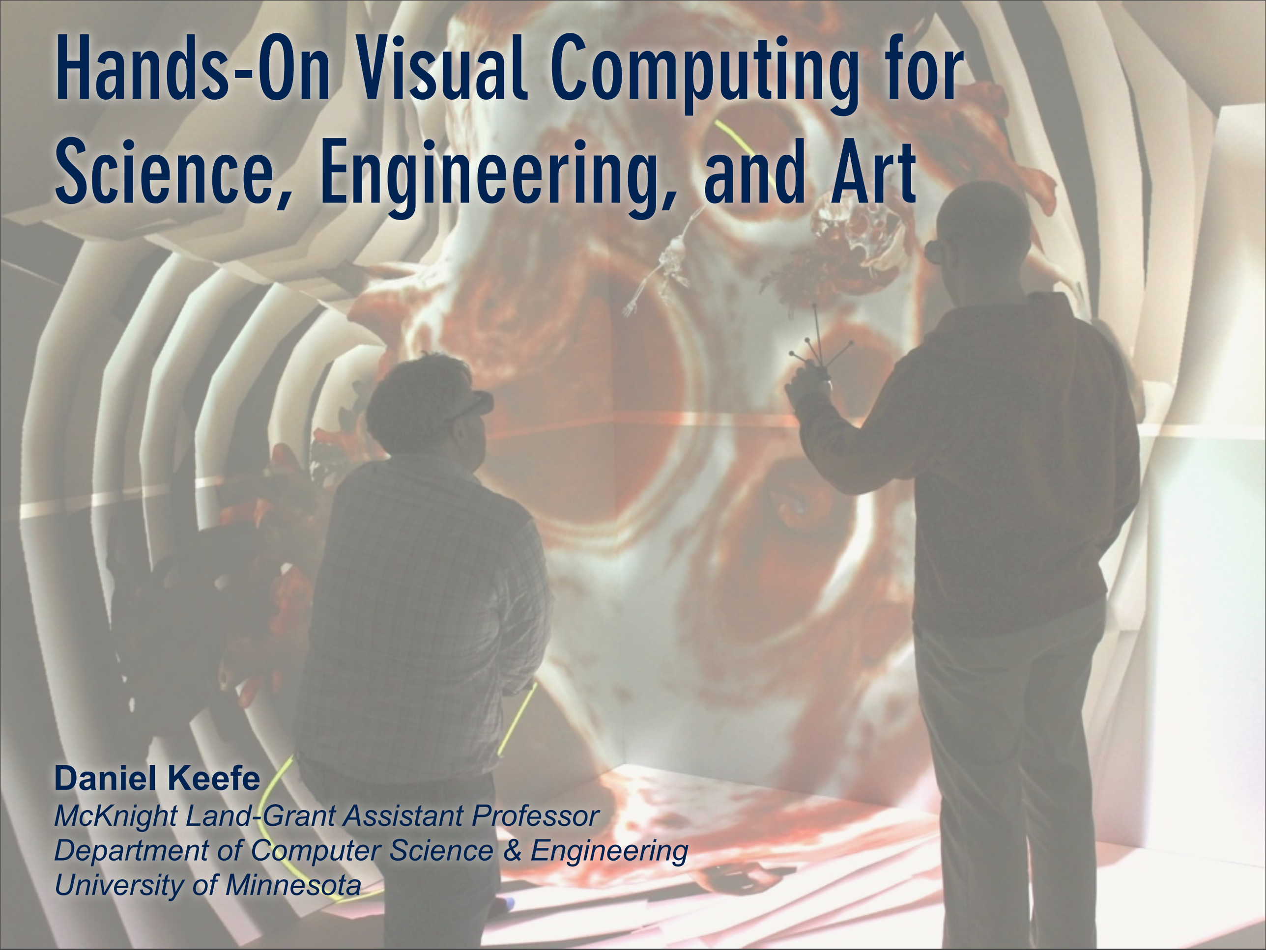
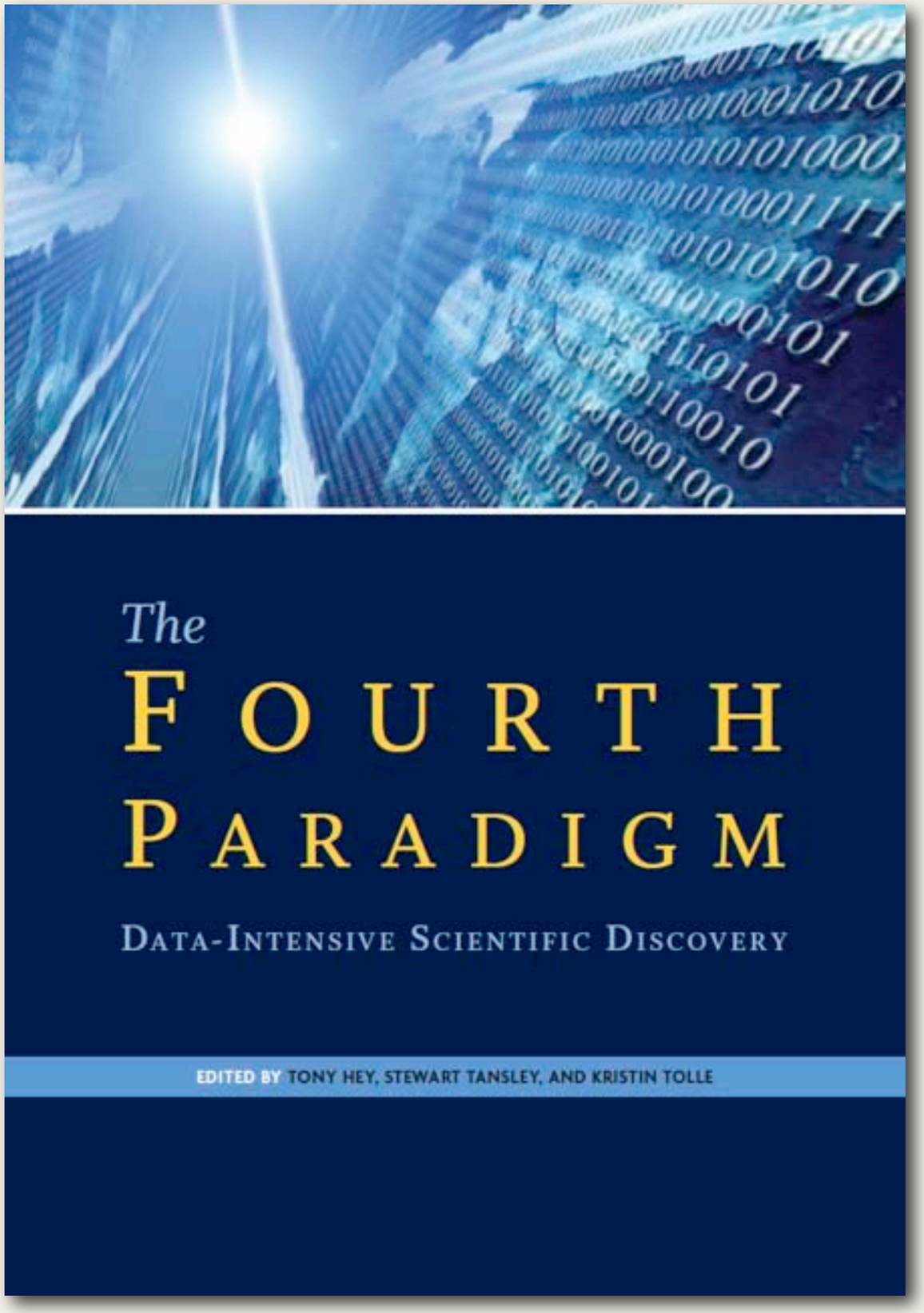
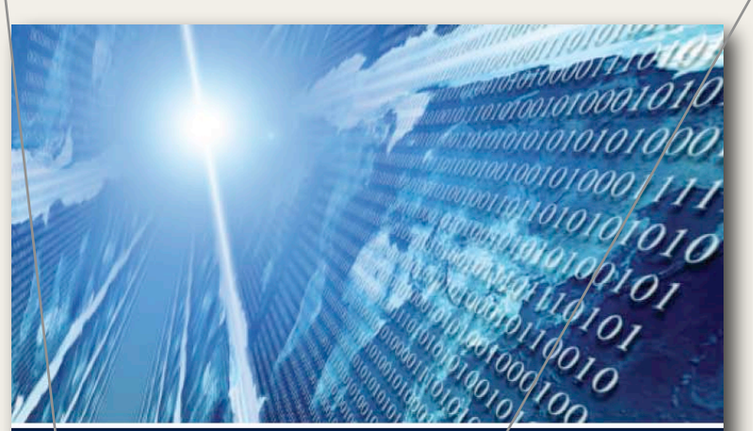
Hands-On Visual Computing for Science, Engineering, and Art



Daniel Keefe
McKnight Land-Grant Assistant Professor
Department of Computer Science & Engineering
University of Minnesota


The
FOURTH
PARADIGM
DATA-INTENSIVE SCIENTIFIC DISCOVERY
EDITED BY TONY HEY, STEWART TANSLEY, AND KRISTIN TOLLE

DATA-INTENSIVE



The
FOURTH
PARADIGM

DATA-INTENSIVE SCIENTIFIC DISCOVERY

EDITED BY TONY HEY, STEWART TANSLEY, AND KRISTIN TOLLE

\+ Design

IV/LAB

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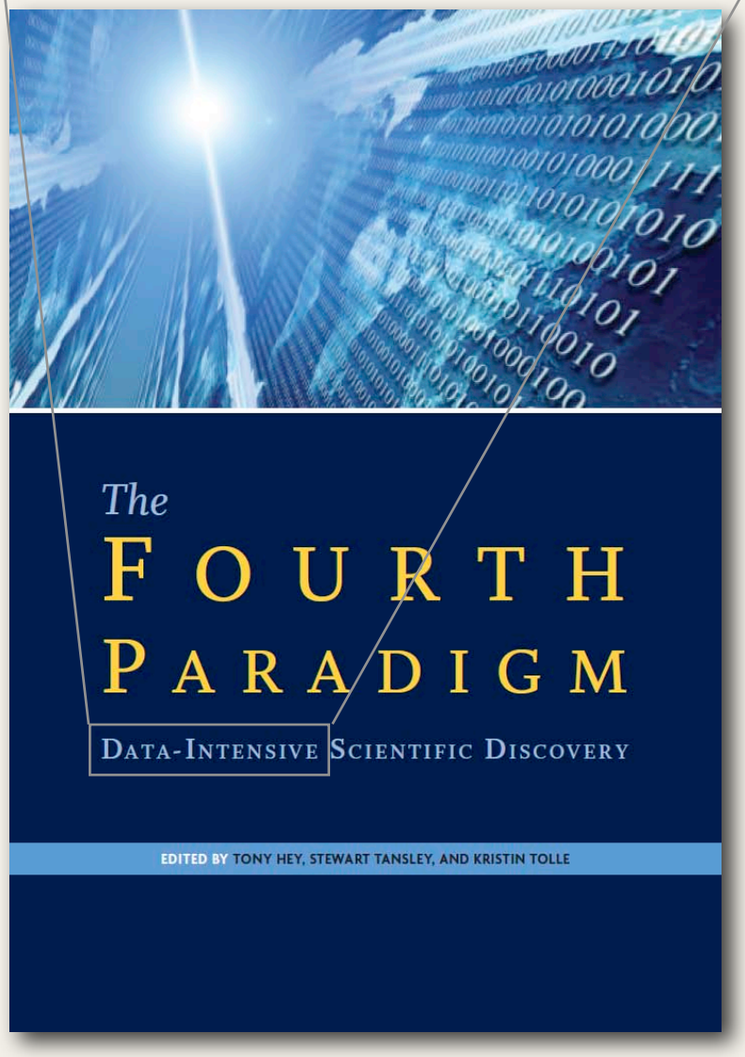
INTERACTIVE VISUALIZATION LAB

