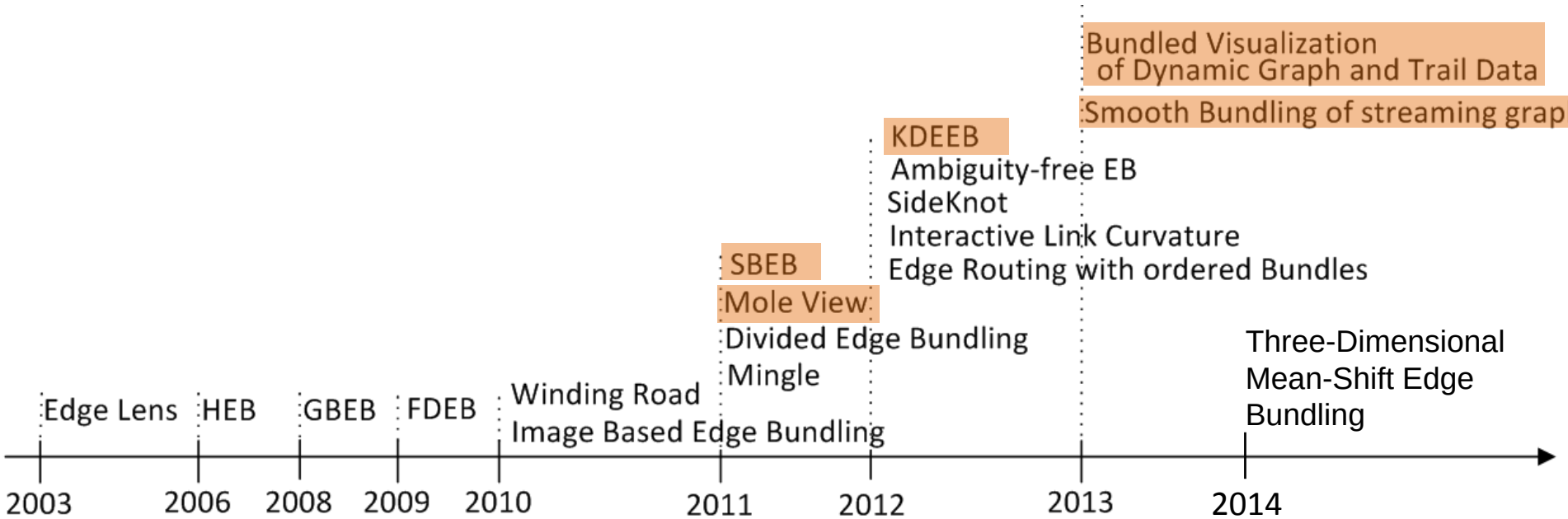
# Demo mouse bundling

# Instance of pixel based algorithm KDEEB

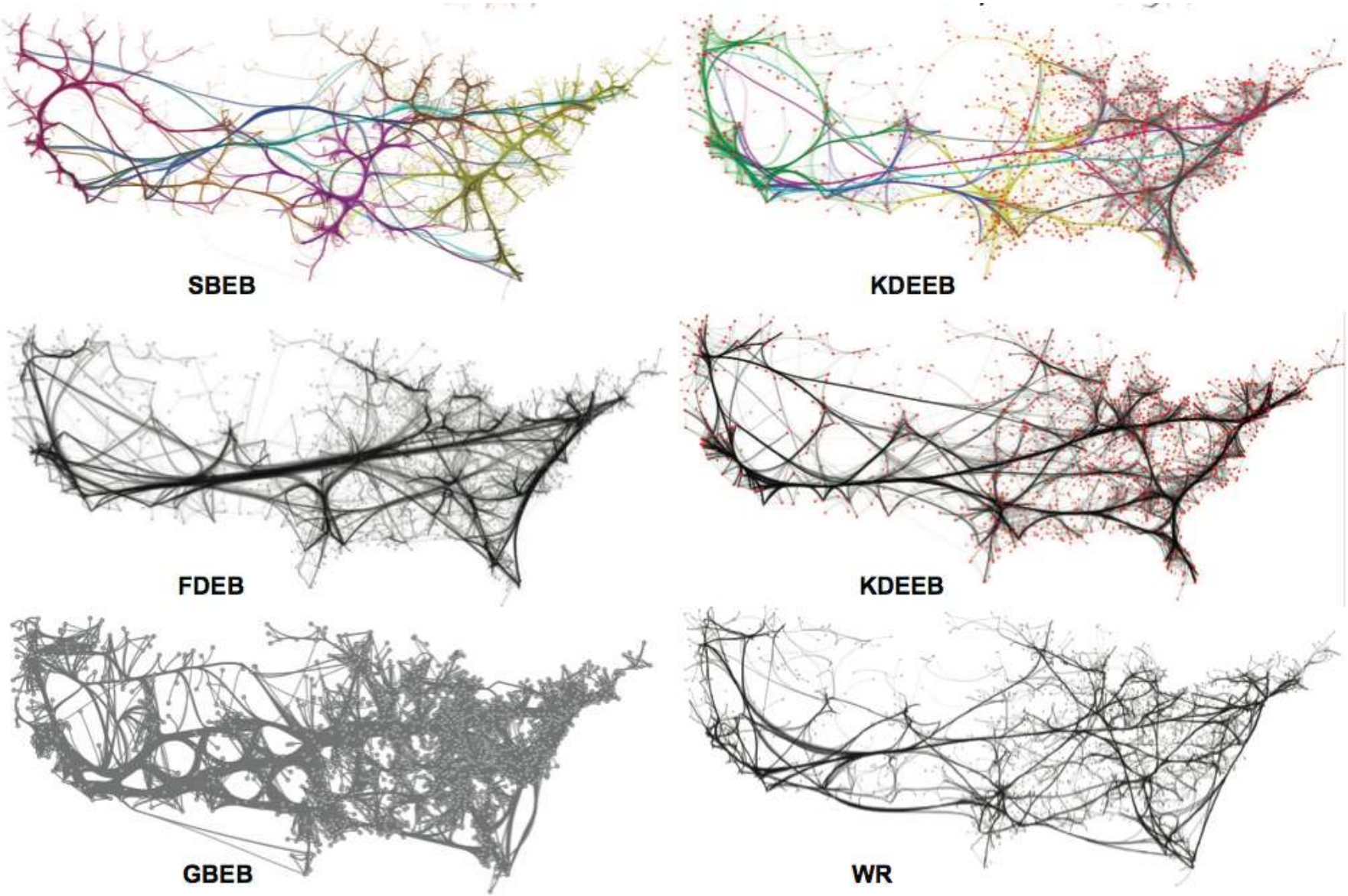
KDEEB assets :

