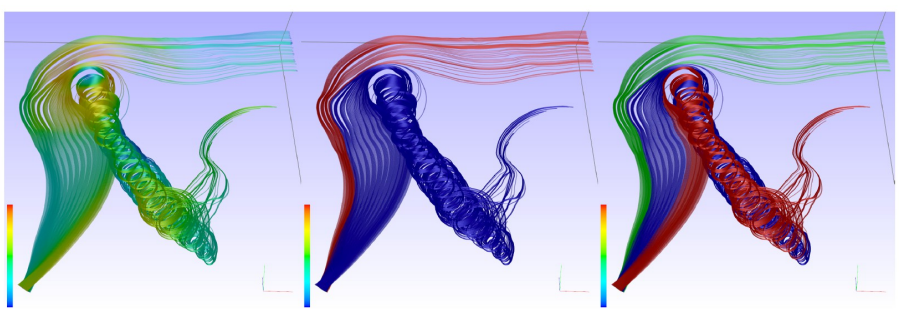
Similarity Measures for Enhancing Interactive Streamline Seeding

Tony McLoughlin[1], Mark W Jones[1], Robert S. Laramee[1], Rami Malki[2], Ian Masters[2], Charles D Hansen[3]

[1]Department of Computer Science, [2]College of Engineering, Swansea University, Wales, UK,

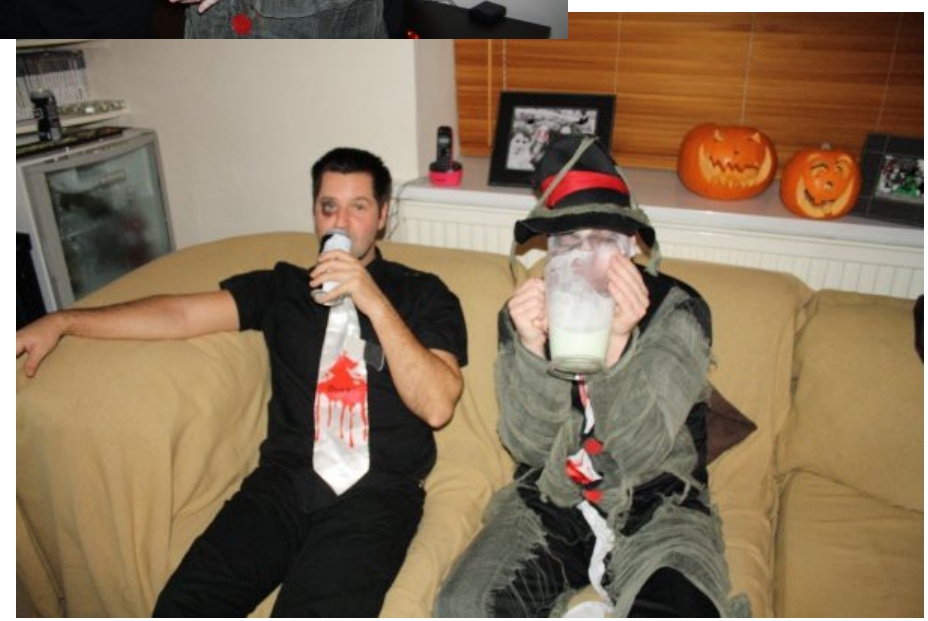
[3]Scientific Computing and Imaging Institute (SCI), University of Utah