Data-Intensive + Design

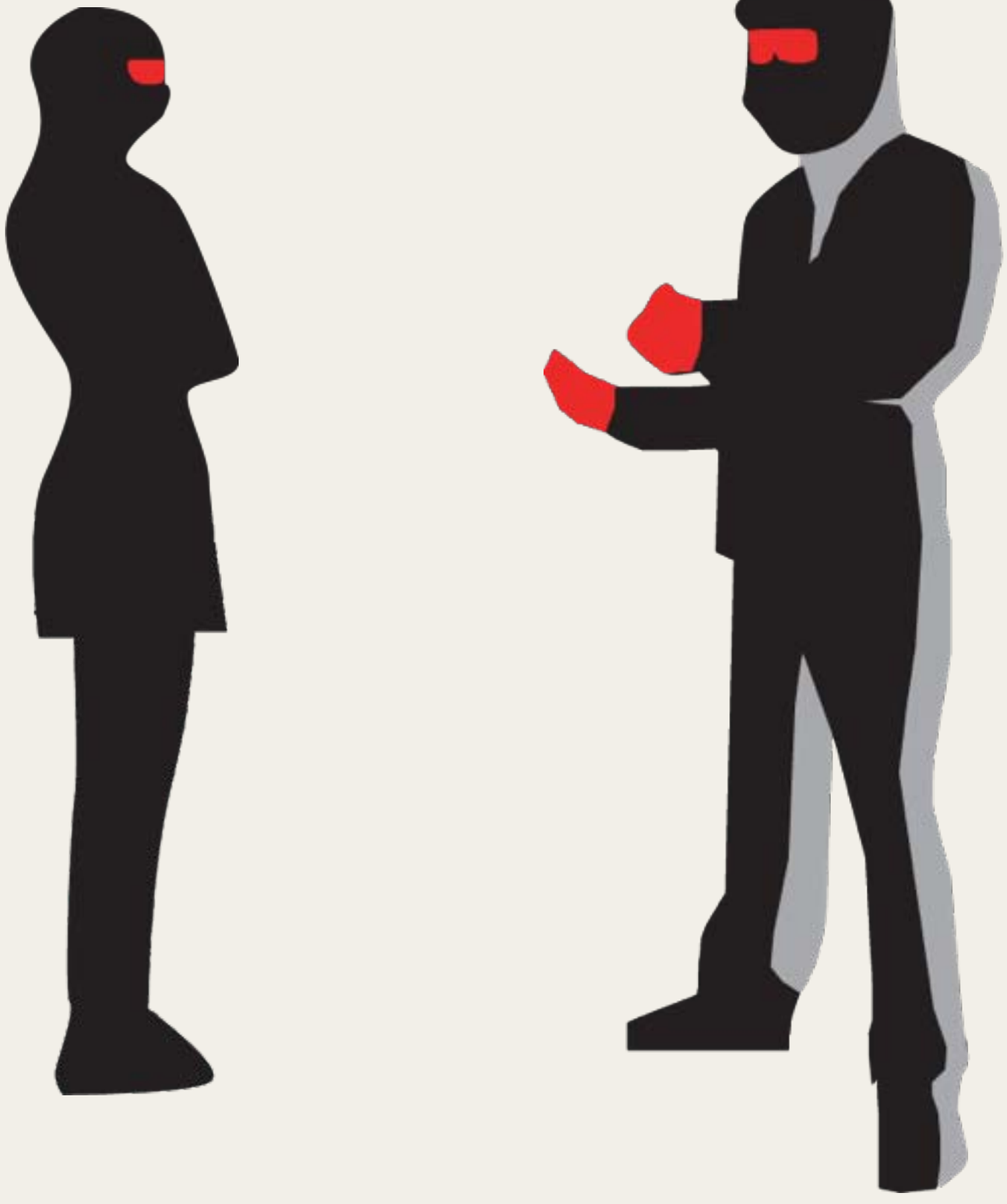


IV/LAB

UNIVERSITY OF MINNESOTA
INTERACTIVE VISUALIZATION LAB

Data-Intensive

+ Design



IV/LAB

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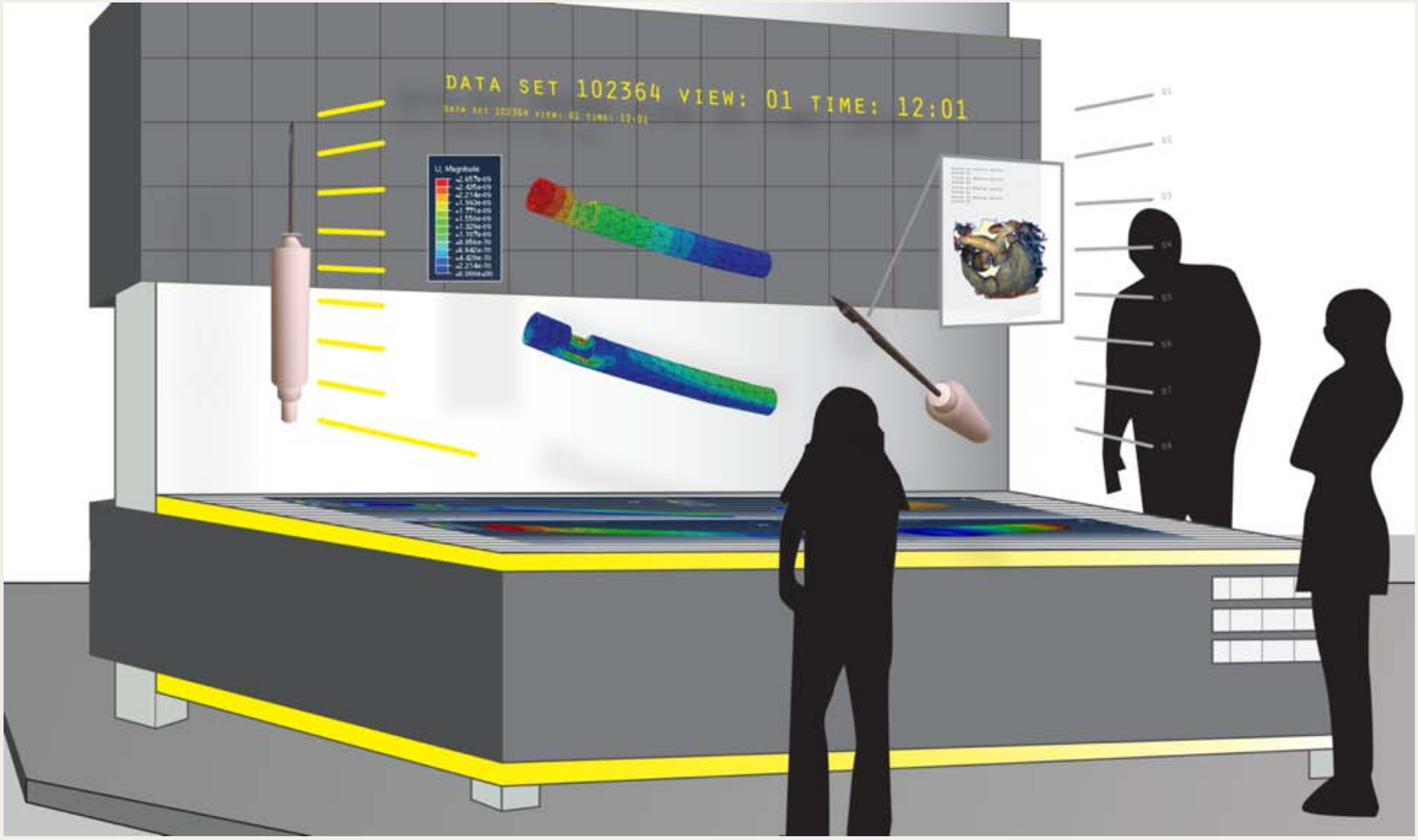
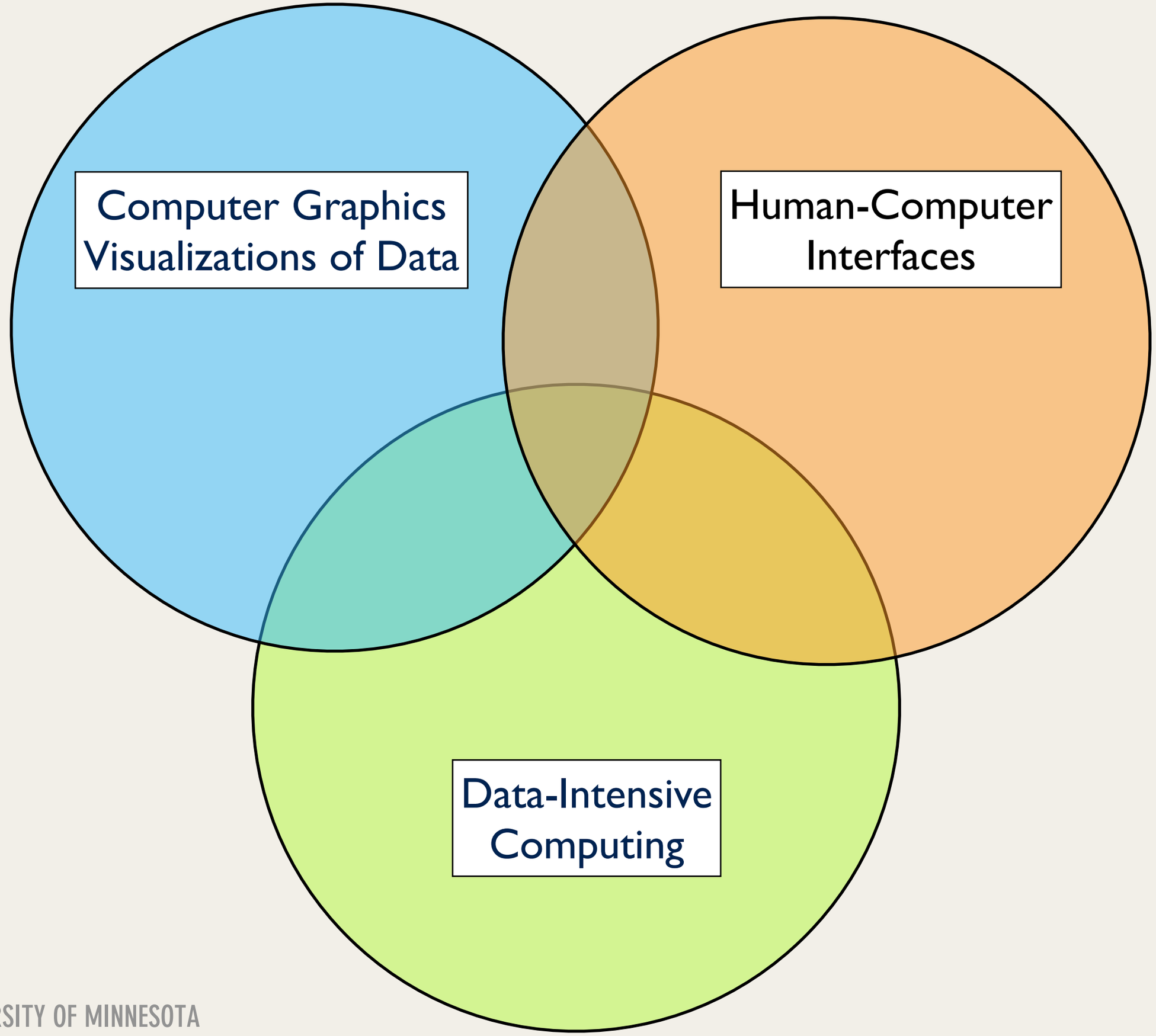