- Flexibility (no need of clustering, applicable to general graph)
- Few parameters
- Allows dynamic visualization
- Fast implementation(CPU or GPU)

# Edge Bundling papers



# Comparison: Bundling style

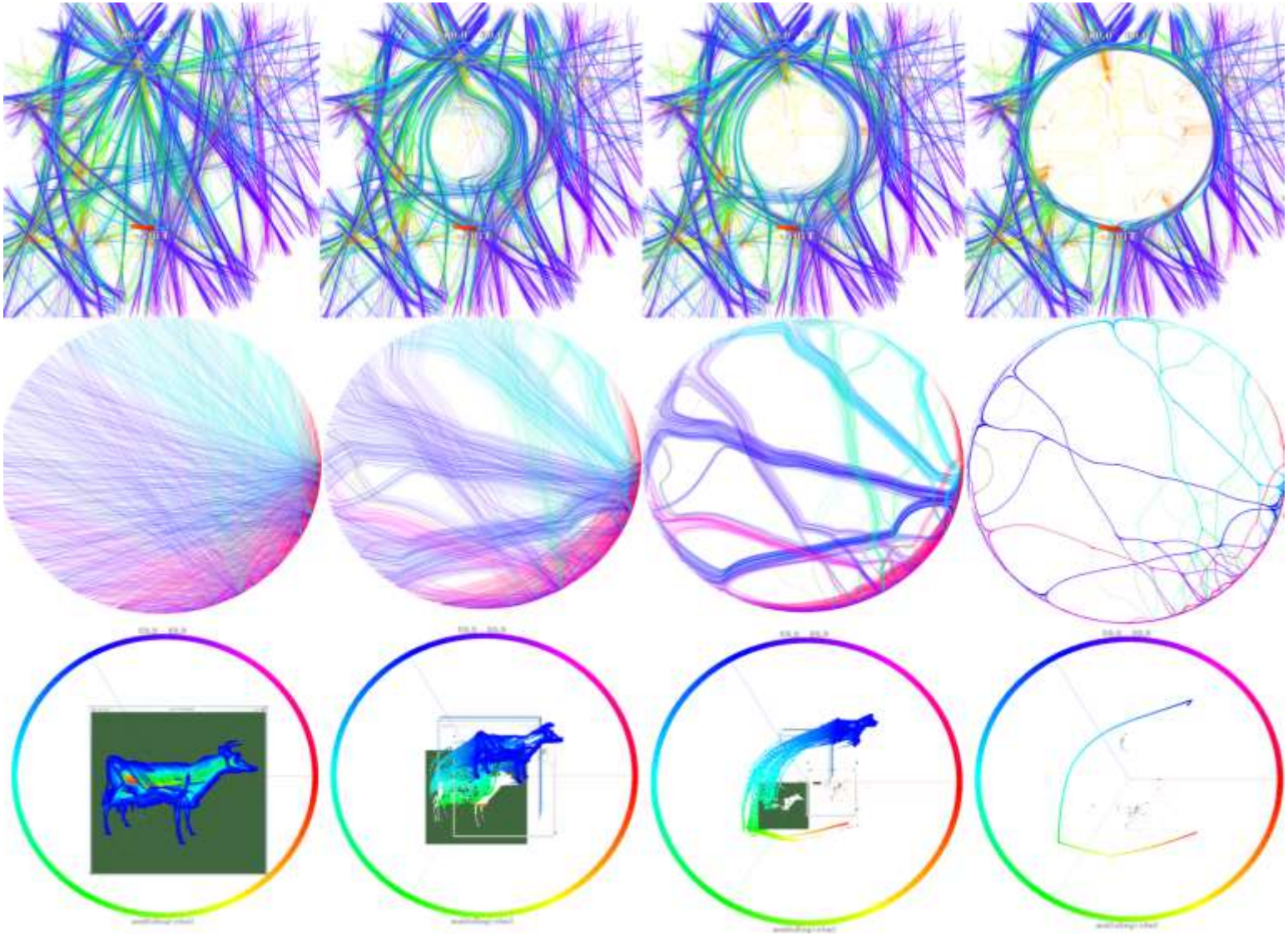


**View animation**

MoleView

ColorTunneling

# The MoleView



Christophe Hurter, Ozan Ersoy and Alexandru Telea. 2011.
**MoleView: An Attribute and Structure-Based Semantic Lens for Large Element-Based Plots.**
***InfoVis 2011***

# Design rationale

MoleView

Focus + context technique

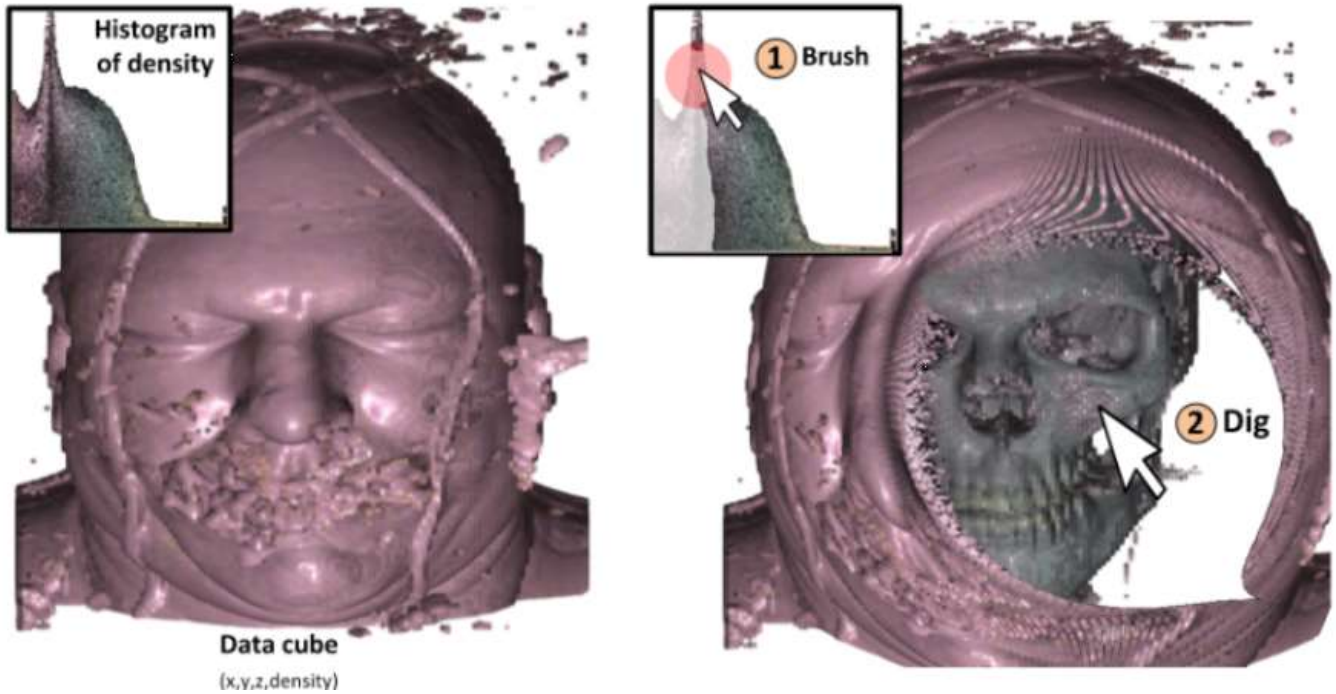
Interactive exploration of multivariate relational data

