Image based algorithm to support interactive data exploration

20th November 2014
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
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
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
Kernel Density Based Edge Bundling
22 million vertexes

Shading
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

1. **Input graph**
2. **Edge resampling**
3. **Splatting**
4. **Gradient estimation**
5. **Edge advection**
6. **Laplacian smoothing**
7. **Rendering**

After each iteration, the process produces:

- **Sampled edges**
- **Density map**
- **Gradient map**
- **Bundled graph**
- **Smooth bundles**
- **Final image**
Hurter, C.; Ersoy, O.; Fabrikant, S.; Klein, T.; Telea, A.,
**Bundled Visualization of Dynamic Graph and Trail Data.**
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.
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

- Three-Dimensional Mean-Shift Edge Bundling
- Smooth Bundling of streaming graphs
- Bundled Visualization of Dynamic Graph and Trail Data
  - Ambiguity-free EB
  - SideKnot
  - Interactive Link Curvature
  - Edge Routing with ordered Bundles
- Mole View:
  - Divided Edge Bundling
  - Mingle
- SBEB
- Winding Road Image Based Edge Bundling

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

d new interaction, the lock view

Brush Add

Lock view

Brush add

High and low density values are locked

Addition of unlocked data

High and low density values are locked, only average density values (skin) are added
Contributions

new interaction, the lock view

High density values are locked, only low density values are pushed
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.
Summary of pixel-based techniques

• FromDaDy:
  – Brushing lines and points
  – Density maps

• KDEEB/ dynamic KDEEB / multi dimensional B
  – Density maps
  – Geometry computation
  – shading
• MoleView
  – fixed pipeline, scalability issues

• ColorTunneling
  – Render feedback buffer (pan/zoom/interpolation)
  – OpenCL for filtering
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.**

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.**

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.**

Christophe Hurter, Ozan Ersoy, Alexandru Telea.

**Graph Bundling by Kernel Density Estimation.**

Ozan Ersoy, Christophe Hurter, Fernando Paulovich, Gabriel Cantareiro, and Alex Telea. 2011.

**Skeleton-Based Edge Bundling for Graph Visualization.**

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.


Christophe Hurter, Benjamin Tissoires, Stéphane Conversy.

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