Predictability-Based Adaptive Mouse Interaction for Visual Flow Exploration

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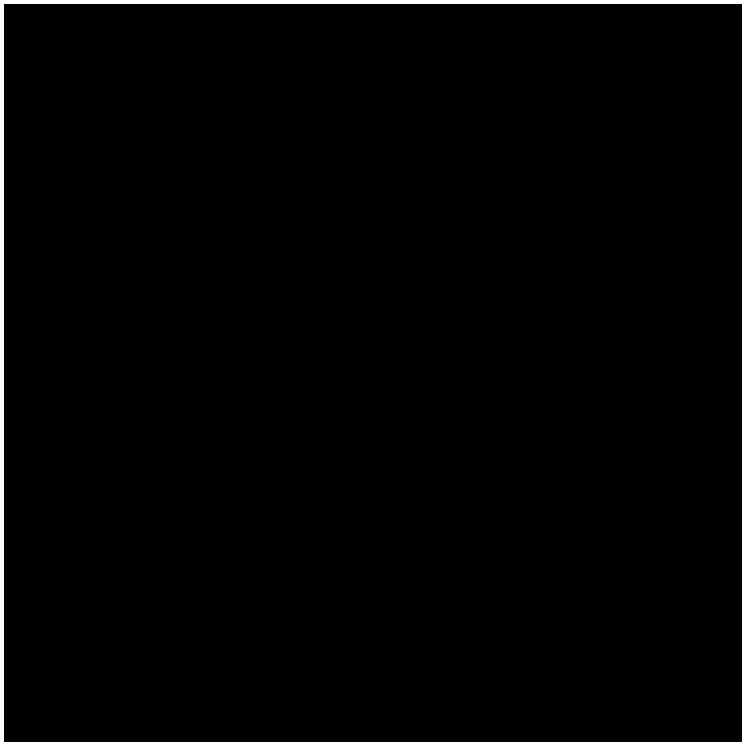
Intro

- Interactive flow visualization
- Analysis of transport

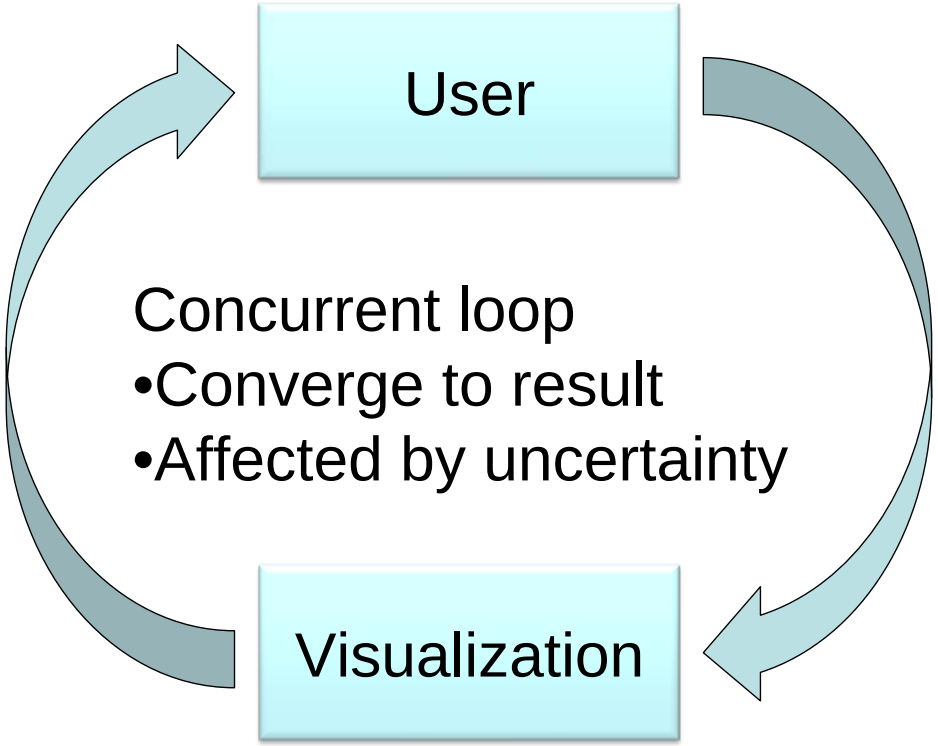


Overview

- Uncertainty and Predictability
- Related Work
- Input Uncertainty - Mouse Input Adaptation
- Output Uncertainty - Zoom Lens
- Summary & Future Work