UNIVERSITY OF MINNESOTA
INTERACTIVE VISUALIZATION LAB


Computer Graphics
Visualizations of Data
Human-Computer
Interfaces
Data-Intensive
Computing

HOME PROJECTS PUBLICATIONS DOWNLOADS LAB PEOPLE EDUCATION CONTACT

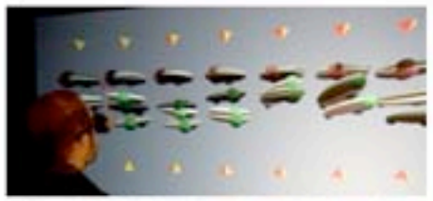
IV/LAB

UNIVERSITY OF MINNESOTA'S **INTERACTIVE VISUALIZATION LAB**

http://ivlab.cs.umn.edu

HOME → RESEARCH → PROJECTS

Research Projects

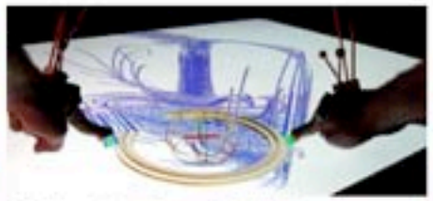


NSF CAREER: Visualizing Scientific Motions

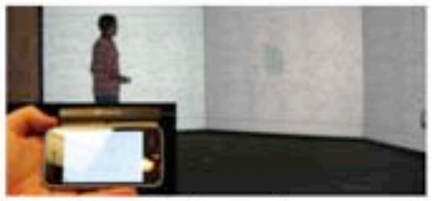
National Academies / Keck Foundation: Intelligent Interactive Imaging (3I)

Art and Design in Visualization

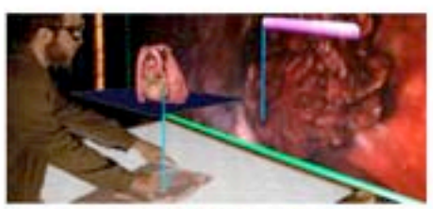
3D Modeling, CavePainting, and Drawing on Air



3D User Interfaces (Multi-Touch, Haptics, Virtual Reality)



Next Generation Immersive Visualization Environments

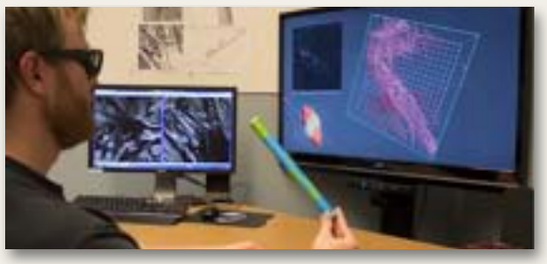


Virtual Prototyping of Medical Devices

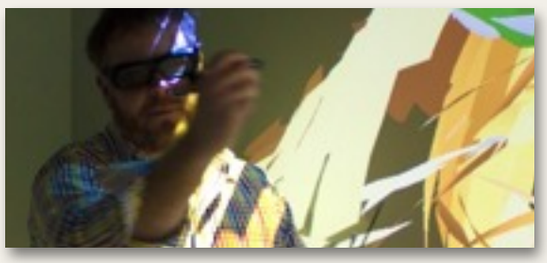
Virtual Classics

Data-Driven Surgical Training

Hands-on, data-driven medical device design



Doing “real work” with volumetric data



Visual computing for science and art

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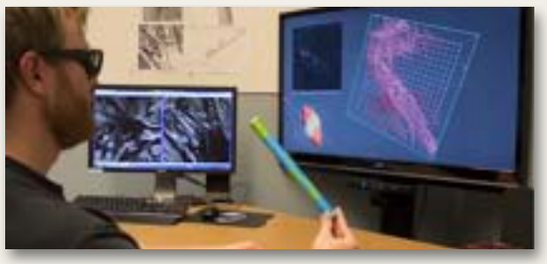
Hands-on, data-driven medical device design



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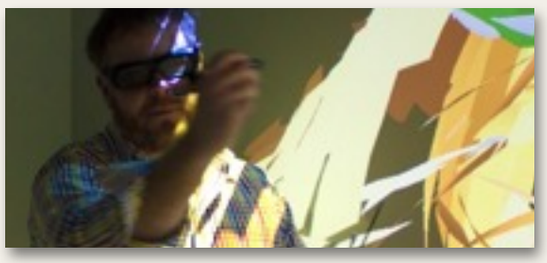

Visual computing for science and art

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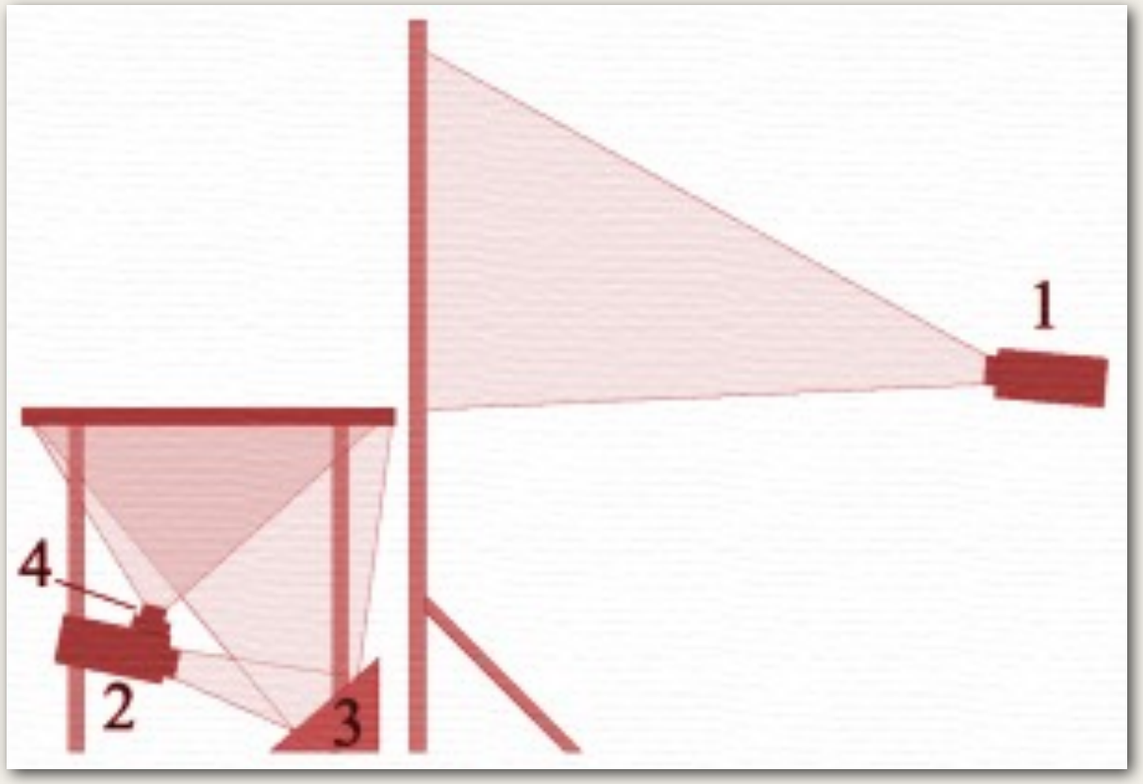
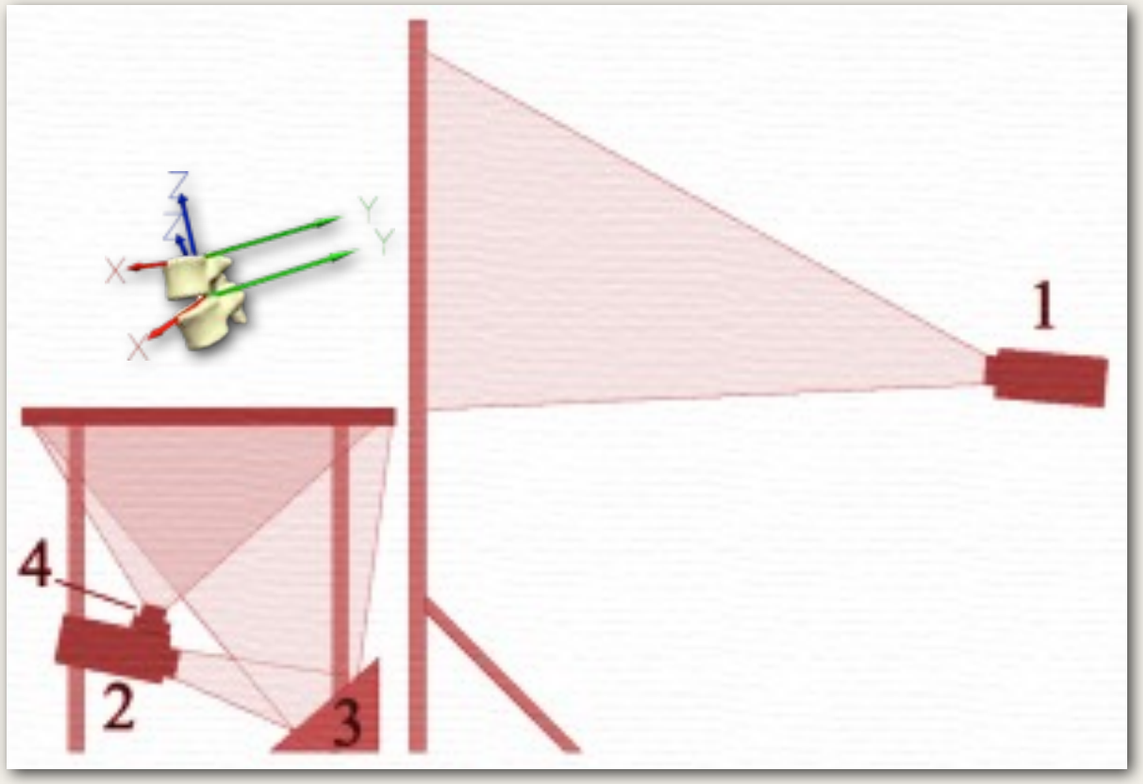
Hardware and software for exploratory data visualization



- 2 display surfaces (wall + table)
- Multi-touch table
- Head-tracked stereoscopic wall

Coffey et al., Low Cost VR Meets Low Cost Multi-touch. In Proceedings of International Symposium on Visual Computing, Springer LNCS 6453, pages 351–360, 2010.