Specific deformations include distance-based repulsion of scatterplot points, deforming straight-line node-link graph drawings, and as varying the simplification degree of bundled edge graph layouts.

Using a brushing-based technique, complex selection of the zones of interest.

# Color Tunneling

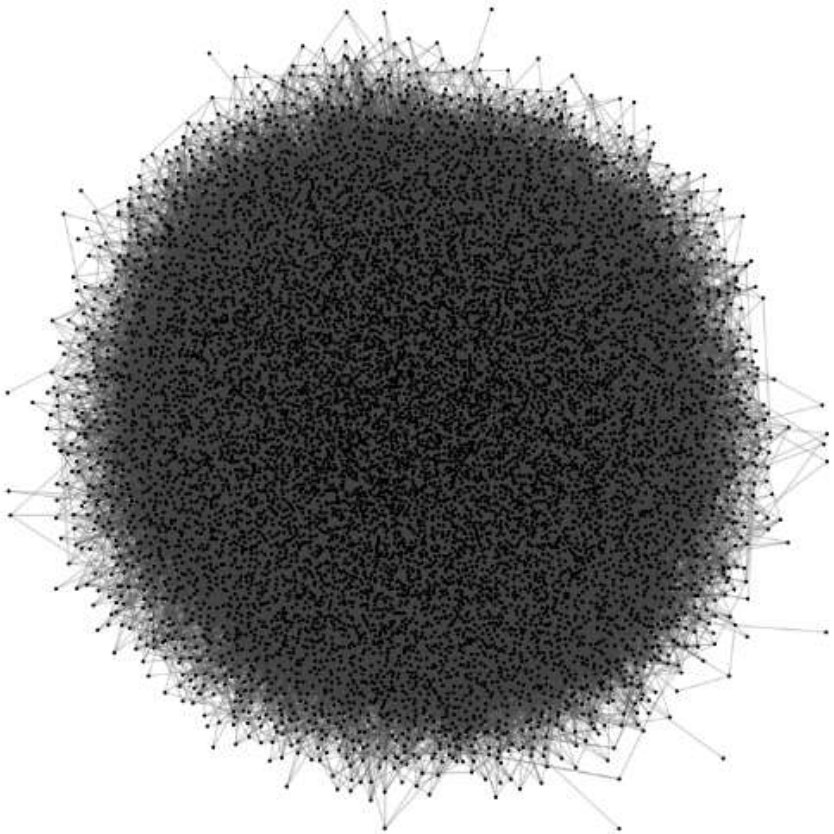
## Pixel based visualization technique




C. Hurter, A. R. Taylor, S. Carpendale and A. Telea
**Color Tunneling : Interactive Exploration and Selection in Volumetric Datasets**
***PacificVis 2014***

# Research question

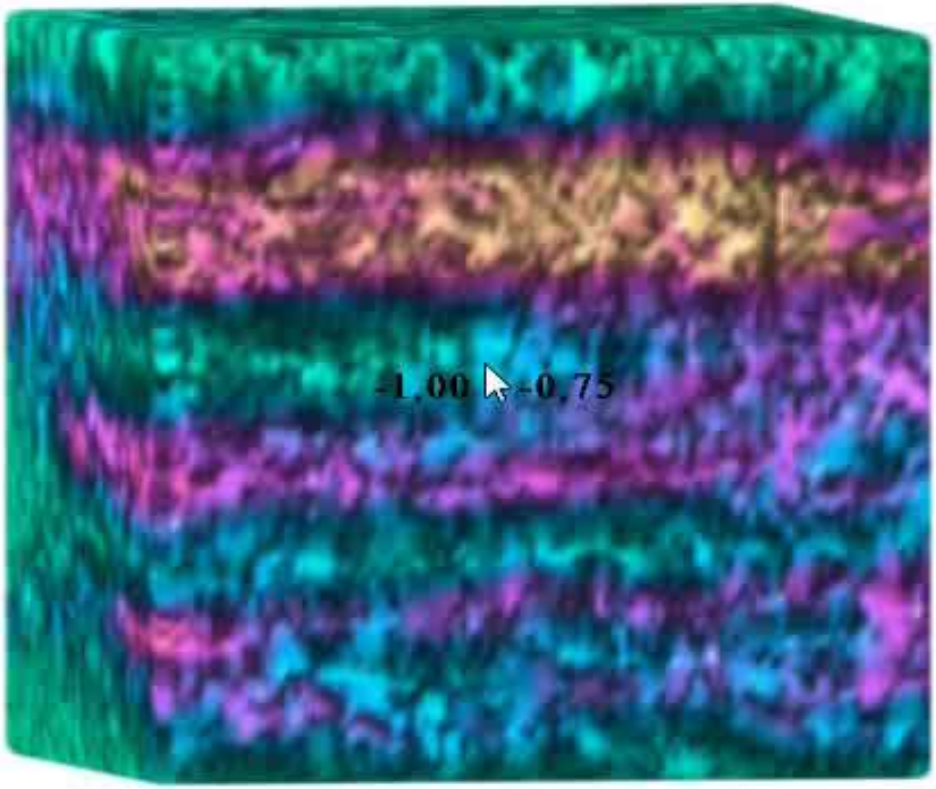
How to deal with large data set visualization and **data occlusion** ?



# Method

We provide a set of **real-time** multi-dimensional data deformation techniques that aim to help

users to easily **select, analyze**, and **eliminate** spatial-and-data **patterns**.