Swansea University
Prifysgol Abertawe

www.sci.utah.edu

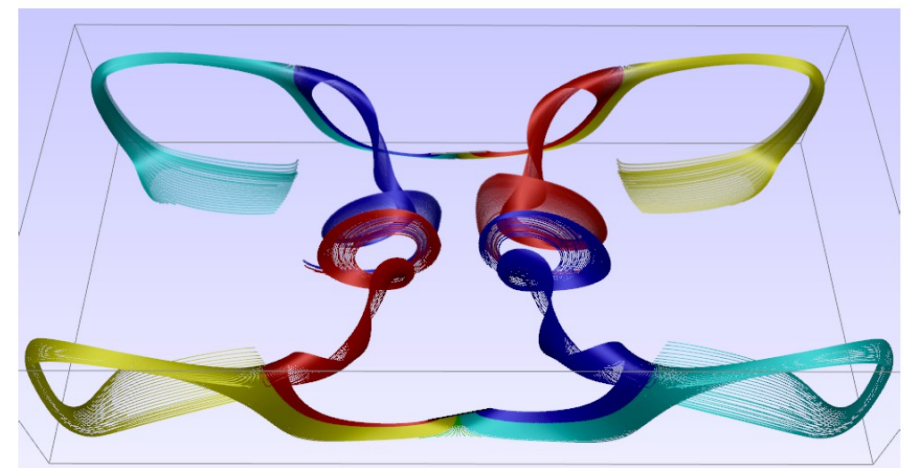
Tony



Robert S. Laramee
r.s.laramee@swansea.ac.uk

Overview

- Introduction and Motivation
- Related Work
- Streamline Similarity Metrics
- Results
- Domain Expert Feedback, Evaluation
- Conclusions and Future Work



Robert S. Laramee
r.s.laramee@swansea.ac.uk

Introduction and Motivation

Observations

- Many automatic streamline seeding algorithms are presented, few used in practice
- Commercial software, e.g., Tecplot, features interactive seeding rakes
- Little focus on seeding rakes in visualization
- Domain Experts may not be interested in entire spatio-temporal domain

Our **contribution**: to enhance streamline seeding in conjunction with seeding rakes, + fast streamline similarity metric