Hardware and software for exploratory data visualization



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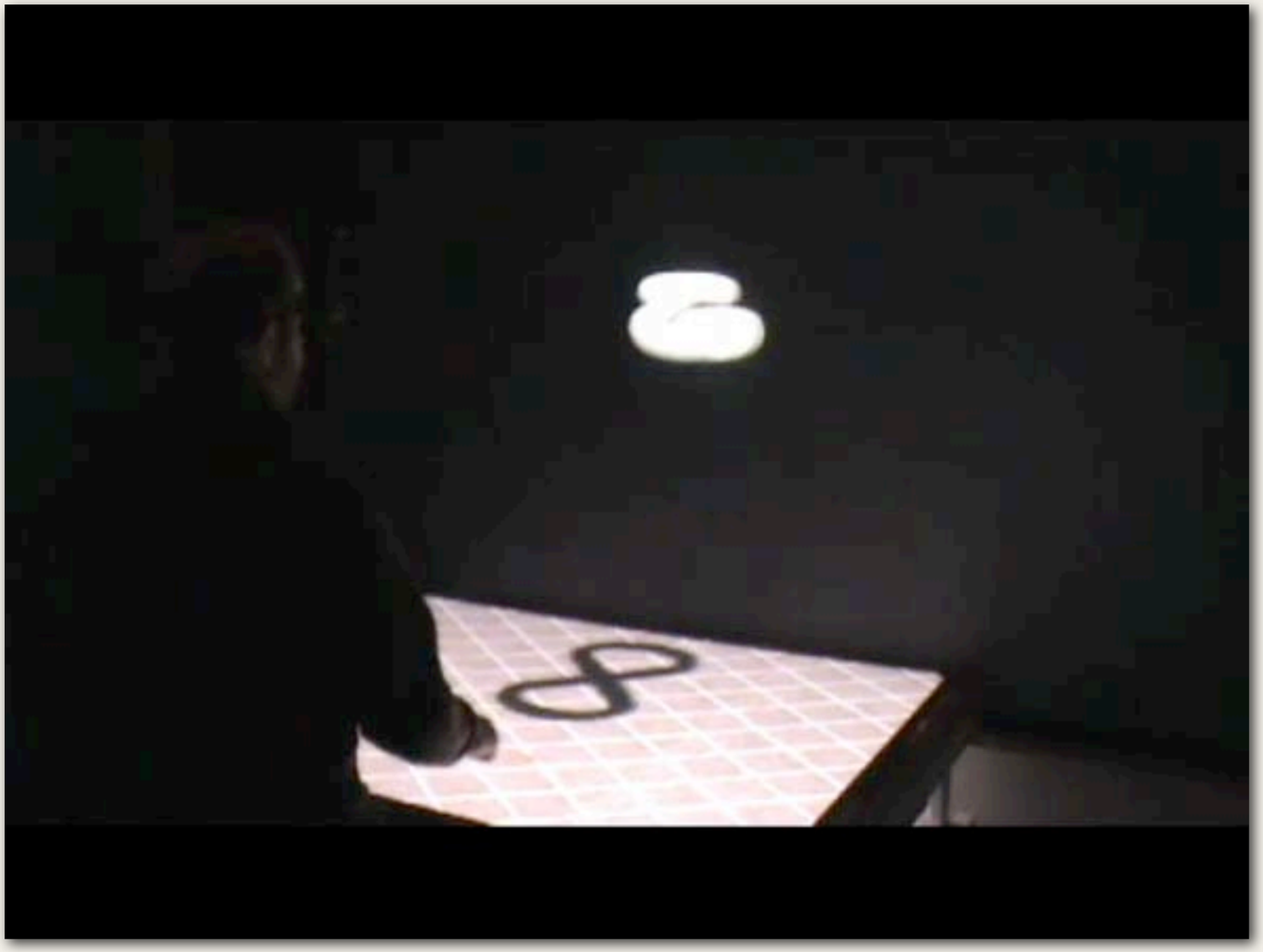
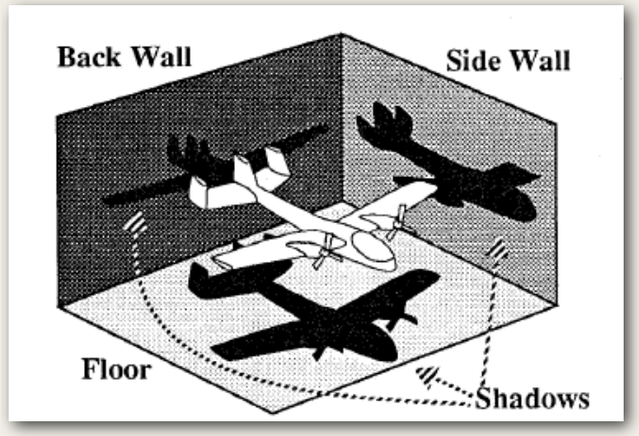
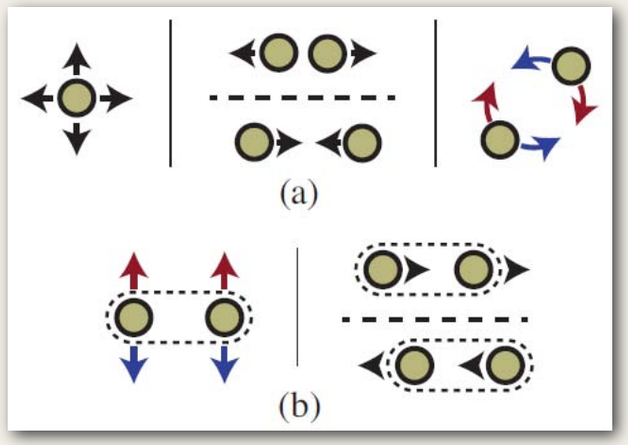


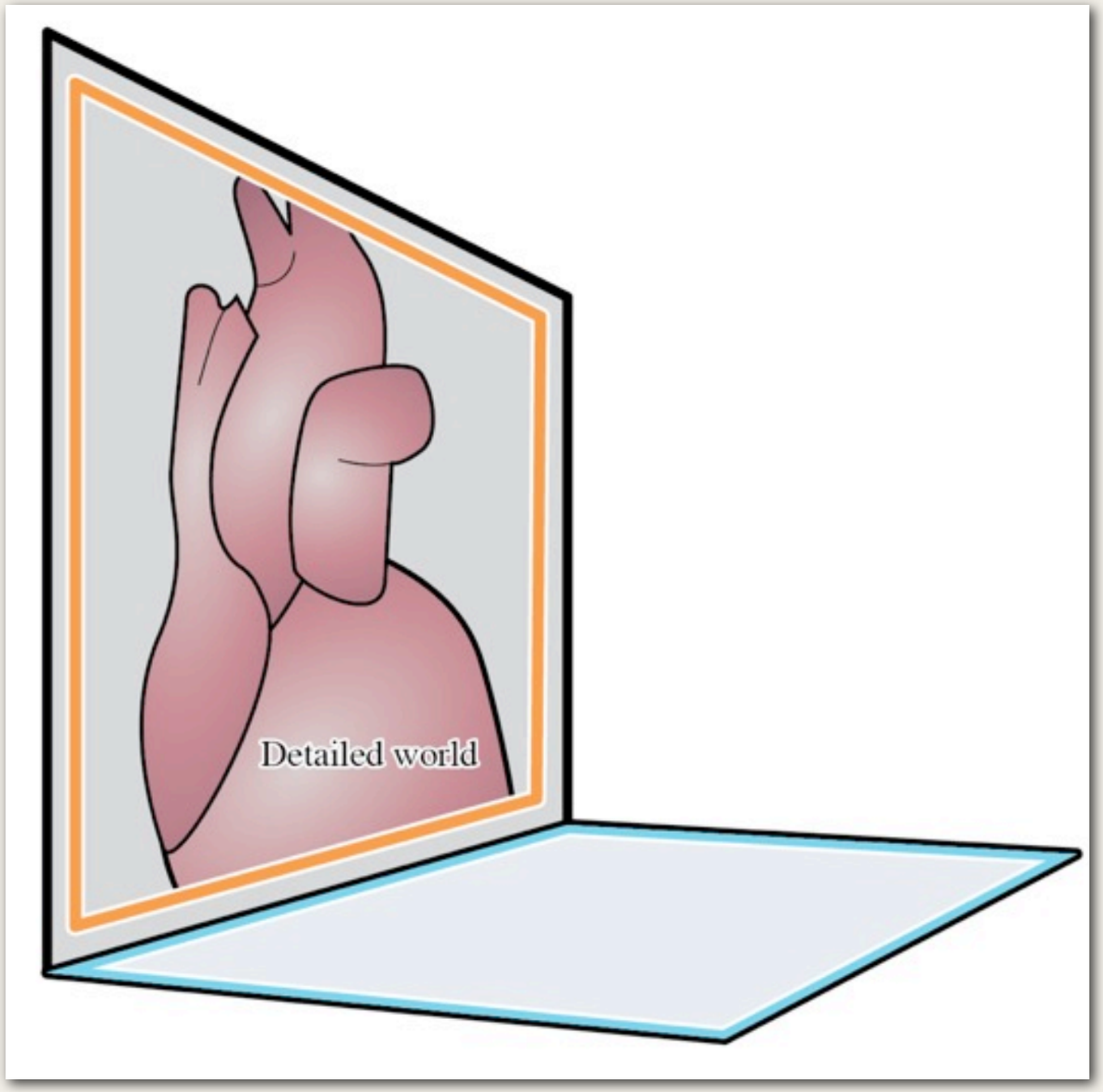
Inspiration:



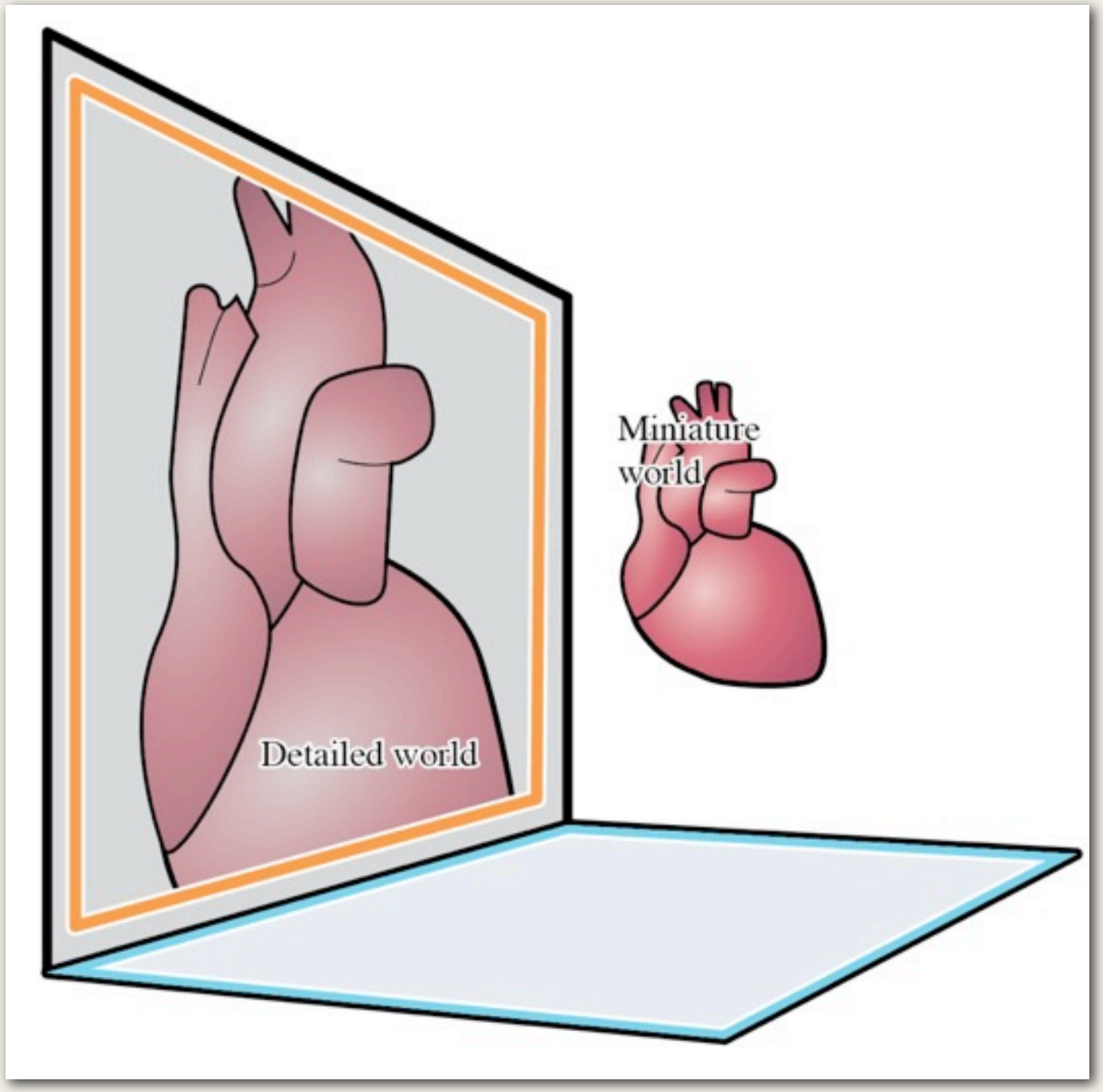
Interactive Shadows, Herndon et al. 1992

Multi-touch gestures:
(a) trans, rot, scale parallel to table
(b) pitch, roll out of plane





Coffey et al., Interactive SliceWIM: Navigating and Interrogating Volume Datasets Using a Multi-Surface, Multi-Touch VR interface. IEEE Transactions on Visualization and Computer Graphics, 2012.
Data: National Library of Medicine, Visible Human Project



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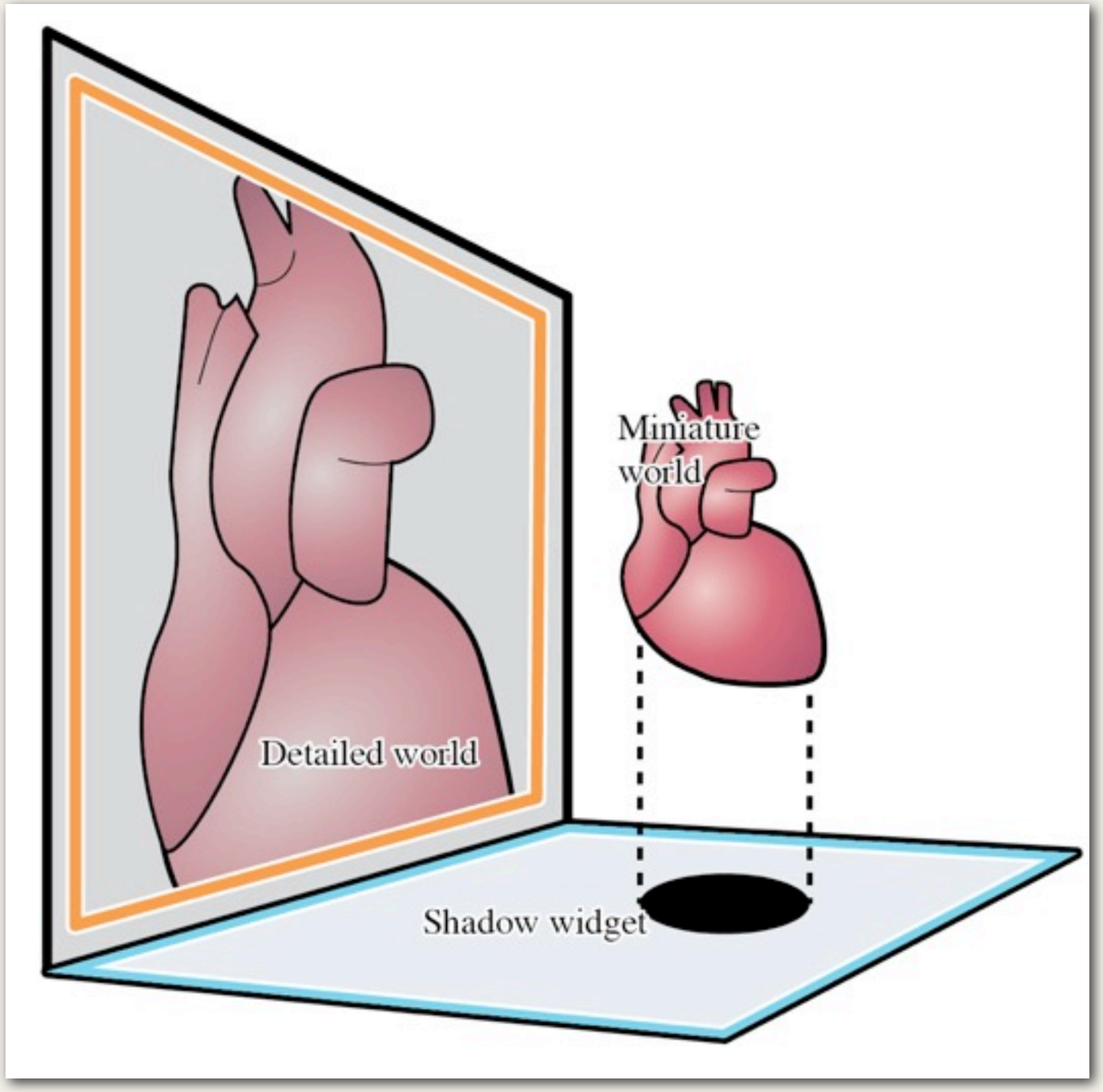

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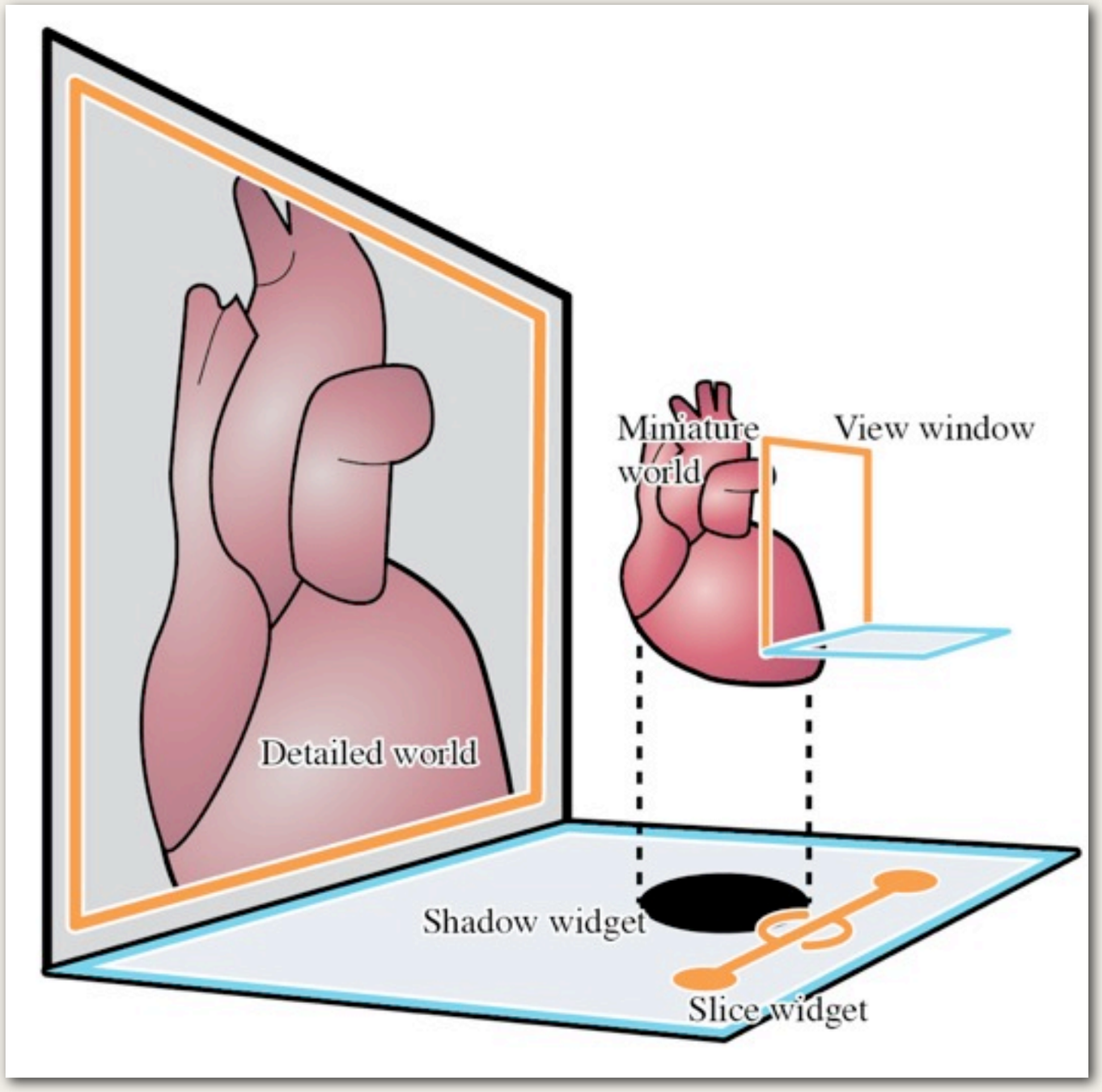