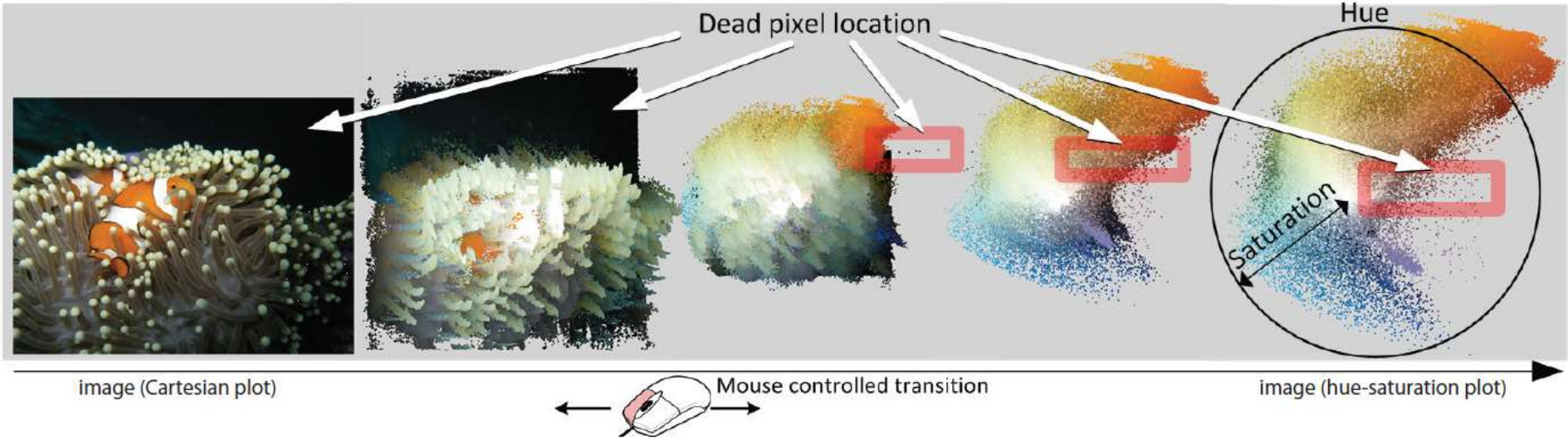
# Design rationale

- Real-time multi-dimensional data deformation techniques.
- Animation between view configurations semantic filtering and view deformation.
- Any data subset can be selected at any step along the animation.

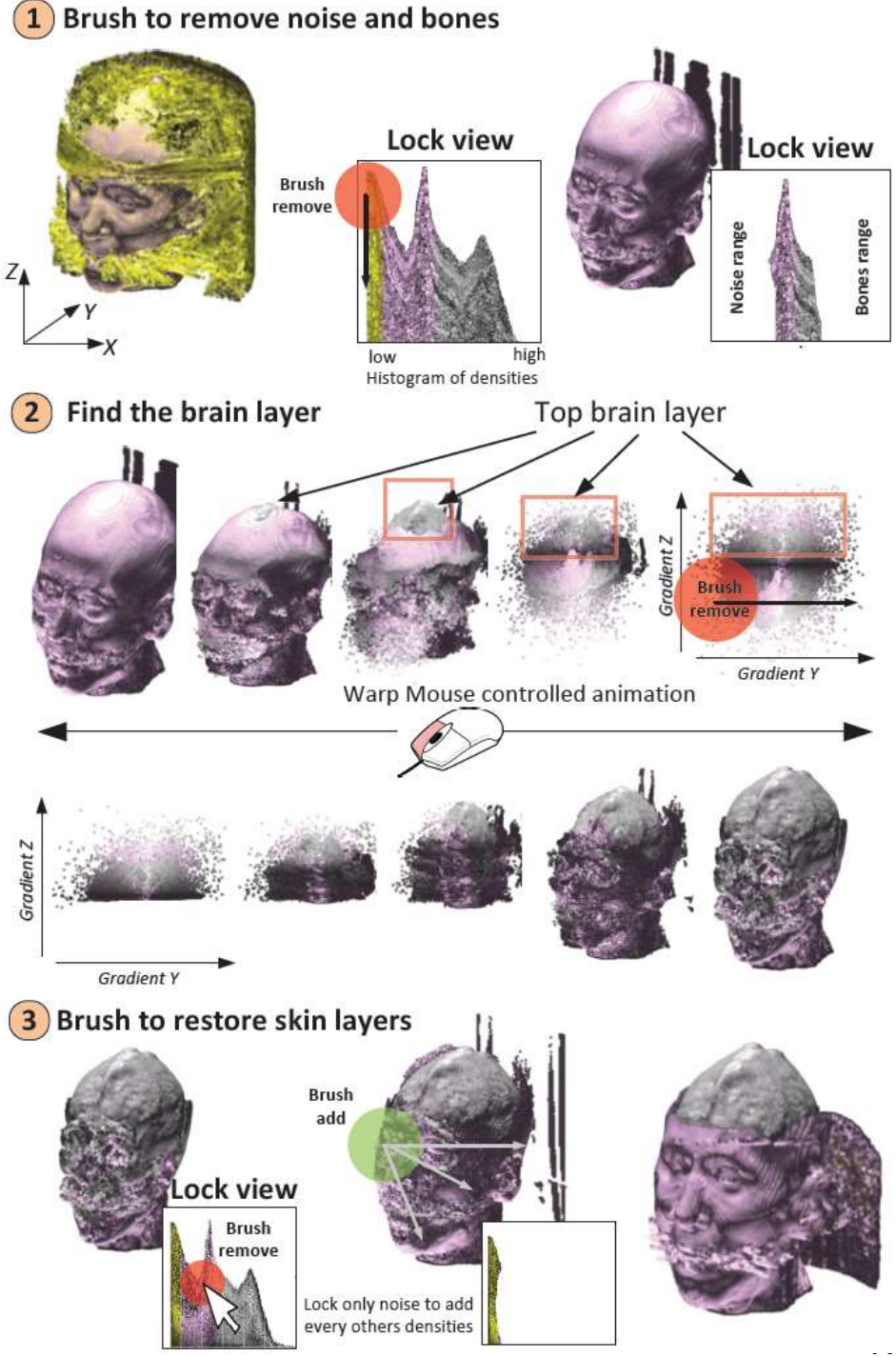
Implementation with **pixel based interaction technique** (GPGPU)