Uncertainty and Interactive Visualization

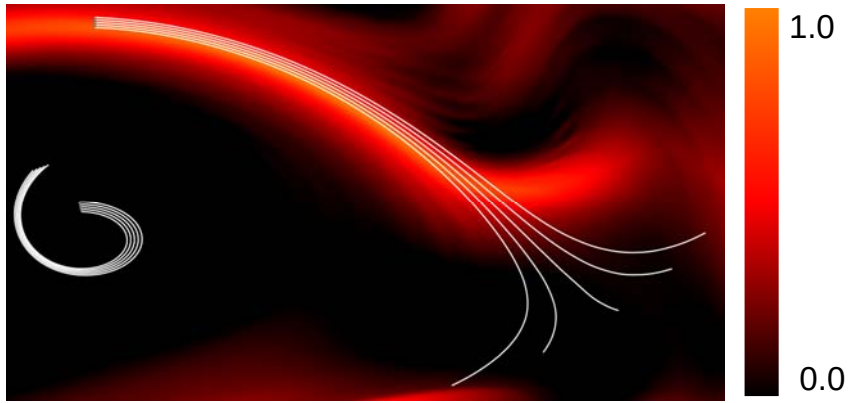
Output
- Display output
- Fixed resolution (pixels)
- Uncertainty



Input
- Mouse input
- Fixed resolution (pixels)
- Uncertainty

Predictability and FTLE

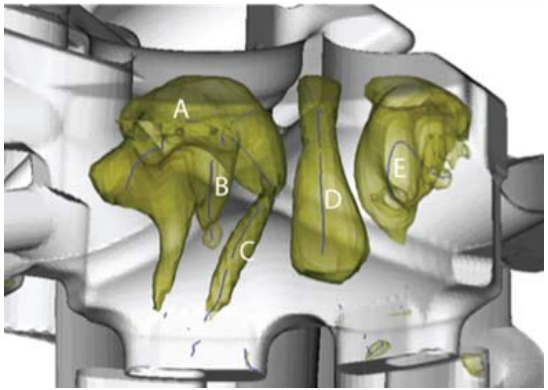
- Transport processes in flow field
- Interactive seeding
- Perturbation through input uncertainty
- Growth of perturbation represents predictability problem
  ⇨ Finite-time Lyapunov exponent (FTLE)



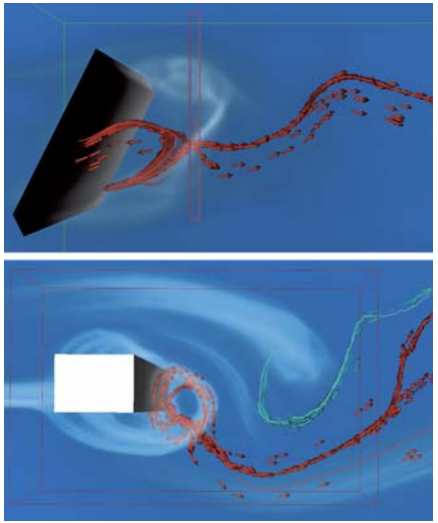
Related Work

- Mouse acceleration
  - User interface level – not data-driven

- Delocalized criteria
- FTLE for seeding



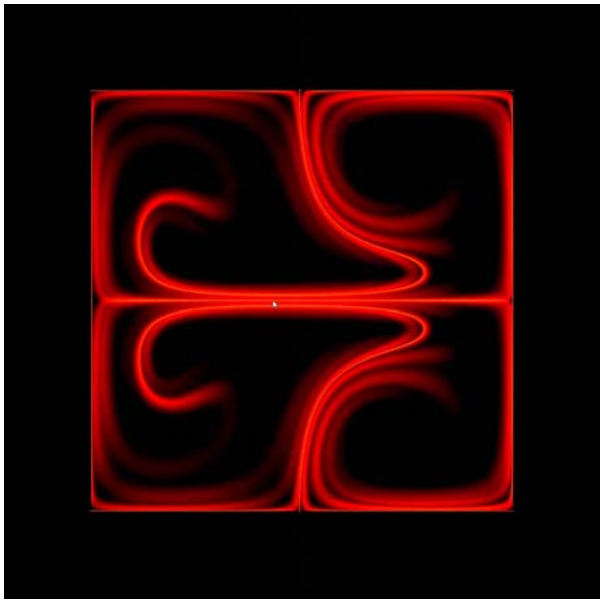
[Fuchs et al., 2008]



[Bürger et al., 2008]

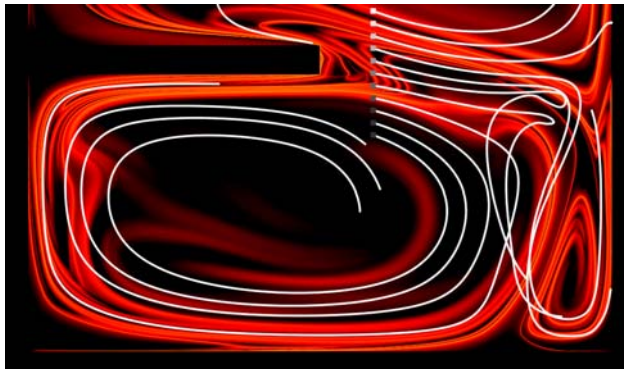
Mouse Input Adaptation

- Data-driven adaptation with FTLE
- Adapted mouse coordinates
  (high precision – sub pixel)
- Activate on demand
  (e.g., right mouse button)
- High predictability – fast motion
- Low predictability – slow motion

