Advanced Visualization in O'Caml

Laying the Foundations for an Advanced Visualization System in O'Caml

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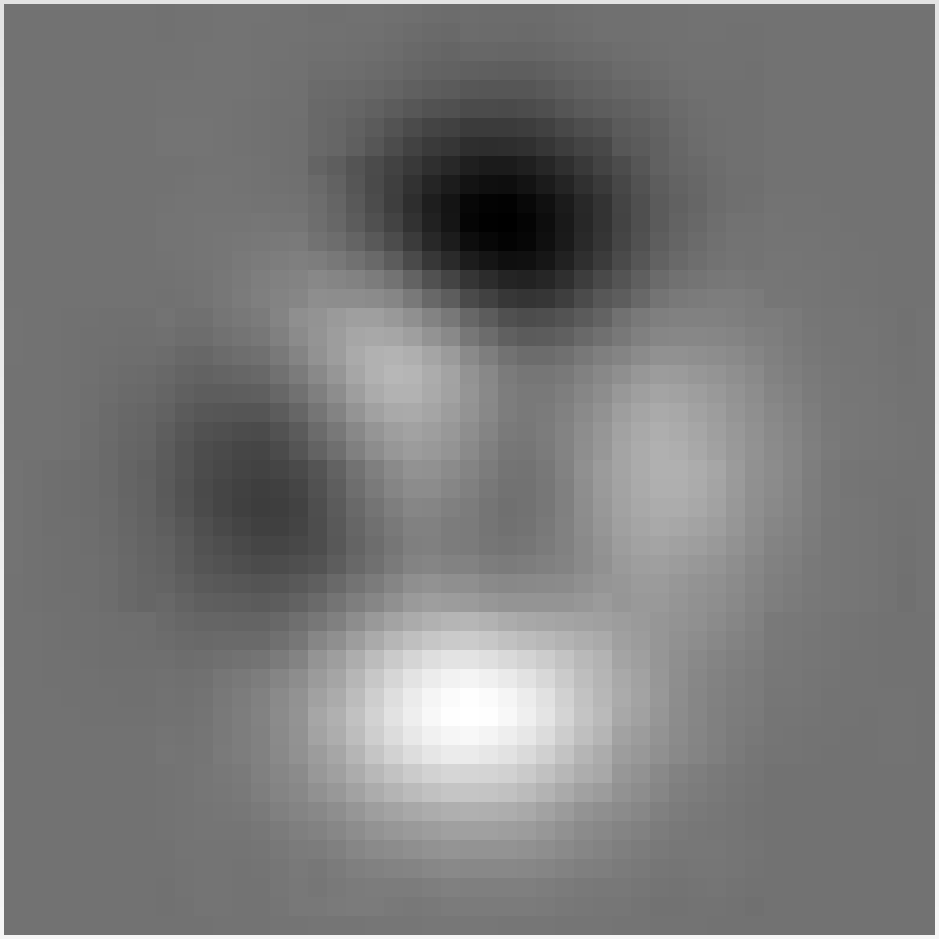
Advanced Visualization in O'Caml

- What is a contour tree?
- Why use a contour tree?
- How to make a contour tree?
- Project status and future work.

What is a contour tree?