# Contributions

## **Animation** as an efficient exploration tool

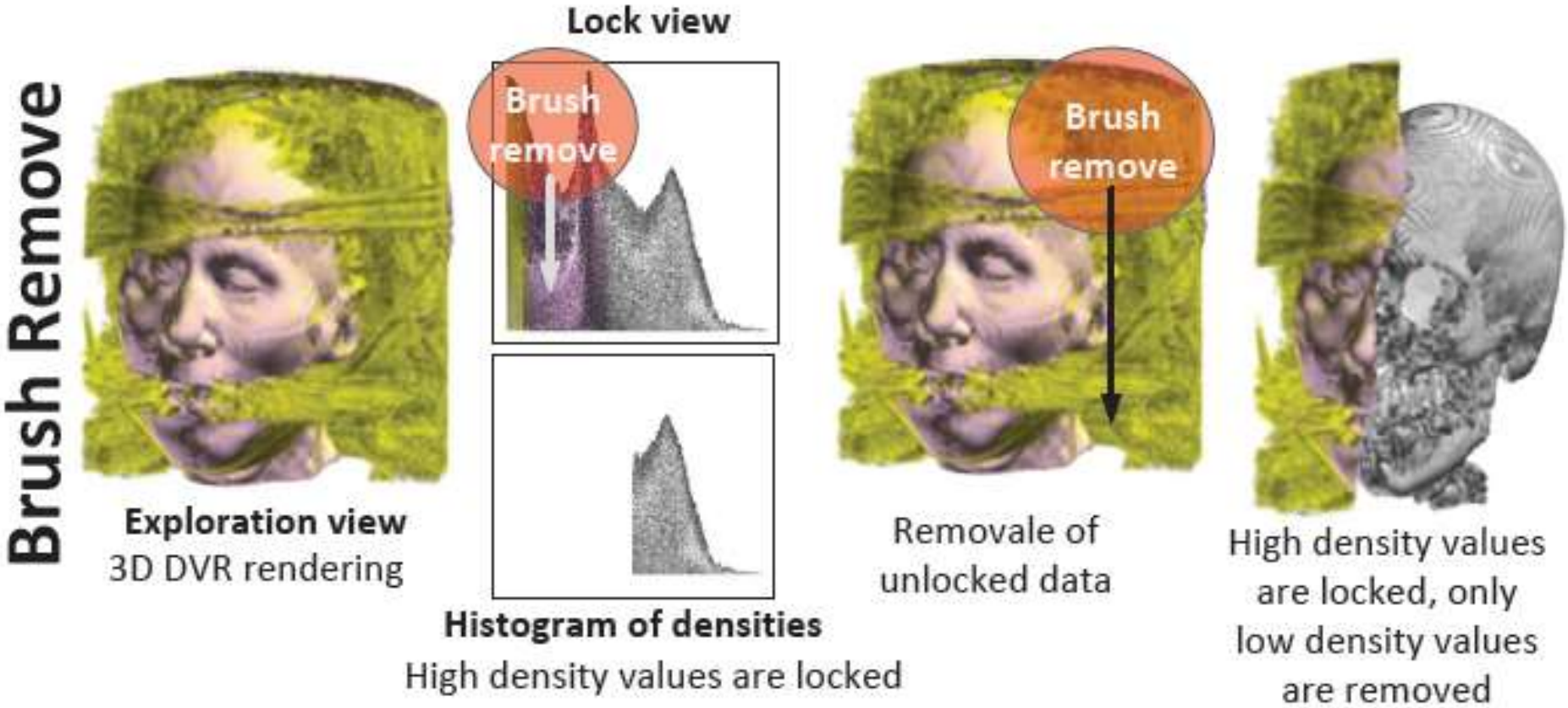


# Use case 2: CT scan exploration



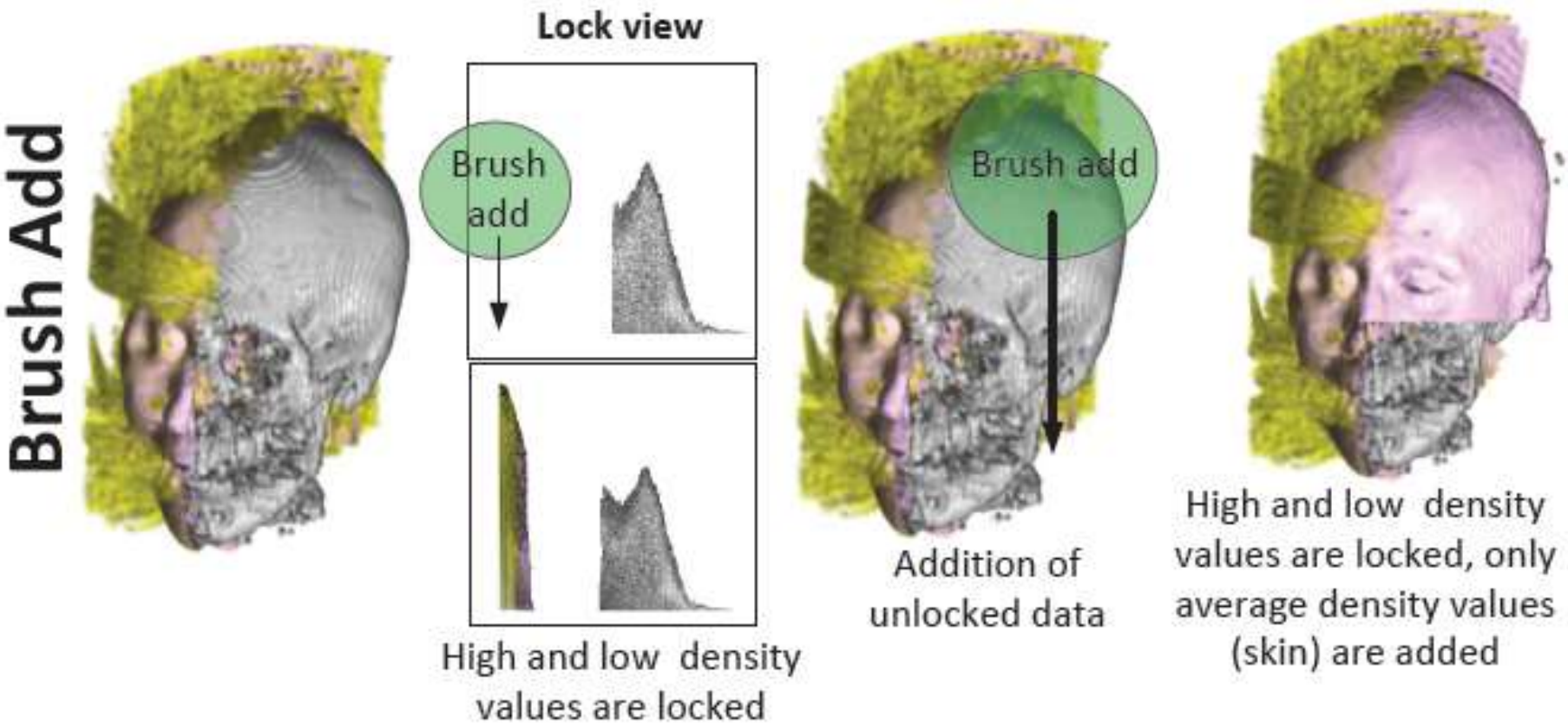
# Contributions

## **new interaction**, the lock view



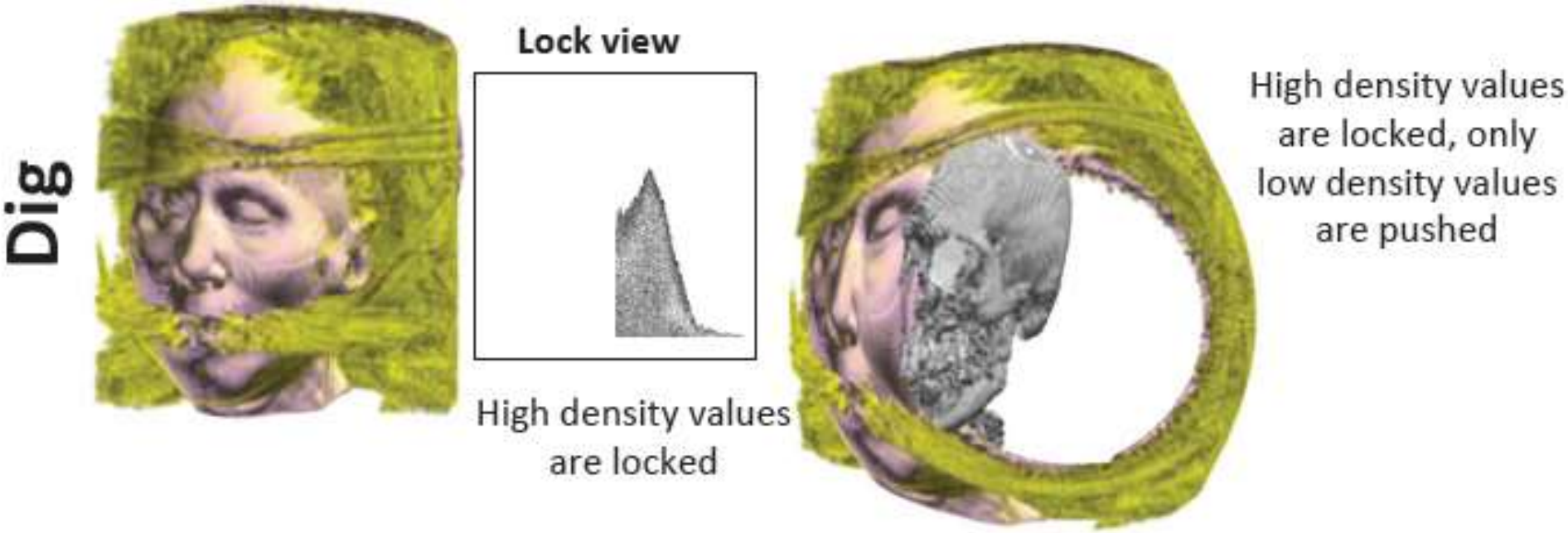
# Contributions

## **new interaction**, the lock view

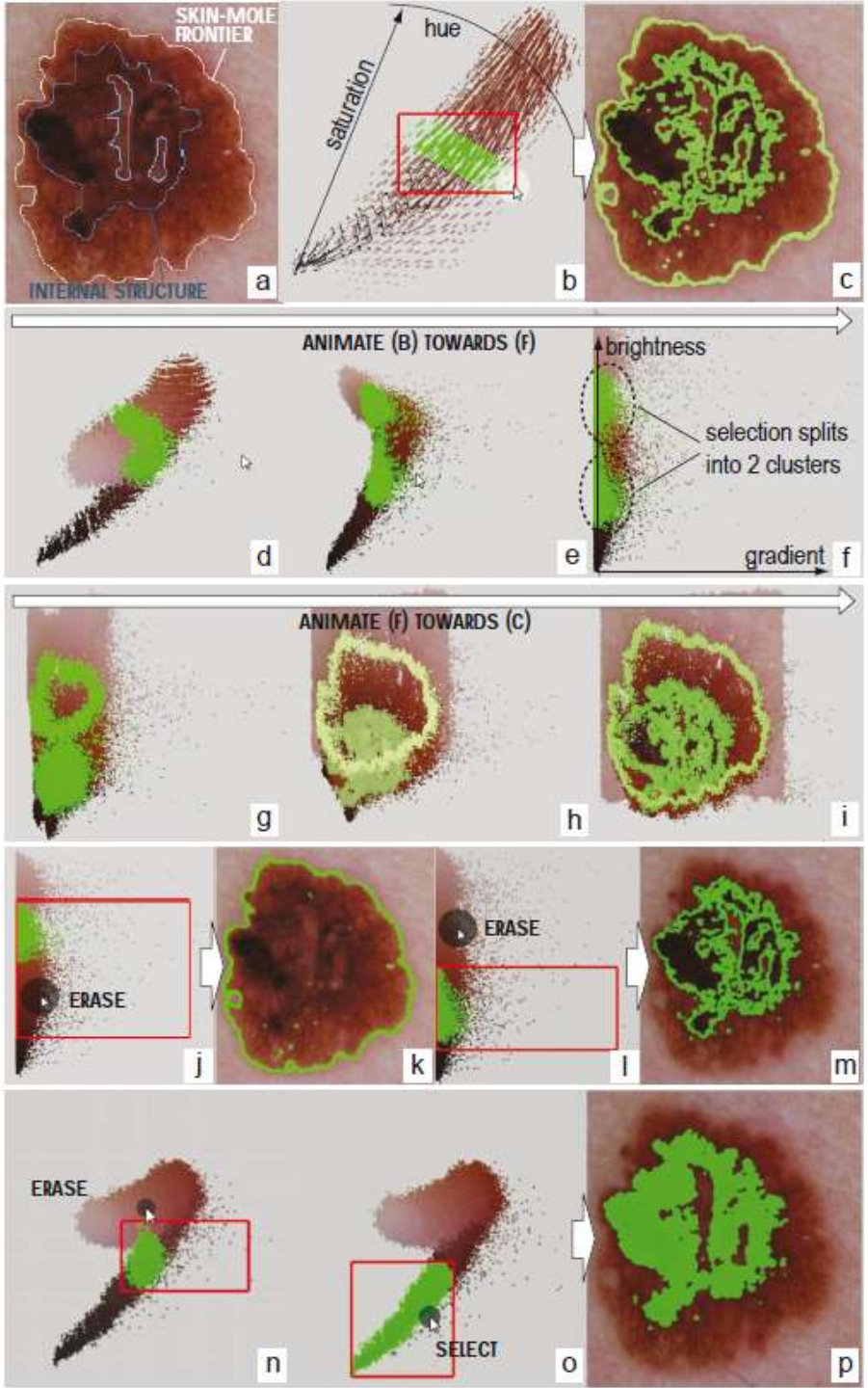