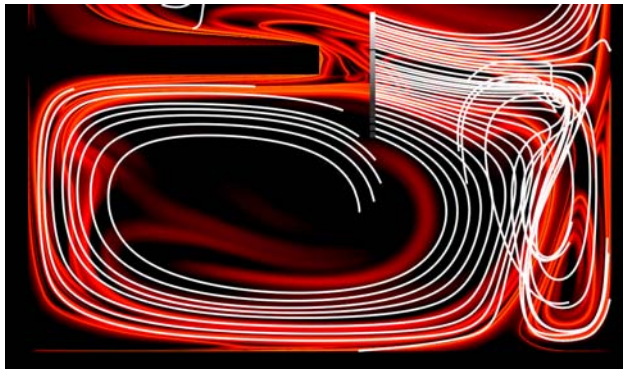


Mouse Input Adaptation – FTLE

- Basic approach: isotropic adaptation
- Scale motion vector with $1/(1 + k\sigma)$
- k – scaling factor
- σ – FTLE



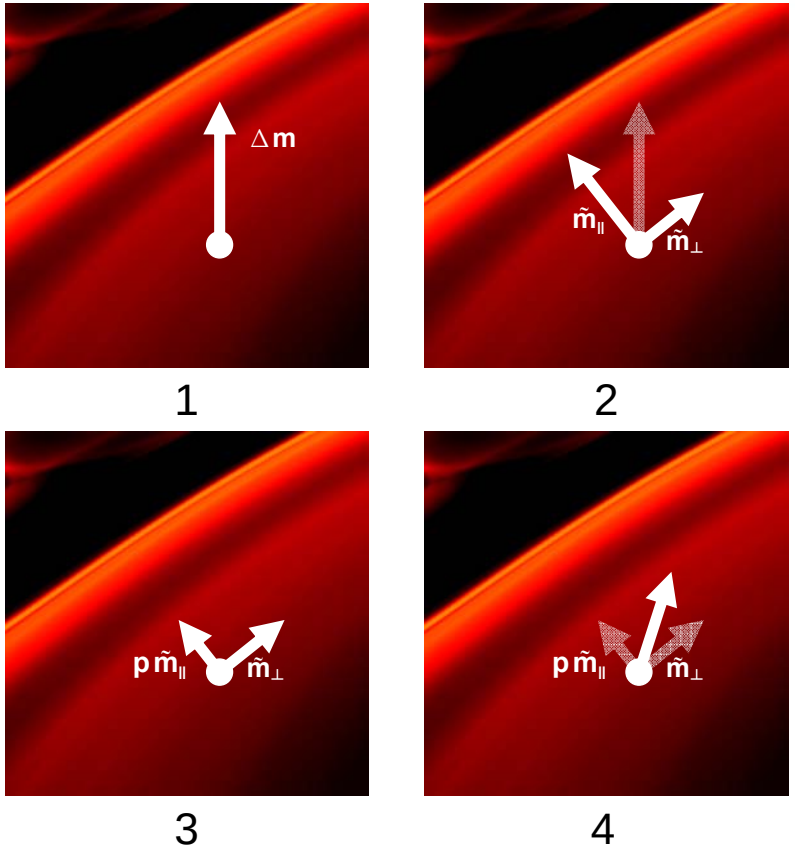
Direct input



FTLE-based Adaptation

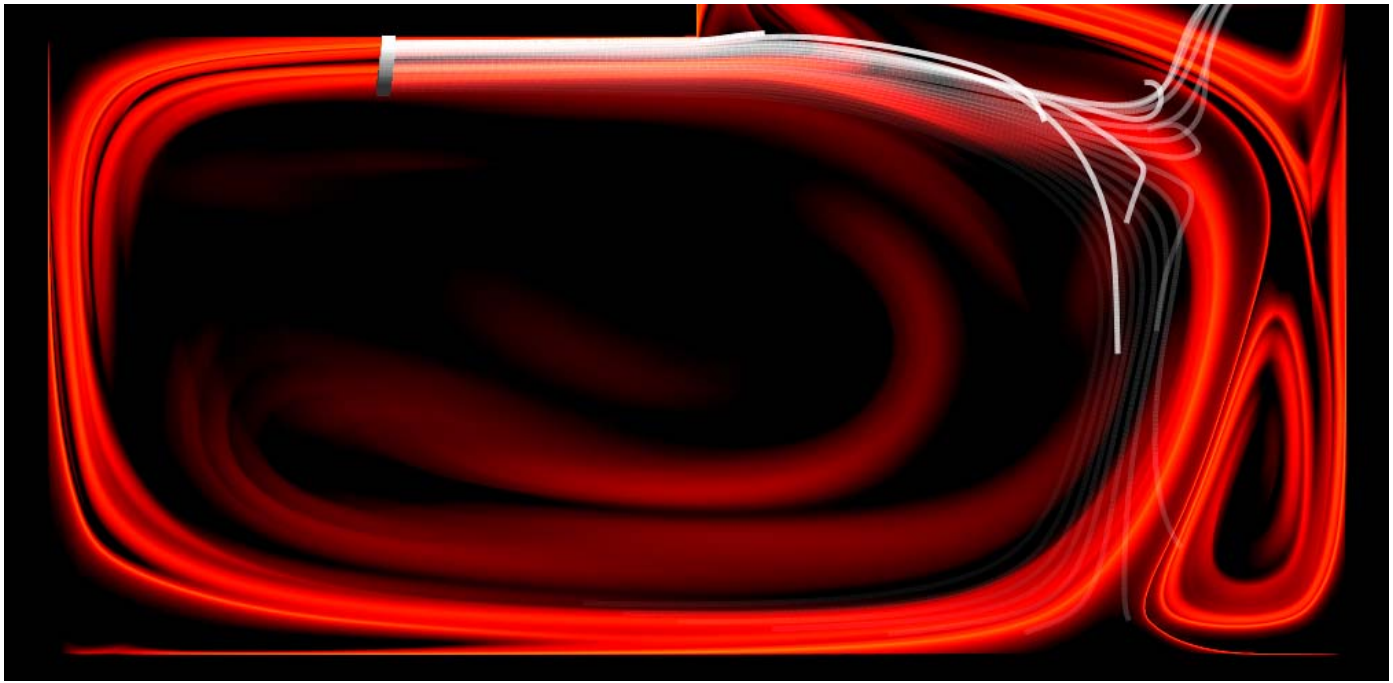
Mouse Input Adaptation – FTLE Gradient

- Extended adaptation (anisotropic)
- Using FTLE gradient:
  1. Input motion vector
  2. Decomposition w.r.t. gradient
  3. Scaling of parallel component by user-defined factor p
  4. Composition