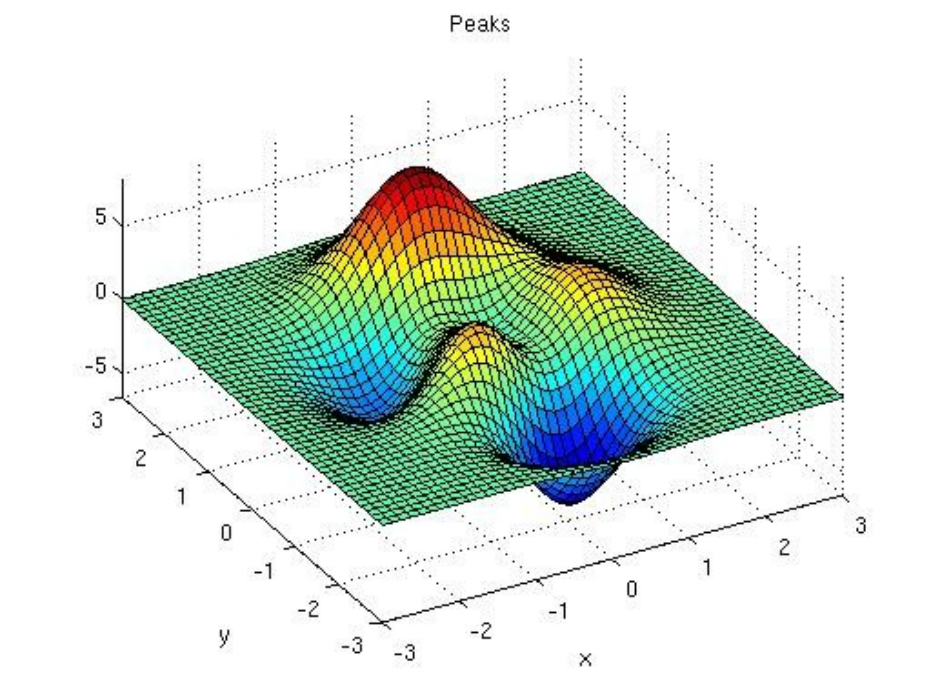
- An image can be viewed as a function:

$$f : \mathbb{R}^2 \rightarrow \mathbb{R}$$

- In general we may consider functions:

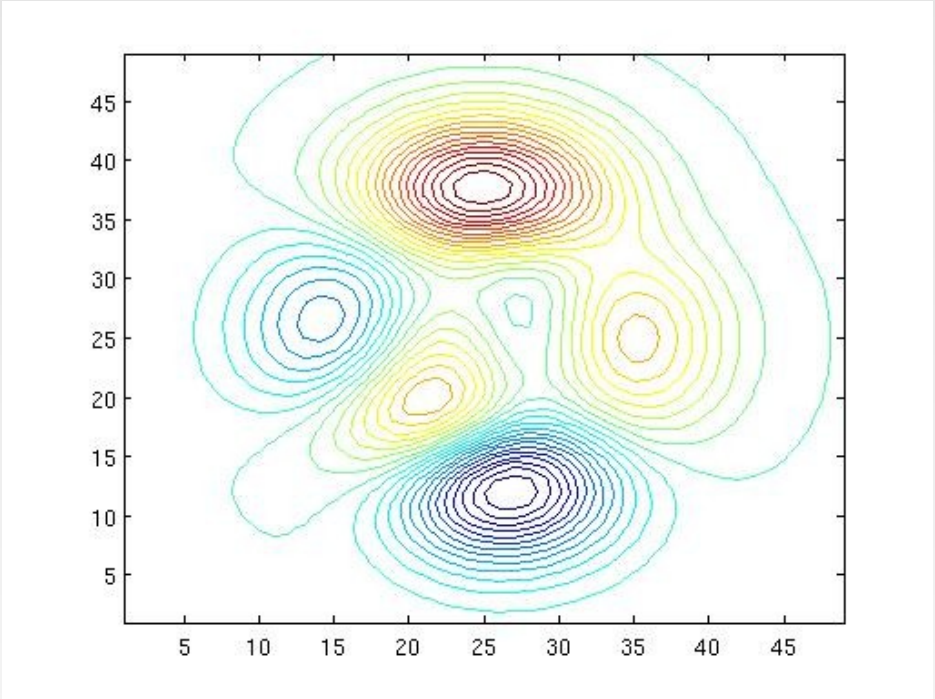
$$f : \mathbb{R}^n \rightarrow \mathbb{R}$$

What is a contour tree?