# Contributions

## **new interaction**, the lock view



# Use case 3: image segmentation

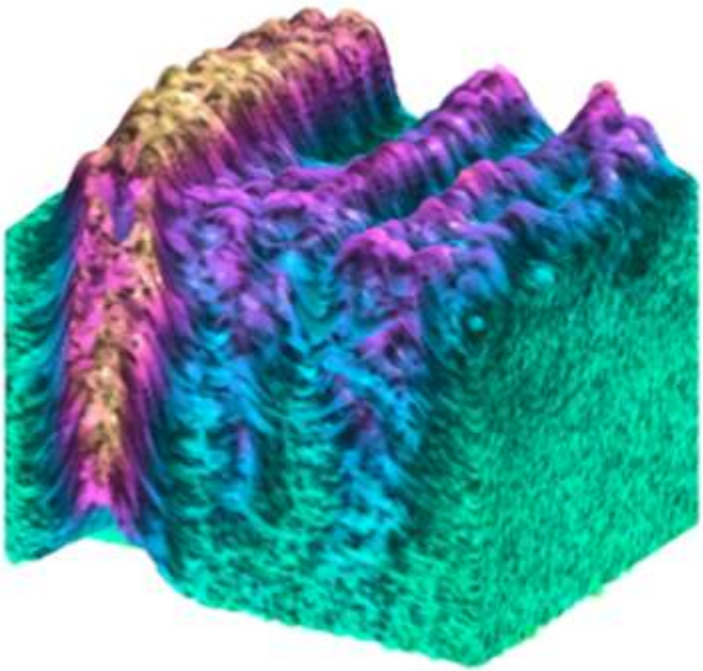


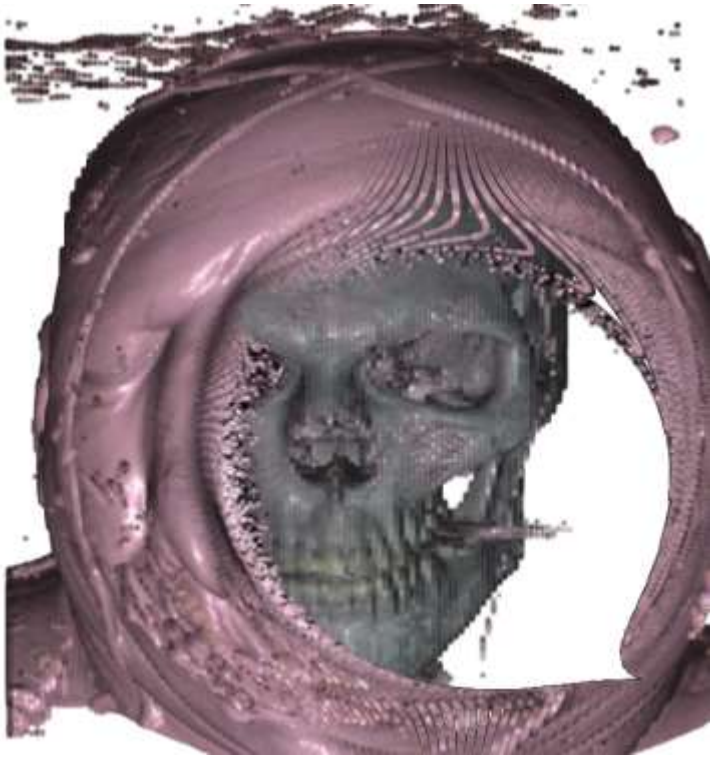
# Contributions

## GPGPU technique

**Transform feedback** :

GPU implementation able to handle over 10M displayed