- Requires interactive computation, evaluation with CFD domain experts

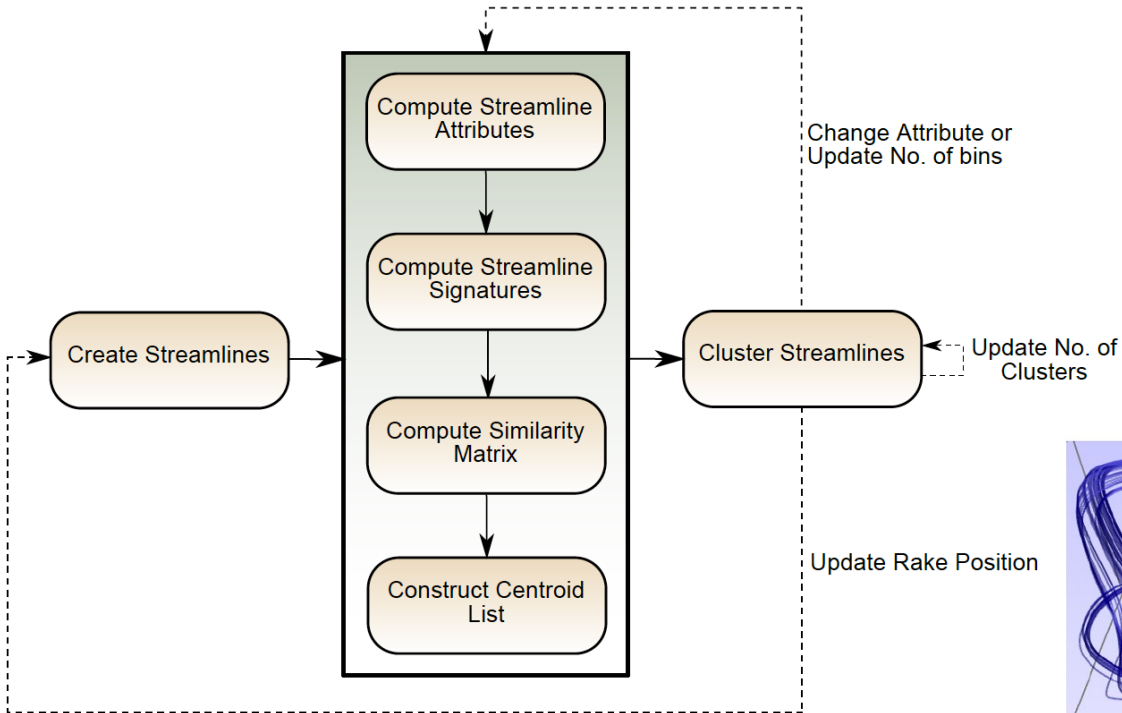
Related Work

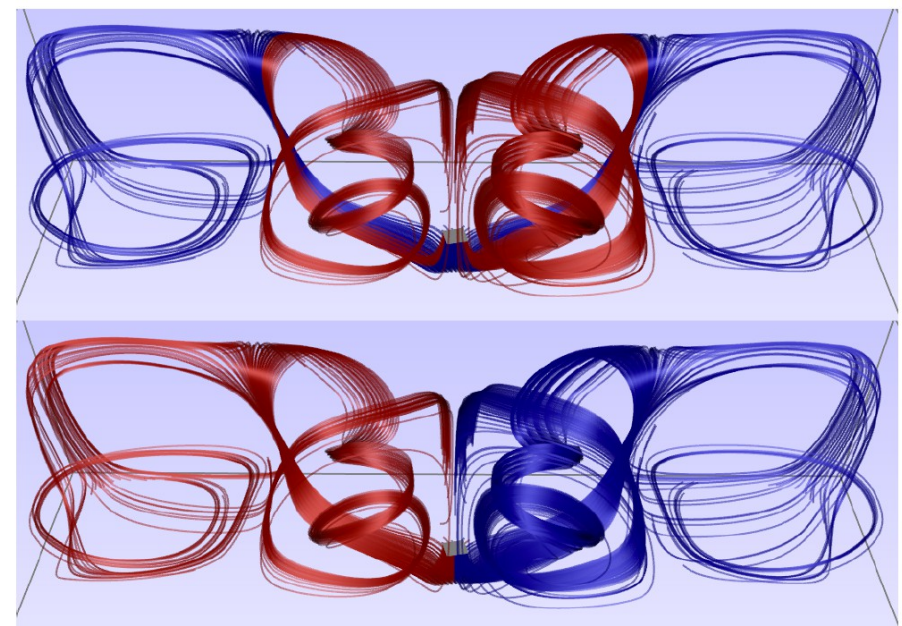
- Y Chen, JD Cohen, J Krolik, **Similarity Guided Streamline Placement with Error Evaluation**, *IEEE TVCG*, 13(6) 1448-1455, 2007

- I Corouge, S Gouttard, G Gerig, **Towards a Shape Model of White Matter Fiber Bundles Using Diffusion Tensor MRI**, *International Symposium on Biomedical Imaging (ISBI)*, pages 344-347, 2004

- S Zhang, S Correia, DH Laidlaw, **Identifying White-Matter Fiber Bundles in DTI Data Using an Automated Proximity-based Fiber-Clustering Method**, *IEEE TVCG*, 14(5): 1044-53, 2008

Method Overview





Streamline Similarity: Streamline Attributes

Streamline Similarity metric starts with: curvature, torsion, and tortuosity

- Curvature: quantifies deviation from a straight line
- Torsion: measures how sharply curve twists out of plane of curvature
- Tortuosity: length of curve / distance between start and end

Each attribute magnitude is normalized, equal weight

Robert S. Laramee
r.s.laramee@swansea.ac.uk

Swansea University
Prifysgol Abertawe
Computer Science
Gwyddor Cyfrifiadur

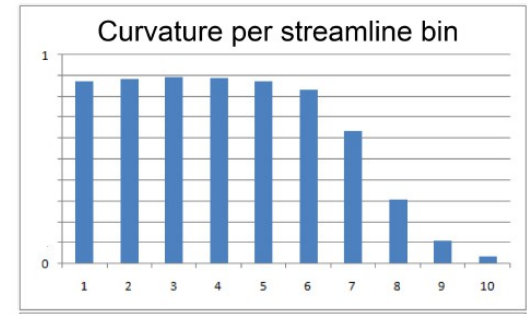
Streamline Similarity: Streamline Signature

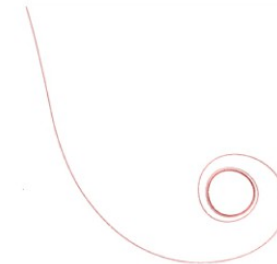
Idea: Divide streamline into bins

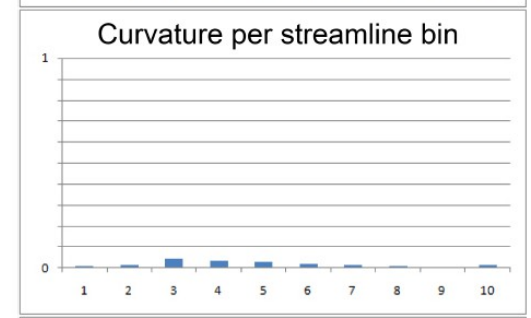
- Similarity metric computed for each bin
- Streamline signature: sum of similarity metric over each bin
- Introduce Chi^2 distance