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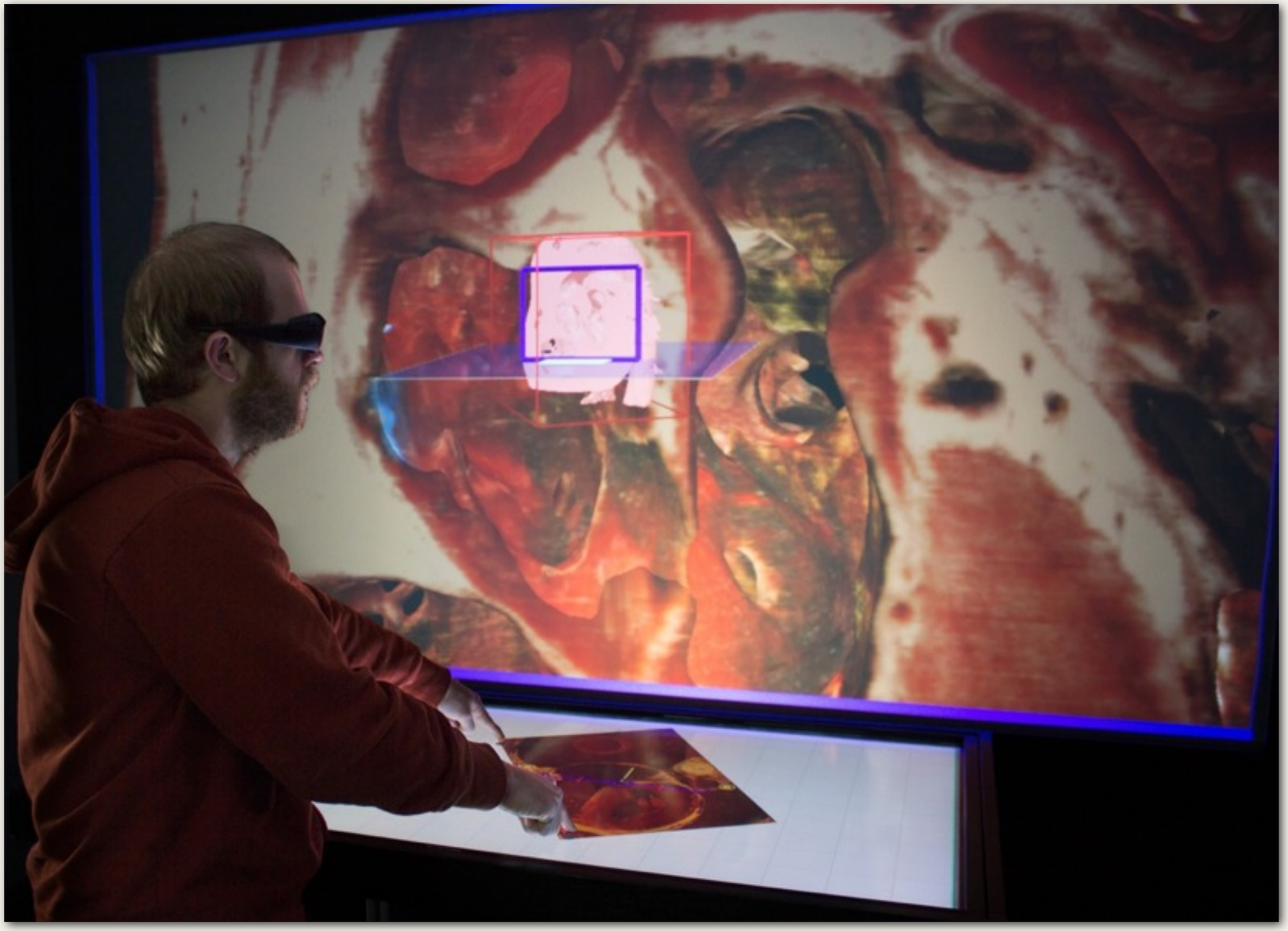

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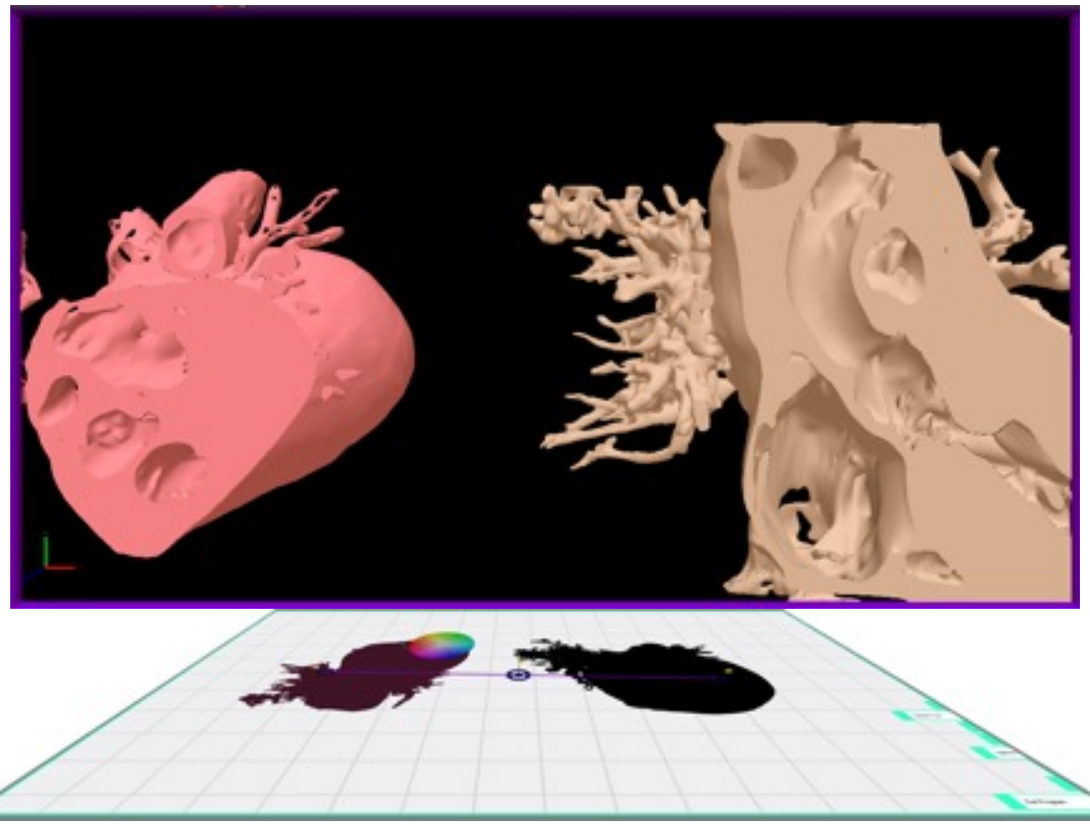
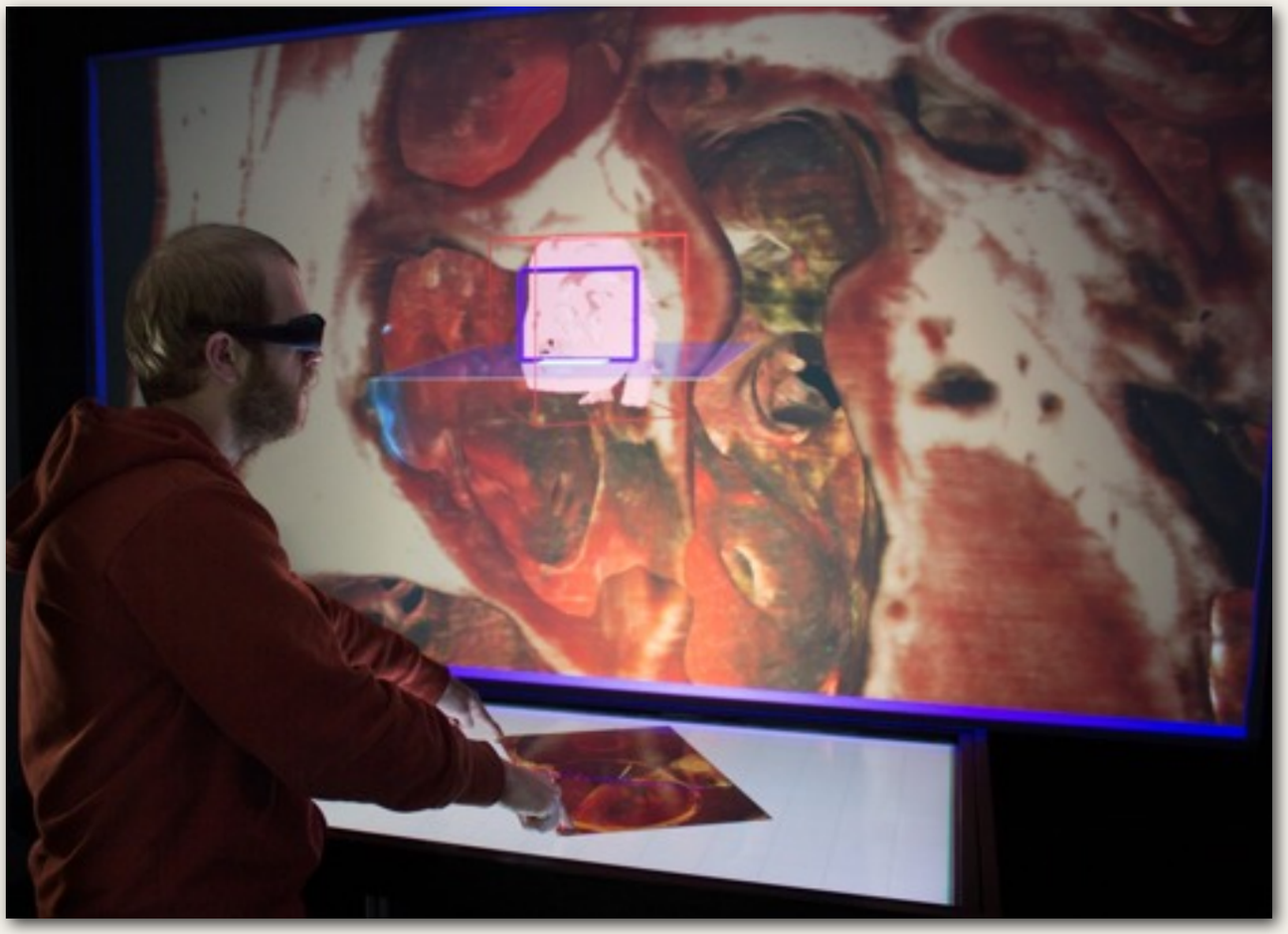
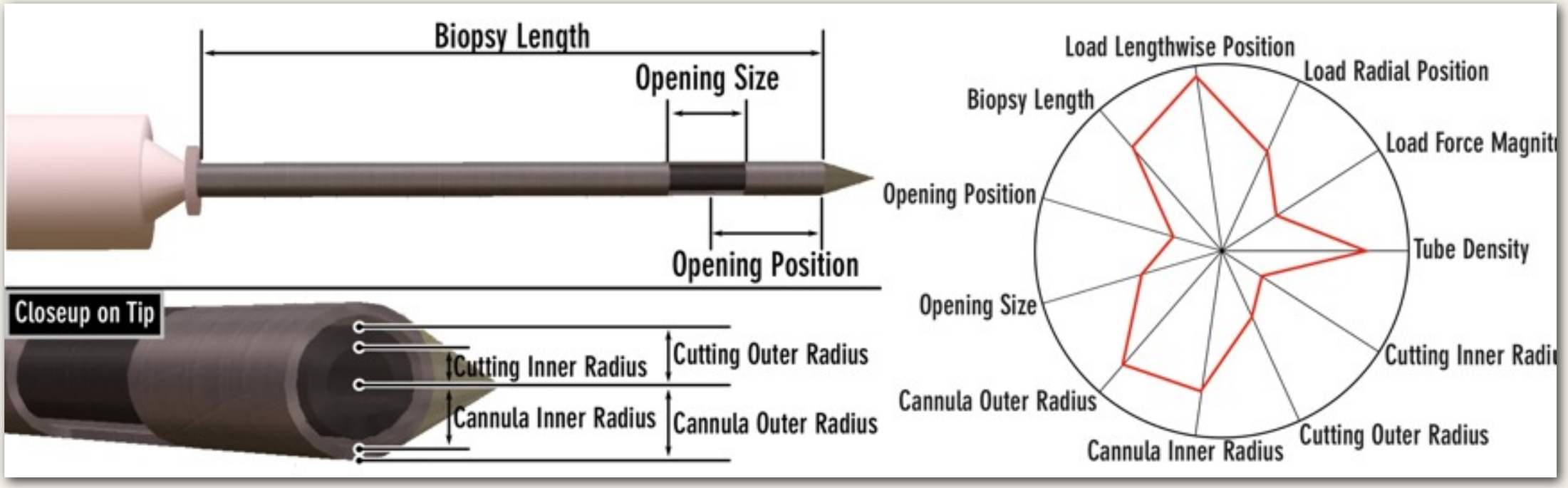
3D Floating Miniature