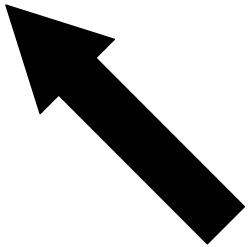


Mouse Input Adaptation – Direction

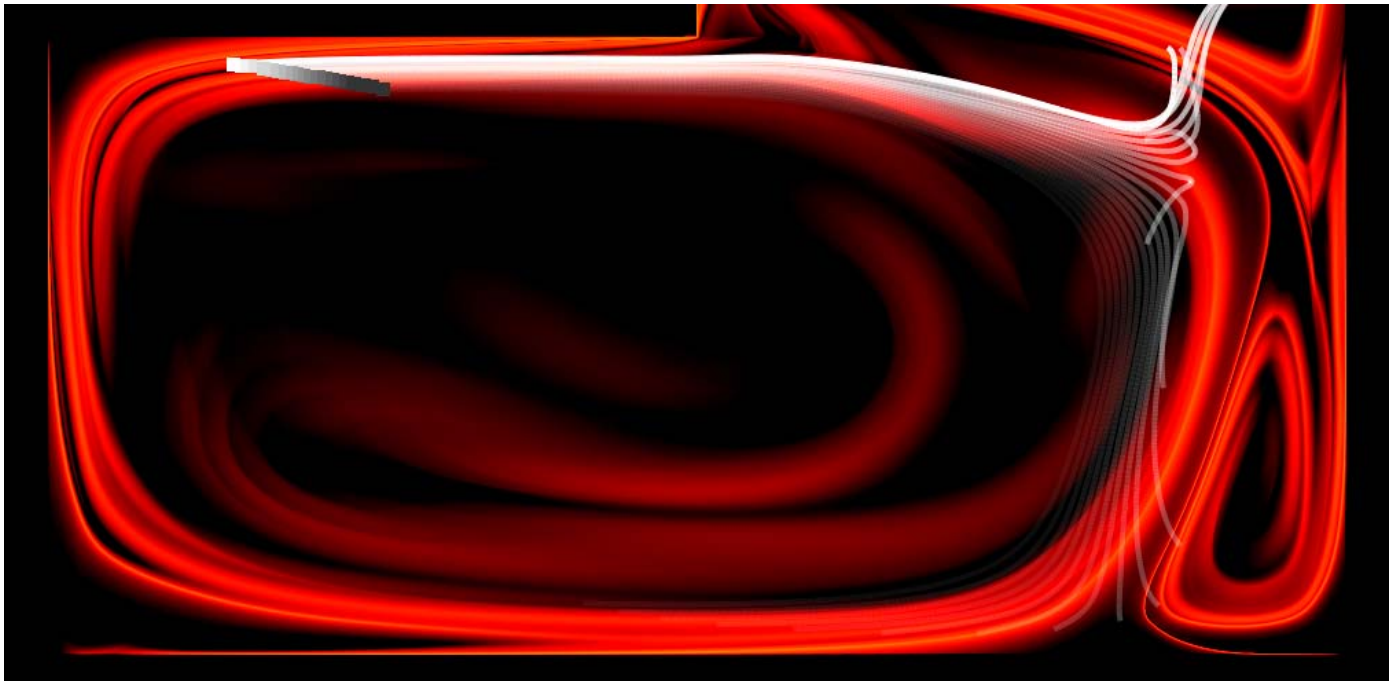
Input vector



Mouse Input Adaptation – Direction

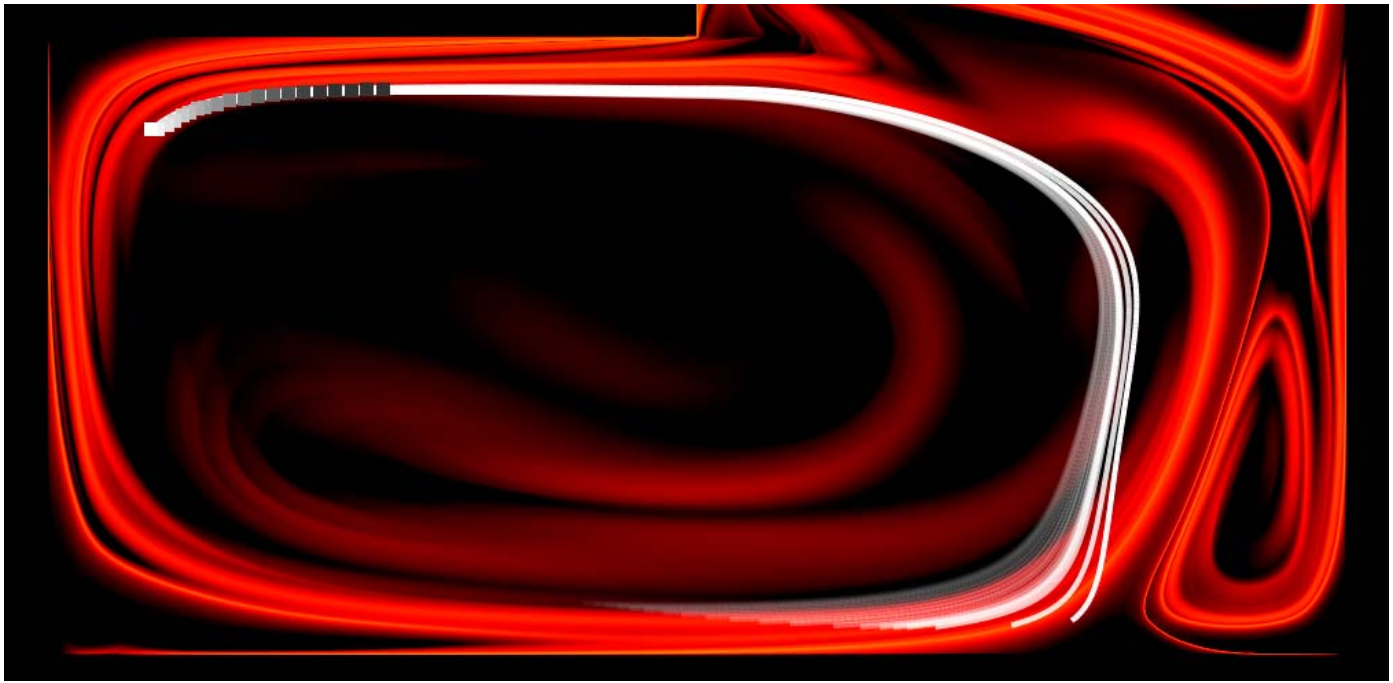


Input vector



Mouse Input Adaptation – Direction