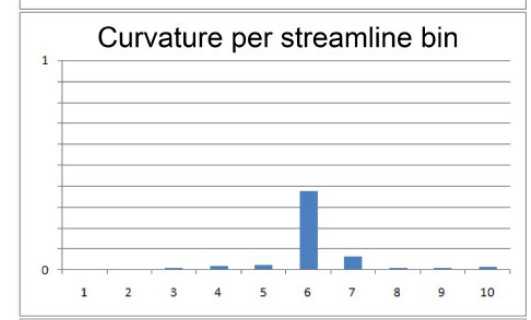
$$\chi^2(P_A, P_B) = \sum_{bin \in B} ((P_{bin,A} - P_{bin,B})^2 / (P_{bin,A} + P_{bin,B}))$$

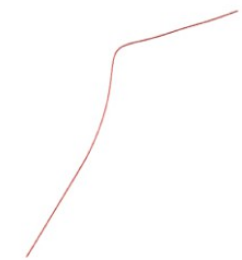
- A single scalar compares streamline signatures on per-bin basis

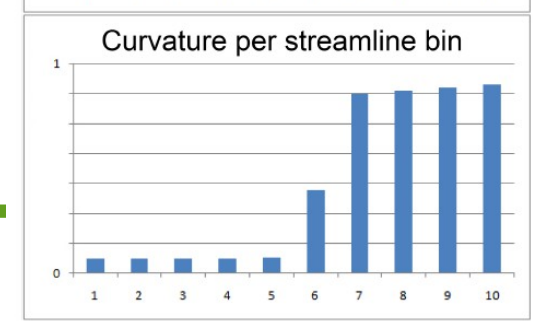


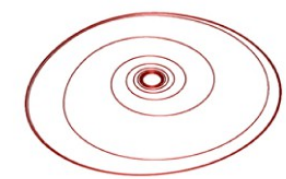










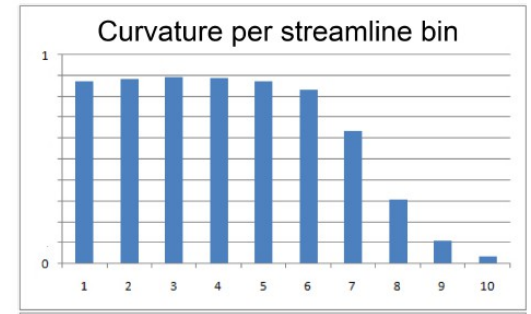


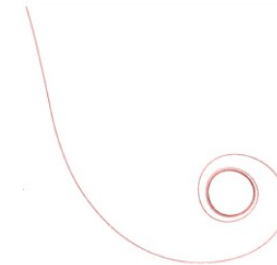
Robert S. Laramee
r.s.laramee@swansea.ac.uk

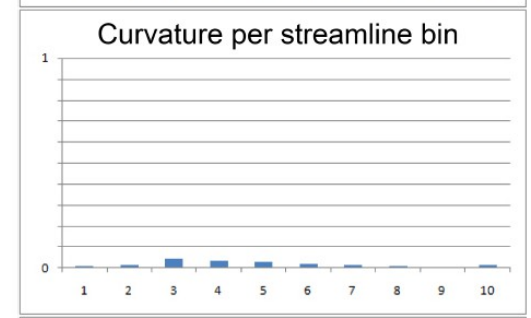
Streamline Similarity: Similarity Matrix

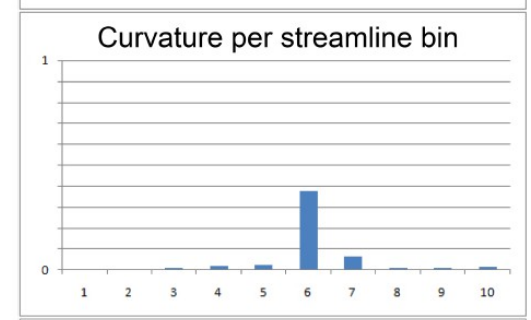
Chi^2 test is performed for all streamline pairs

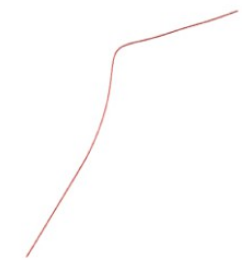
- Forms a 2D matrix, M^{sim}
- Column and row for each streamline
- Symmetric matrix entry stores Chi^2
- Euclidean distance is an optional component of the distance metric (based on last point in each bin for performance)