This is not so obvious… is it a good idea to mix 2D and 3D? We think, YES.





A more specific example: data-driven medical device design



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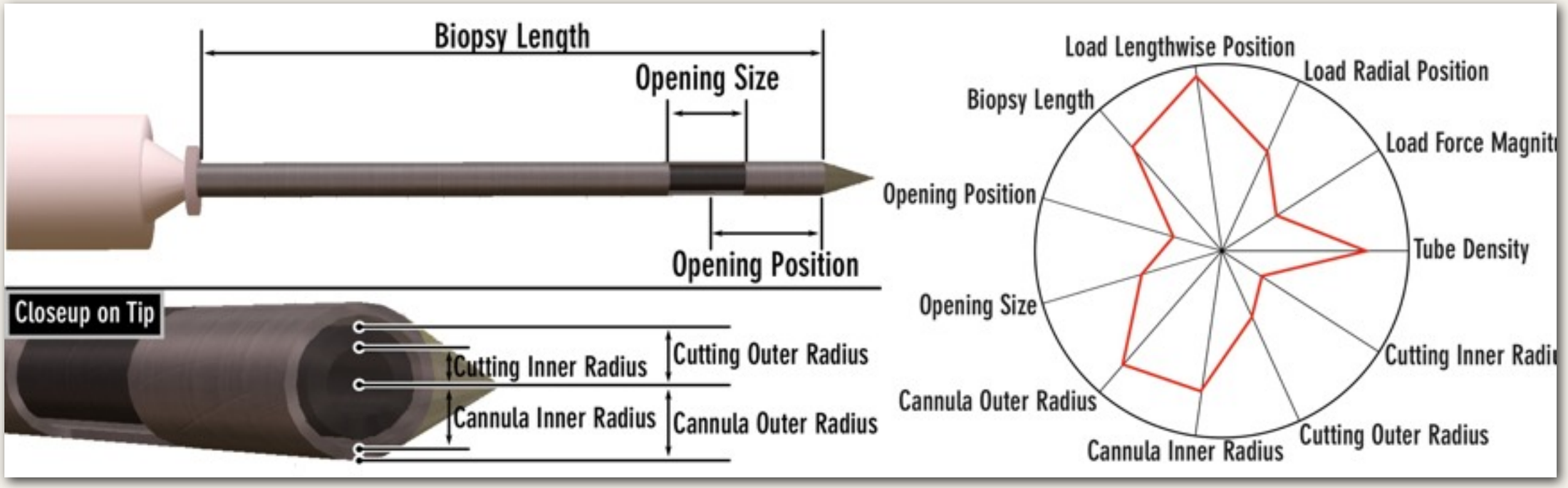
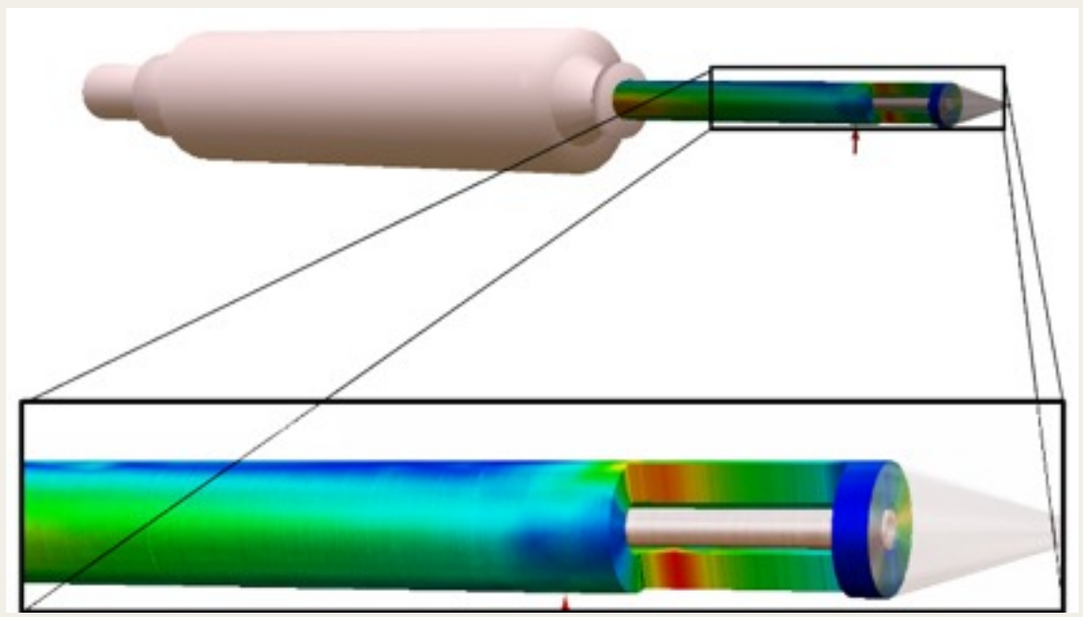
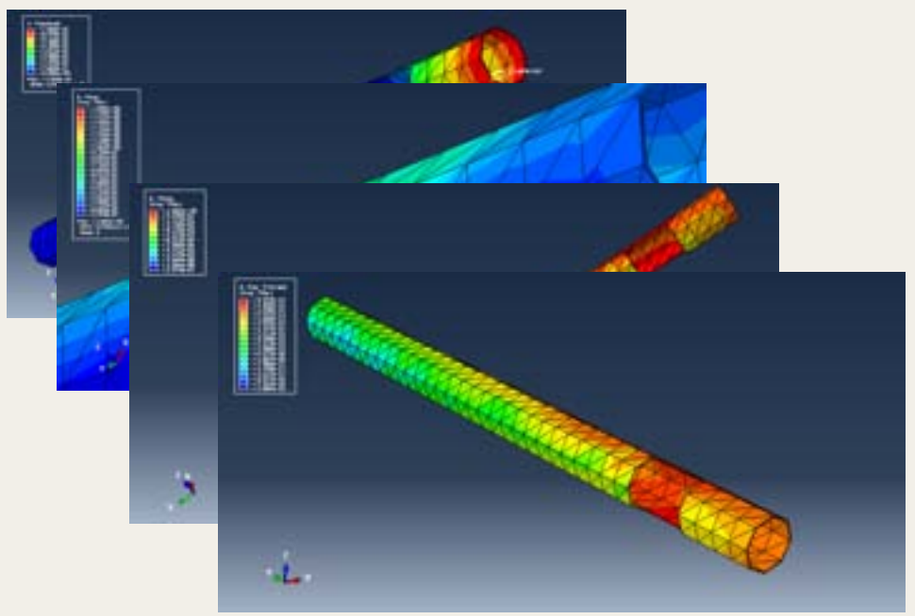
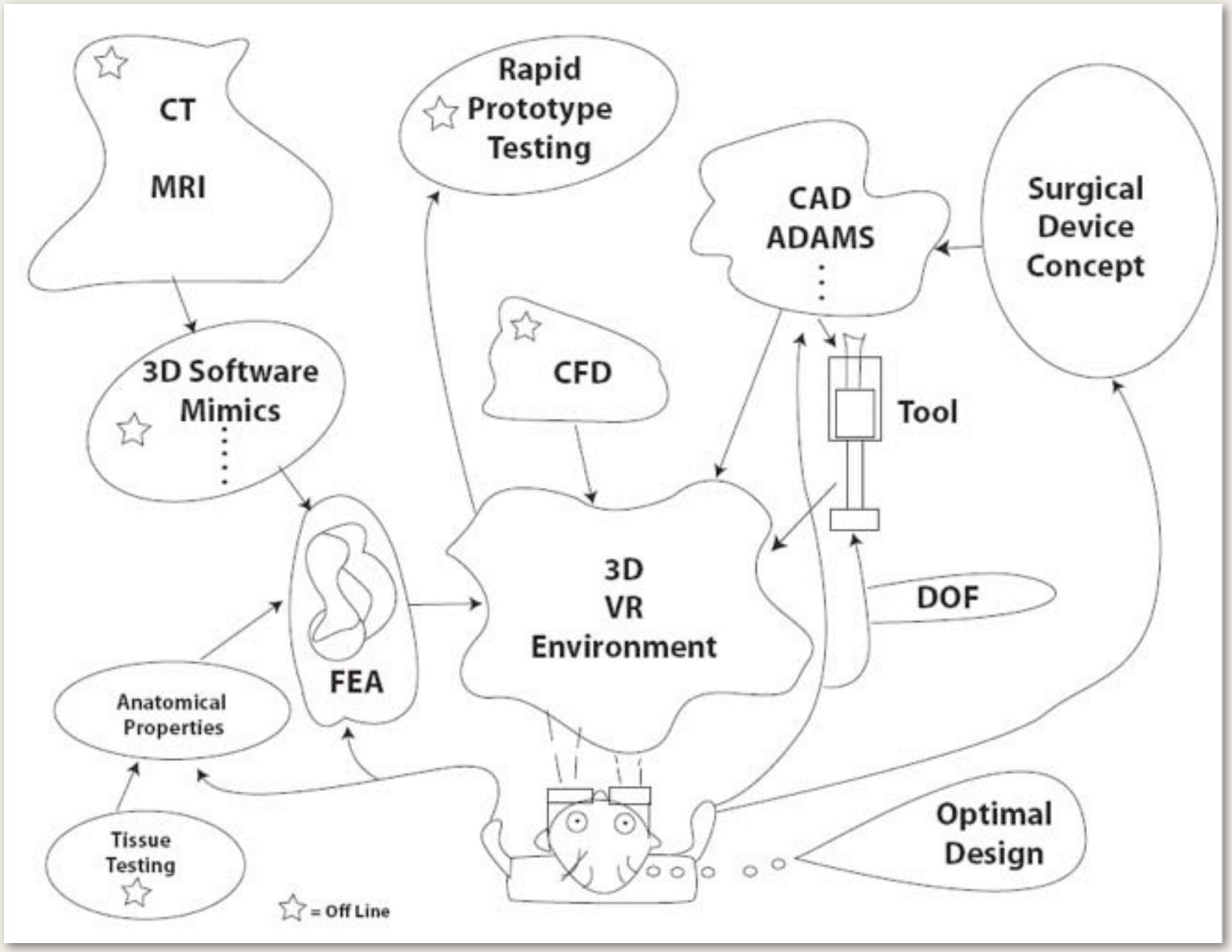