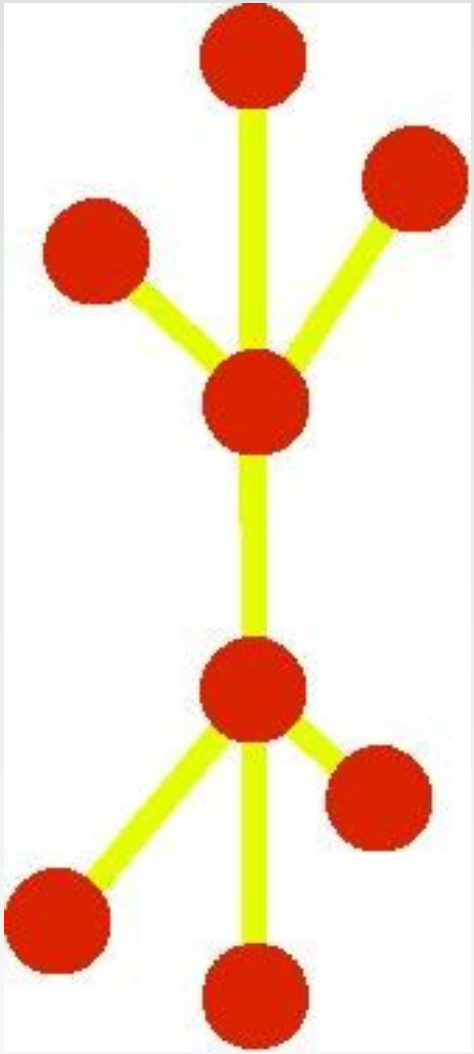
- One may think of such a function as the elevation of a terrain.
- Then we may identify certains points of the terrain as ”critical”.
- These are: minima, maxima, and saddle points.

What is a contour tree?



- We are used to seeing contours on maps indicating the curves of constant elevation.
- A contour is a connected component of a level set of f.

What is a contour tree?



- The contour tree of a function represnts how contours are connected together.
- We explicitly see all the critical points of a function and the connectivity of the level sets.

Why use a contour tree?

- For functions:

$$f : \mathbb{R}^n \rightarrow \mathbb{R}$$

  the levelsets are (n-1)-dimensional.
- However, the contour tree is always a 1-dimensional.
- So it can be used for analysis of high dimensional data.

Why use a contour tree?

- Data associated with levelsets can be assigned to branches of the tree.
- We can pre-compute properties of contours such as:
  - Topolgy (e.g. genus of surface)
  - Surface area
  - Volume enclosed by surface.
  - etc....

Why use a contour tree?

- Data associated with branches of tree can guide visulization algorithms.
- We can store ”seed” cells along branches, which can be used to extract contours.
- The tree can also be used to automatically generate transfer functions for volume rendering.

Why use a contour tree?

- The algorithm generates a multi-scale tree, in which branhces can be filtered out efficiently.
- Thus we may retrieve data or visualize only some relavant portion of the levelset.

How to make a contour tree?

- First construct Join/Split trees.
  - For structured datasets we have a divide and conquer algorithm.
  - Uses a union-find data structure.
- Combine the Join/Split trees to form the contour tree.
  - This step is completely independent of the previous one.
  - Uses a priority queue.

How to make a contour tree?

- Implimenting this algorithm in O'Caml has been quite nice.
- Current results are not perfect.
- However, features such as bigarrays and functors have made for a code base that is easily extendable to datasets of arbitrary dimension.
- I can't imagine a better language for combinatorial algorithm design.

Project Status and Future Work

- Contour tree algorithm: 99%
- Computing seed cells: 33%
- Extracting isocontours: 75% (?)
- GUI: 10%

Project Status and Future Work

- Perfect the contour tree algorithm.
- Get isocontouring working ASAP.
- Augment the isocontouring algorithm with useful topologic/geometric data.
- Improve the GUI.
- Enhance code API and performance.
- Start building the coolset visualization system out there (perhaps merge with Cap's OVS...)

Thank You!

Questions?