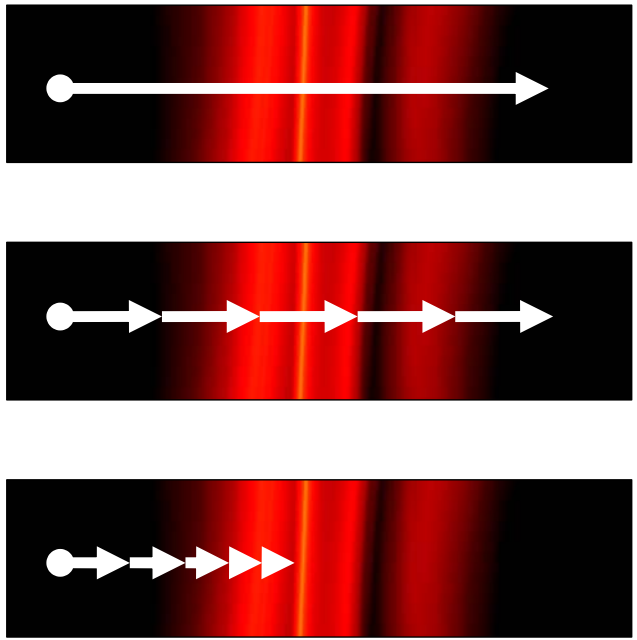
Input vector



Mouse Input Adaptation – Sampling

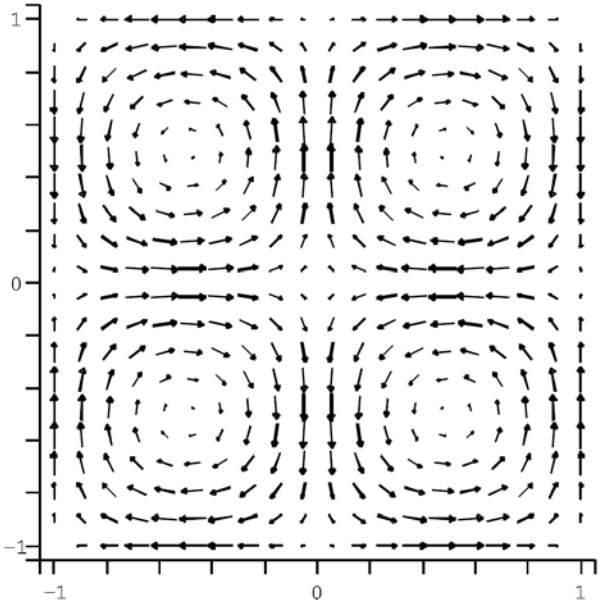
- Fast input motion
  ⇨ risk of missing features

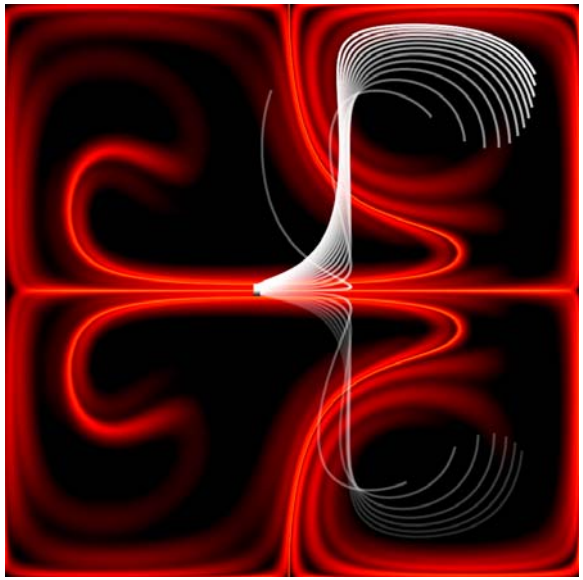
- Supersampling of motion path
  - Iterative application of adaptation method