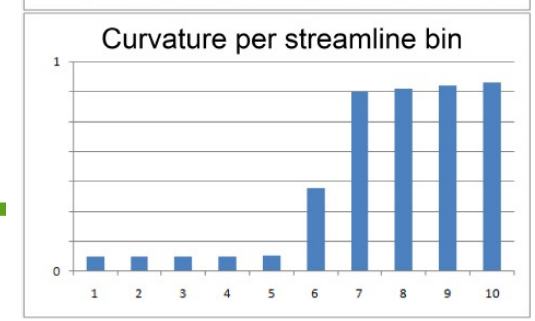


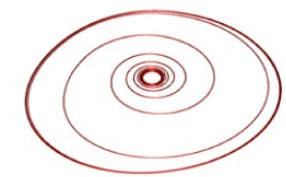












Robert S. Laramee
r.s.laramee@swansea.ac.uk

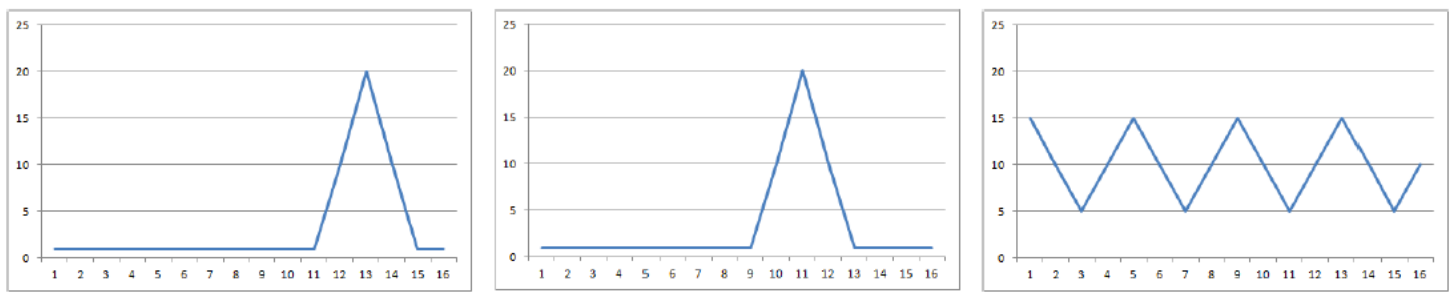
Streamline Similarity: Hierarchical Signatures

Idea: create hierarchy of signatures to handle shifted signatures

- *levels* = $\log_2 x$
- *x* is lowest power of 2 > longest streamline, e.g., streamline length = 1000, *x* = 1020, *levels* = 10.
- Streamline samples per bin = 2^{level}

level 0 → 1 sample/bin, level 1 → 2 samples/bin,

level 2 → 4 samples/bin



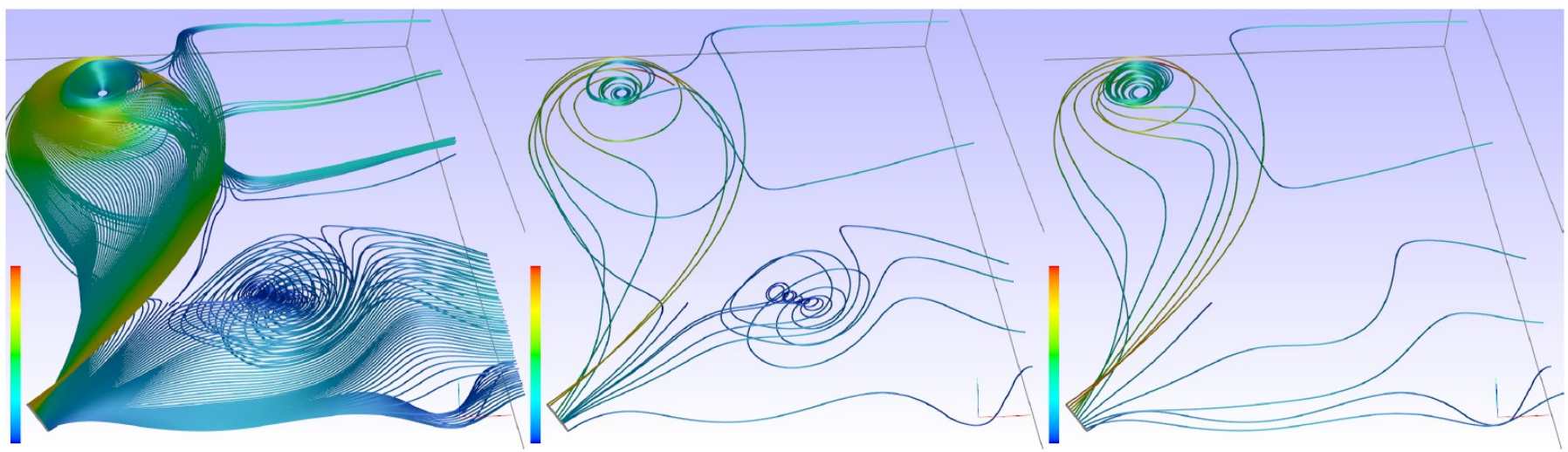
Robert S. Laramee
r.s.laramee@swansea.ac.uk