data points at a frame rate of 20 images per second on a modern graphic card.





# CONCLUSIONS

# Summary of pixel-based techniques

- FromDaDy:
  - Brushing lines and points
  - Density maps

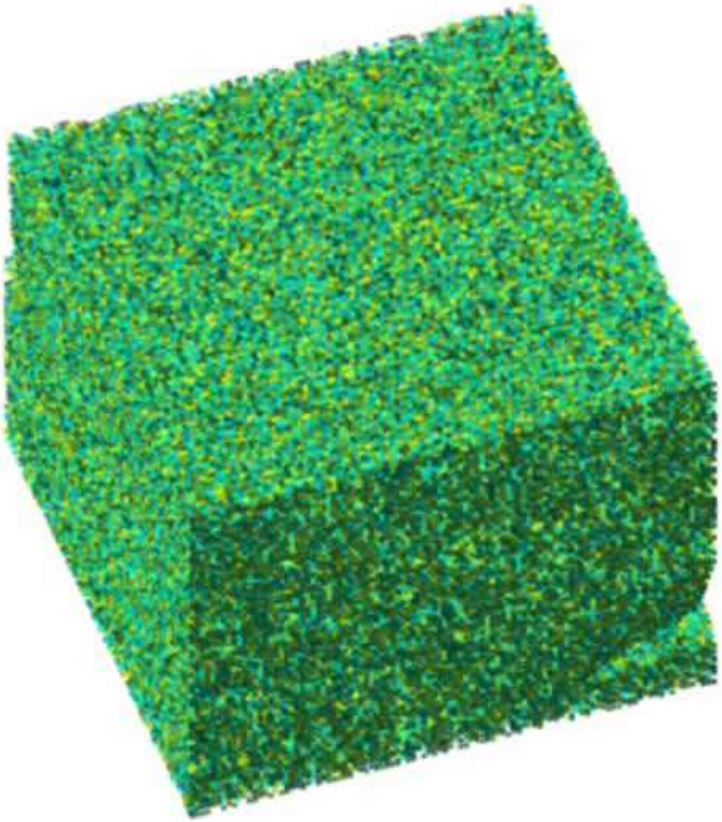
- KDEEB/ dynamic KDEEB / multi dimentional B
  - Density maps
  - Geometry computation
  - shading