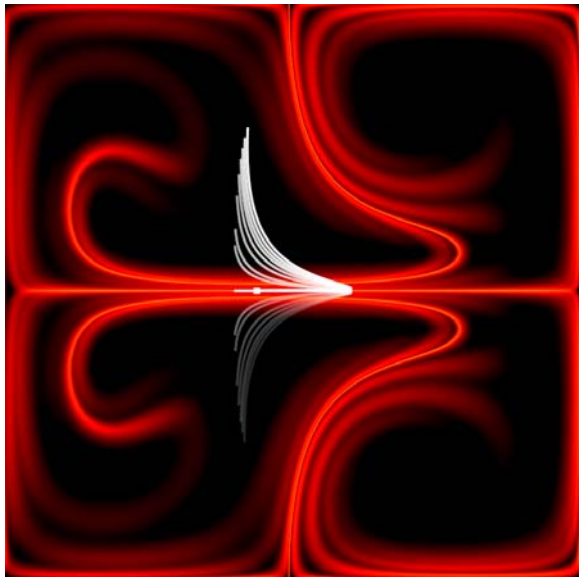
Results – Quad Gyre

Forward FTLE field





Direct input



Adaptive input

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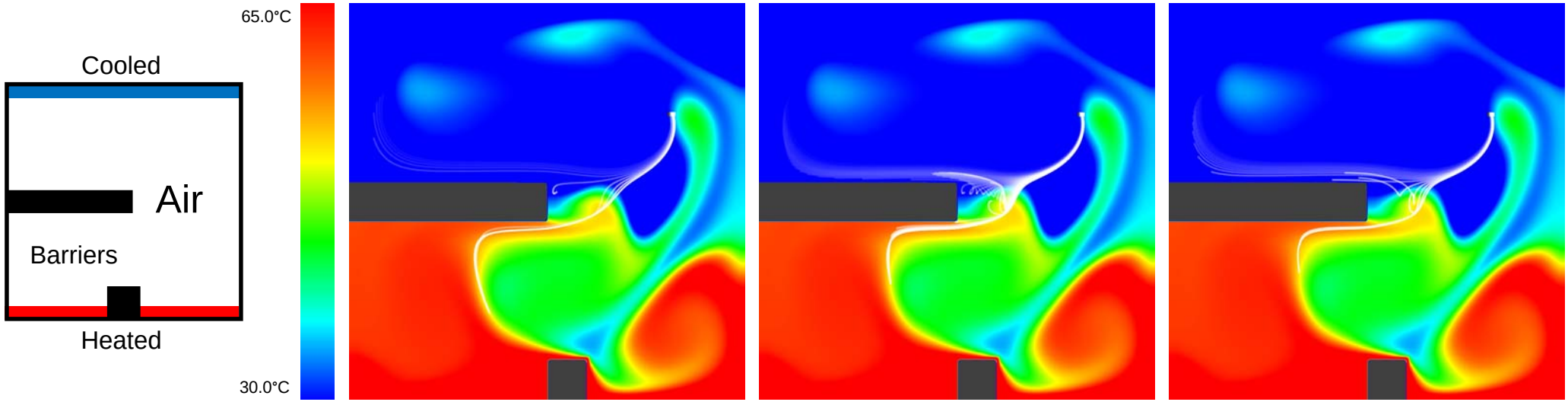
Results – Buoyant Flow: Temperature