Swansea University
Prifysgol Abertawe
Computer Science
Gwyddor Cyfrifiadur

Benefits and Advantages

A fast streamline similarity test enables

- Enhanced perception: reduced visual complexity, clutter, and occlusion
- Interactive performance, application to unsteady flow
- Automatic inter-seed spacing along seeding rake
- Streamline filtering
- Focus+Context visualization



Robert S. Laramee
r.s.laramee@swansea.ac.uk

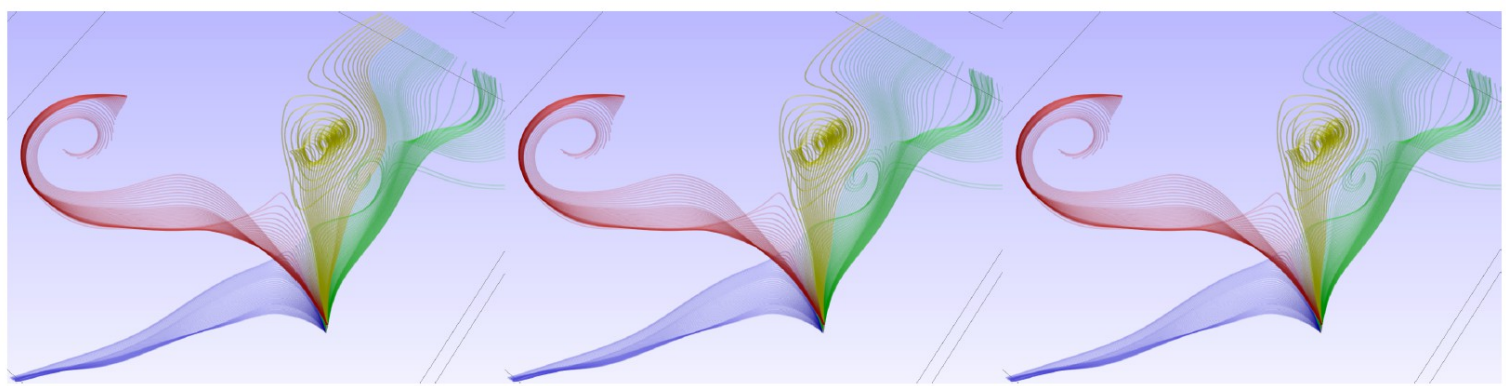
Features and Results

Robert S. Laramee
r.s.laramee@swansea.ac.uk

Domain Expert Feedback

Work carried out with two CFD experts from Marine Turbine Energy group, Swansea University

- Emphasized need for interaction
- Provides effective visual searching through enhanced perception
- Engaging
- Large regions of uninteresting flow (large spatial aspect ratios)



Eurovis 2014 | The Eurogr

eurovis.swansea.ac.uk

Diese Seite ist auf Englisch Soll sie übersetzt werden? Nein Übersetzen Englisch nie übersetzen Optionen

EuroVis 2014

The Eurographics Conference on Visualization

9–13 June 2014,
Swansea, South Wales, UK

- Home
- News
- Call for Participation
- Important Dates
- Committees
- Invited Speakers
- Author Guidelines
- Submission Guidelines
- Registration
- Venue
- Travel
- Accommodation
- Tourist Information
- Previous EuroVis Events
- Sponsors
- Contact

Welcome

EuroVis 2014, hosted by Swansea University in the UK, is the 16th annual visualization gathering organized by the Eurographics Working Group on Data Visualization and supported by the IEEE Visualization and Graphics Technical Committee (IEEE VGTC). EuroVis has been a Eurographics and IEEE co-supported international visualization symposium held in Europe annually since 1999. Since 2012 EuroVis is a conference.