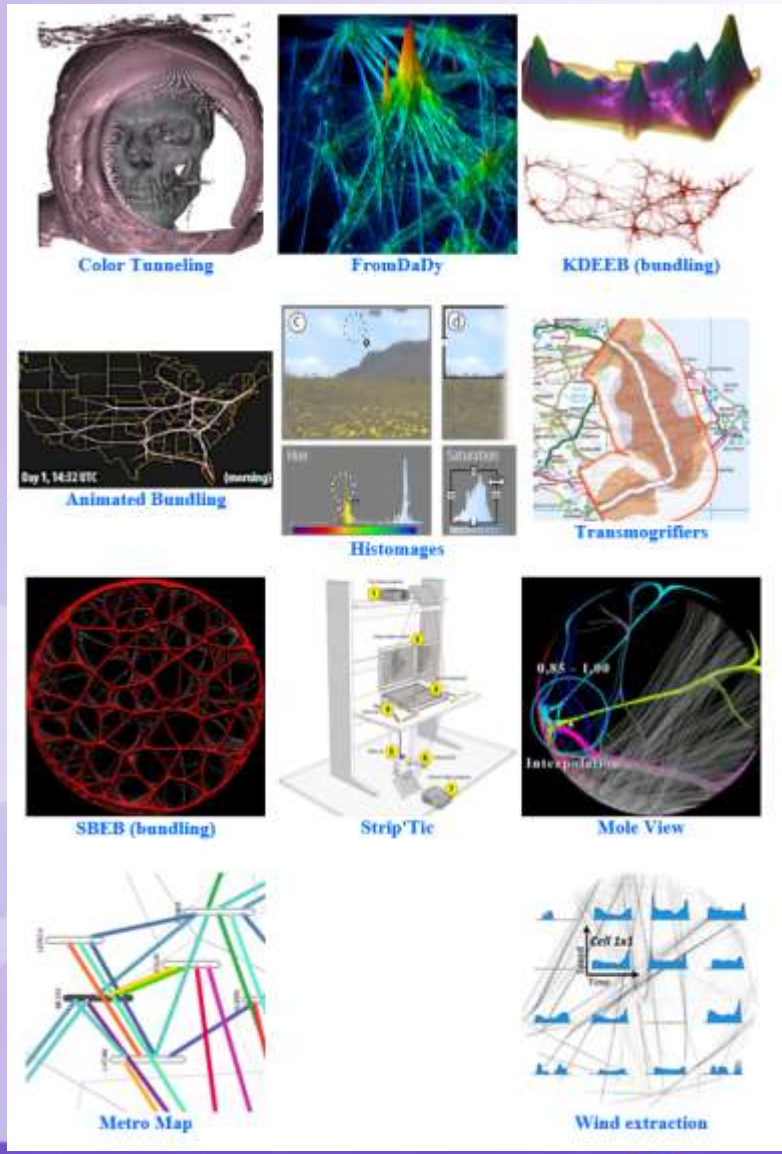
- MoleView
  - fixed pipeline, scalability issues
- ColorTunneling
  - Render feedback buffer (pan/zoom/interpolation)
  - OpenCL for filtering

*ENAC- Ecole Nationale de l'Aviation Civile*
Toulouse, France

# Christophe Hurter

http://www.recherche.enac.fr/~hurter/





# Main Publications


C. Hurter, M. Cordeil, A. R. Taylor, S. Carpendale and A. Telea
**Color Tunneling : Interactive Exploration and Selection in Volumetric Datasets**
PacificVis 2014

Hurter, C.; Ersoy, O.; Fabrikant, S.; Klein, T.; Telea, A.,
**Bundled Visualization of Dynamic Graph and Trail Data.**
(TVCG) *Visualization and Computer Graphics, IEEE Transactions on* , vol.PP, no.99, pp.1,1

Christophe Hurter, Ozan Ersoy, Alexandru Telea.
**Smooth Bundling of Large Streaming and Sequence Graphs**.
(PAcificVis 2013) Proceedings of IEEE Pacific Visualization 2013

Catherine Letondal, Christophe Hurter, Jean-Luc Vinot, Rémi Lesbordes and Stéphane Conversy.
**Strip'TIC: designing a paper-based tangible interactive space for air traffic controllers.**
(CHI 2013) In Proceedings of ACM SIGCHI 2013.

Maxime Cordeil, Christophe Hurter, Stéphane Conversy and Mickaël Causse
**Assessing and Improving 3D Rotation Transition in Dense Visualizations.**
*(BCS-HCI'13)*In *Proc. of the 27th BCS Conference on Human Computer Interaction*

Christophe Hurter, Rémi Lesbordes, Catherine Letondal, Jean-Luc Vinot and Stéphane Conversy**.**
**Strip'TIC: Exploring Automatic Paper Strip for Air Traffic Controllers.**
(AVI '12) In Proceedings of the International Working Conference on Advanced Visual Interfaces, Genny Tortora, Stefano Levialdi, and Maurizio Tucci (Eds.). ACM, New York, NY, USA, 225-232.

Christophe Hurter, Ozan Ersoy, Alexandru Telea.
**Graph Bundling by Kernel Density Estimation**.
(EuroVis 2012). Computer Graphics Forum 31, 3pt1 (june 2012) p865 874.

Ozan Ersoy, Christophe Hurter, Fernando Paulovich, Gabriel Cantareiro, and Alex Telea. 2011.
**Skeleton-Based Edge Bundling for Graph Visualization**.
(InfoVis 2011), IEEE Transactions on Visualization and Computer Graphics 17, 12 (December 2011), 2364-2373.

Christophe Hurter, Ozan Ersoy and Alexandru Telea. 2011.
**MoleView: An Attribute and Structure-Based Semantic Lens for Large Element-Based Plots.**
(InfoVis 2011) IEEE Transactions on Visualization and Computer Graphics 17, 12 (December 2011), 2600-2609.

Hurter, C., Serrurier, M., Gilles, T., and Vinot, J. 2010. **An automatic generation of metro-like maps to display Flight Routes for Air Traffic Controllers: structure and color optimization**. Conference Proceedings of AVI'10, Advanced Visual Interfaces, Roma, Italy may 2010, ACM Press.

Christophe Hurter, Benjamin Tissoires, Stéphane Conversy.
**FromDaDy: spreading data across views to support iterative exploration of aircraft trajectories.**
(Infovis 2009) In IEEE Transactions on Visualization and Computer Graphics xx(y), (Proceedings of IEEE InfoVis 2009). IEEE Transactions on Visualization and Computer Graphics, vol. 15, no. 6, pp. xxviv-xxvv, Nov./Dec. 2009.