- Backward path lines – heat transport



Direct – single pixel steps

Adapted – single pixel steps

Adapted – faster motion

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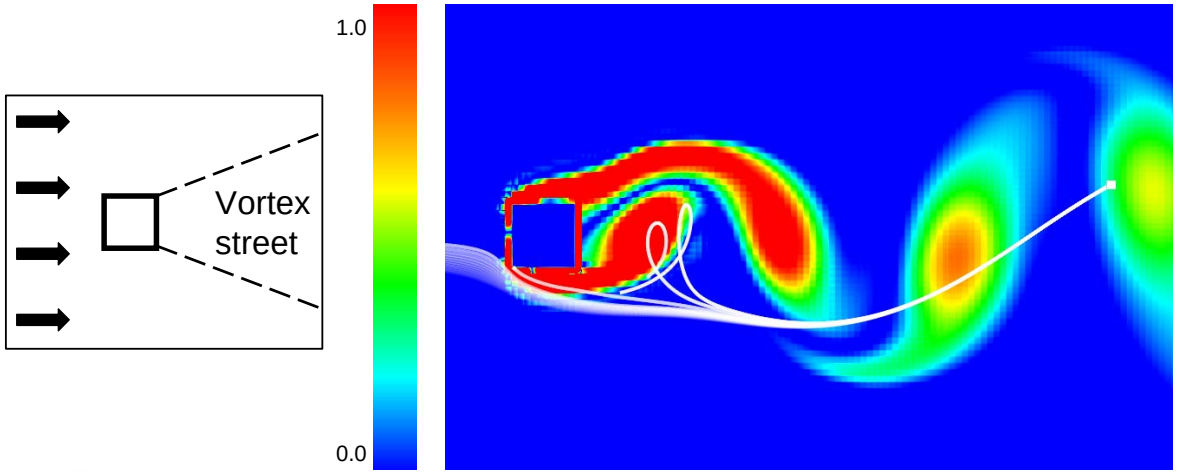
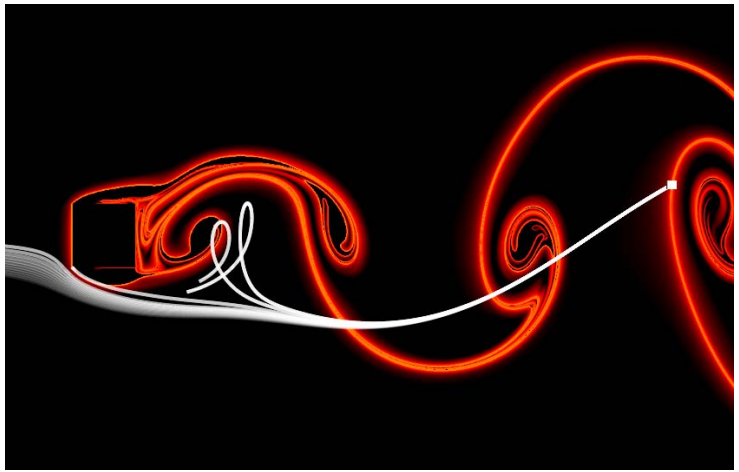
Results – Kármán Vortex Street