The exciting and vibrant field of Visualization is an increasingly important research area due to its wide range of applications in many disciplines. In general, our ability to collect, store, and archive data vastly exceeds our ability derive useful knowledge and insight from it. This is a ubiquitous problem. Data visualization is key in gaining an understanding large, complex data sets by exploiting the human visual system. Data visualization leverages computer graphics in order to provide a visual overview, explore, analyze, and present phenomena which is often difficult to understand.

The objective of EuroVis is to foster greater exchange between visualization researchers and practitioners, and to draw more researchers and industry partners in Europe to enter this rapidly growing area of research. EuroVis has an expanded scope to include all areas of visualization, and a steadily more wide-spread visibility that achieves a more wide-spread impact.

EuroVis papers are published as a special issue of Computer Graphics Forum, (CGF) the International Journal of the Eurographics Association, using a two-stage review process.

The main conference is preceded by Workshops such as EuroVA 2012, the 5th international EuroVis Workshop on Visual Analytics, which will be held in the same location on June 9 and 10, 2012. Other closely related workshops will also be held.

New to EuroVis 2014

STARS

For the first time in 2014, EuroVis also features a survey paper track (also known as State-of-the-Art Report, STAR) which aims to foster an overview presentation of a particular sub-field of data visualization. STAR papers will be electronically archived and are fully citeable publications which will undergo a one-stage peer-review process by an international program committee. A selection of STAR submissions will be invited for a subsequent submission to the CGF journal. Details will be posted on the web site.

Short Paper Acceptance

Short papers will feature two acceptance categories: accept for oral presentation and accept as poster presentation. This way, more presenters will have the opportunity to showcase their work.

Follow us:

Gold Sponsors

Knowledge Transfer Network
Electronics, Sensors, Photonics

Harwell Imaging Partnership

we predict

grid-tools

Silver Sponsors

RIVIC

In Cooperation with

Prifysgol Abertawe
Swansea University

EG

Acknowledgements

Thank you for your attention

Any Questions?

Thanks to the following:

This research was funded, in part, by the EPSRC (EP/F002335/1) and The Welsh Research Institute for Visual Computing, (RIVIC, www.rivic.org)

Question: What about performance?

(Excellent question!)

Algorithm	Integration	Similarity & Clustering	Total	Factor
Our Method	0.017s	0.021s	0.048s	1.0x
Our Method (hierarchical)	0.017s	0.112s	0.129s	2.69x
Chen *et al.* [2]	0.017s	6.103s	6.120s	127.5x
Corouge *et al.* [3]	0.017s	5.260s	5.277s	109.94x
Zhang *et al.* [29]	0.017s	5.450s	5.467s	113.90x
Our Method	0.031s	0.042s	0.073s	1.0x
Our Method (hierarchical)	0.031s	0.267s	0.298s	4.08x
Chen *et al.* [2]	0.031s	22.400s	22.431s	307.27x
Corouge *et al.* [3]	0.031s	20.150s	20.181s	276.45x
Zhang *et al.* [29]	0.031s	20.210s	20.241s	227.27x
Our Method	0.062s	0.165s	0.227s	1.0x
Our Method (hierarchical)	0.062s	1.451s	0.102s	6.39x
Chen *et al.* [2]	0.062s	97.300s	97.362s	428.91x
Corouge *et al.* [3]	0.062s	82.050s	80.112s	352.92
Zhang *et al.* [29]	0.062s	84.010s	84.072s	370.36x

TABLE 2

Performance times of our algorithm in comparison with [2], [3] and [29]. The first column identifies the algorithm used. The second column shows the integration time for the streamlines. The similarity computation and clustering times are combined in the third column and the fourth column shows the total computation time. The final column shows the total computation times as a factor of our algorithm. The top, middle and bottom results were generated using 100, 200 and 400 streamlines respectively.

Robert S. Laramee
r.s.laramee@swansea.ac.uk

Question: What if streamlines do not have same number of bins?

(Good question)

Smaller number of bins is used.

Question: What affect does bin size have on algorithm?

(Good question)

Affects streamline similarity metric.

Robert S. Laramee
r.s.laramee@swansea.ac.uk