- Backward path lines
- Transport of vorticity from boundary shear flow



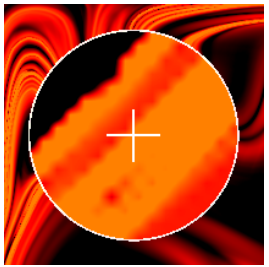
Vorticity magnitude



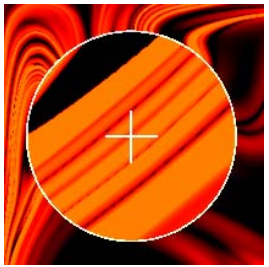
Backward FTLE

Output Adaptation – Zoom Lens

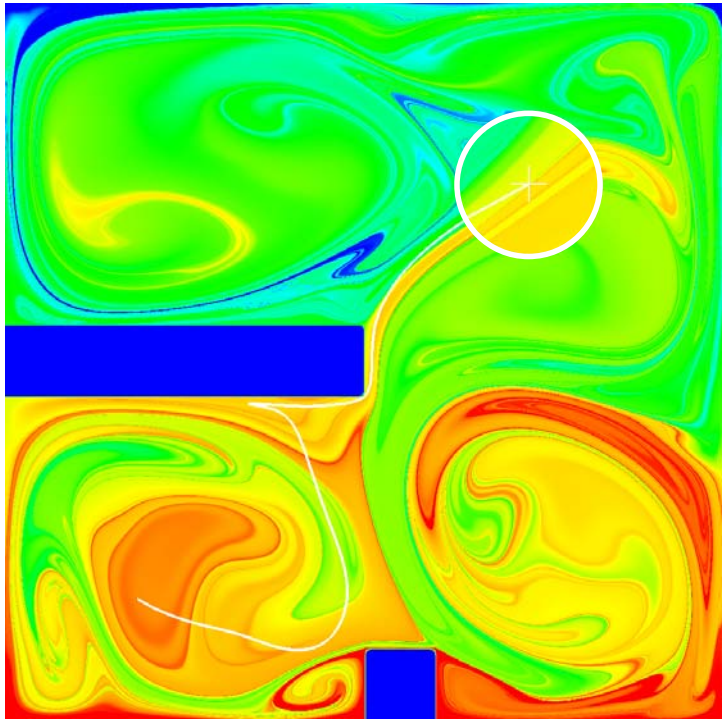
- Uncertainty of display output
  ⇨ provide sufficient resolution
- Lens – maintains context
- FTLE for adaptive zooming
- Interaction – mouse adaptation
- Zoomed output by scaling or on-the-fly computation



Scaling

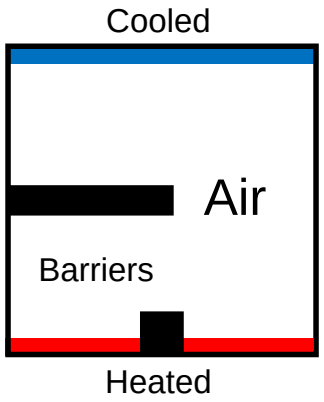


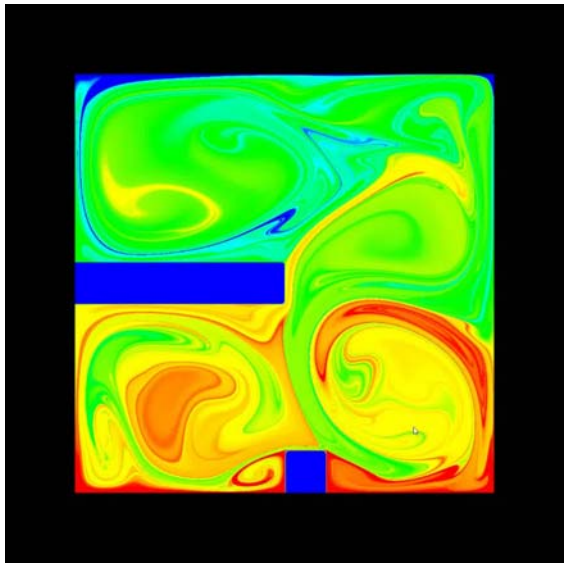
On-the-fly



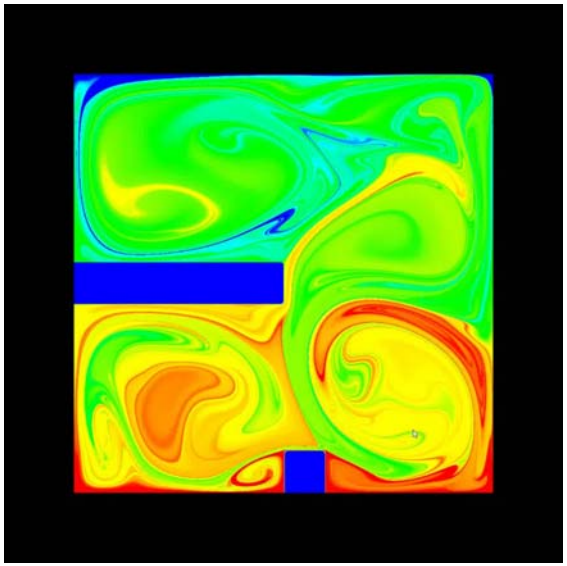
Zoom Lens – Buoyant Flow

- Delocalized temperature: Temperature averaged along path line





Direct mouse motion



Adapted mouse motion

Summary

- Mouse input: - Input uncertainty reduced
  - No switching between interaction styles
- Zoom lens: - Output uncertainty reduced
  - Context preserved
  - No switching between zoom levels
- Data-driven adaptation
- Risk of missing important features lowered
- Overall exploration more efficient

Future work

- Use of other input devices, e.g., Phantom
  - Haptic feedback
  - 3D input
- User study
  - Confirm usefulness
  - Compare adaptation schemes
- 3D flow

Thank you. Questions?