...

A sketch of the future



by Dr. Art Erdman
Director, University of Minnesota Medical Devices Center

Simulation and Data-Intensive Design for Medical Device Engineering

Anatomical Databases

Initial Device Concepts

Revolutionary Simulation Power

1. Scalable modeling and simulation tools that take advantage of high-performance computing power
2. Seamless integration of multiple simulation frameworks and data sources
3. Real-time interactive supercomputing analysis
4. Remote and cloud computing

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Simulation and Data-Intensive Design for Medical Device Engineering

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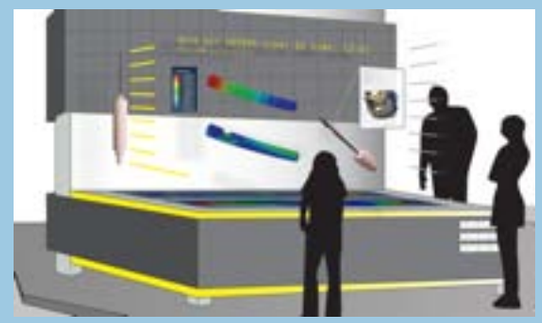
From Data to Insight

1. Tools to query and analyze massive high-dimensional space-time datasets
2. Accurate visualization of multi-variate relationships, variance, and uncertainty in simulation results
3. Interactive device modifications
4. New simulation-based engineering workflows



Iterative Discovery & Design Process

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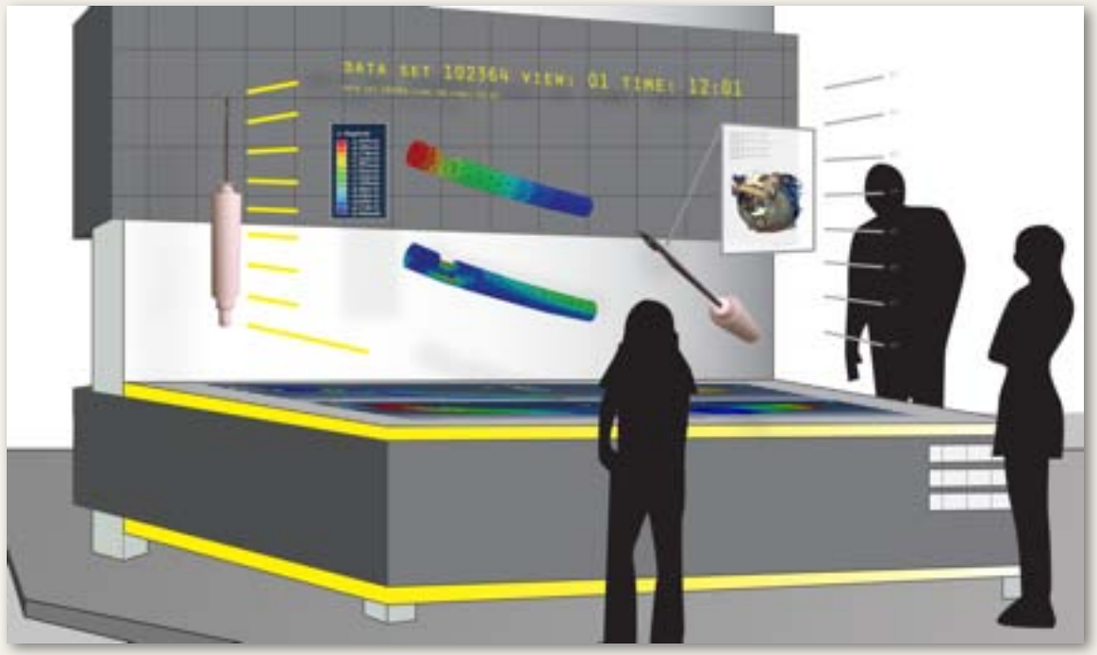
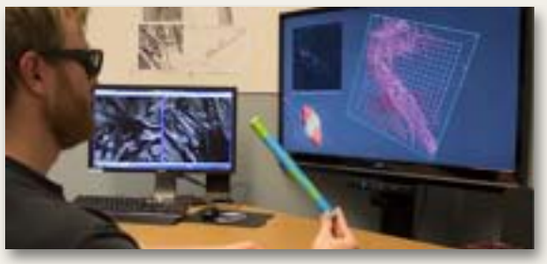
What would make this data-intensive design really work for engineers?

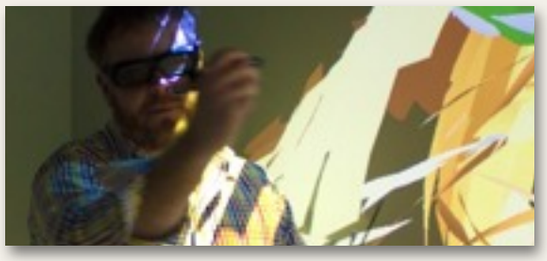


- Define and automatically run sets of many simultaneous simulations using high-performance computing platforms.
- Receive real time or near real time feedback.
- Interrogate these data via “ensemble” visualizations of 100’s of outputs (e.g., parameter space studies, different anatomical contexts).
- Refine and collaboratively (re)design using spatial inputs and visualization to match the complexity of the data.

Hands-on, data-driven medical device design



Doing “real work” with volumetric data



Visual computing for science and art

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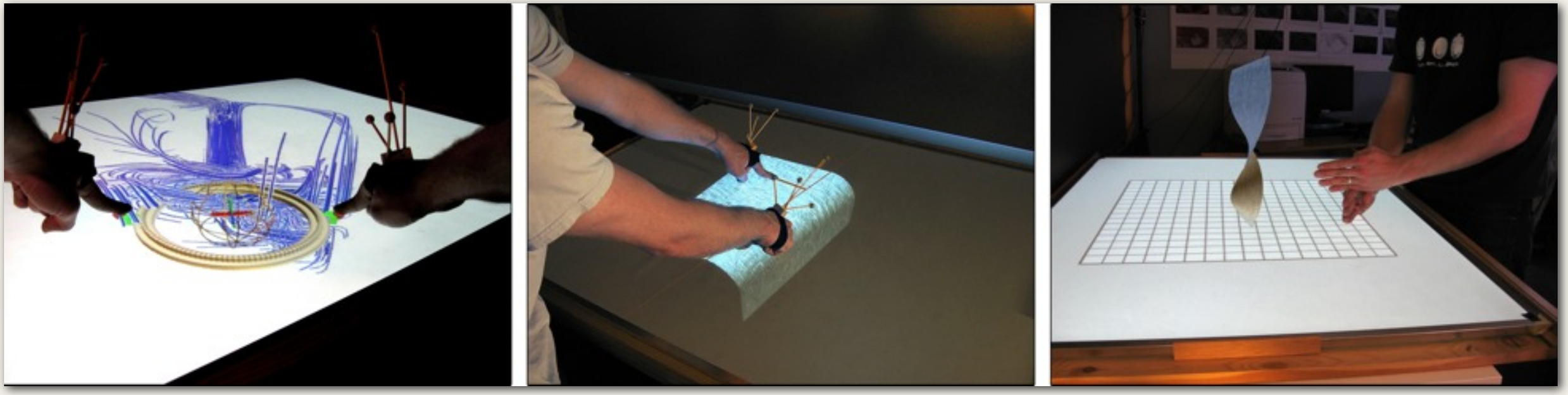
Extending iPhone-style natural user interfaces to 3-dimensions



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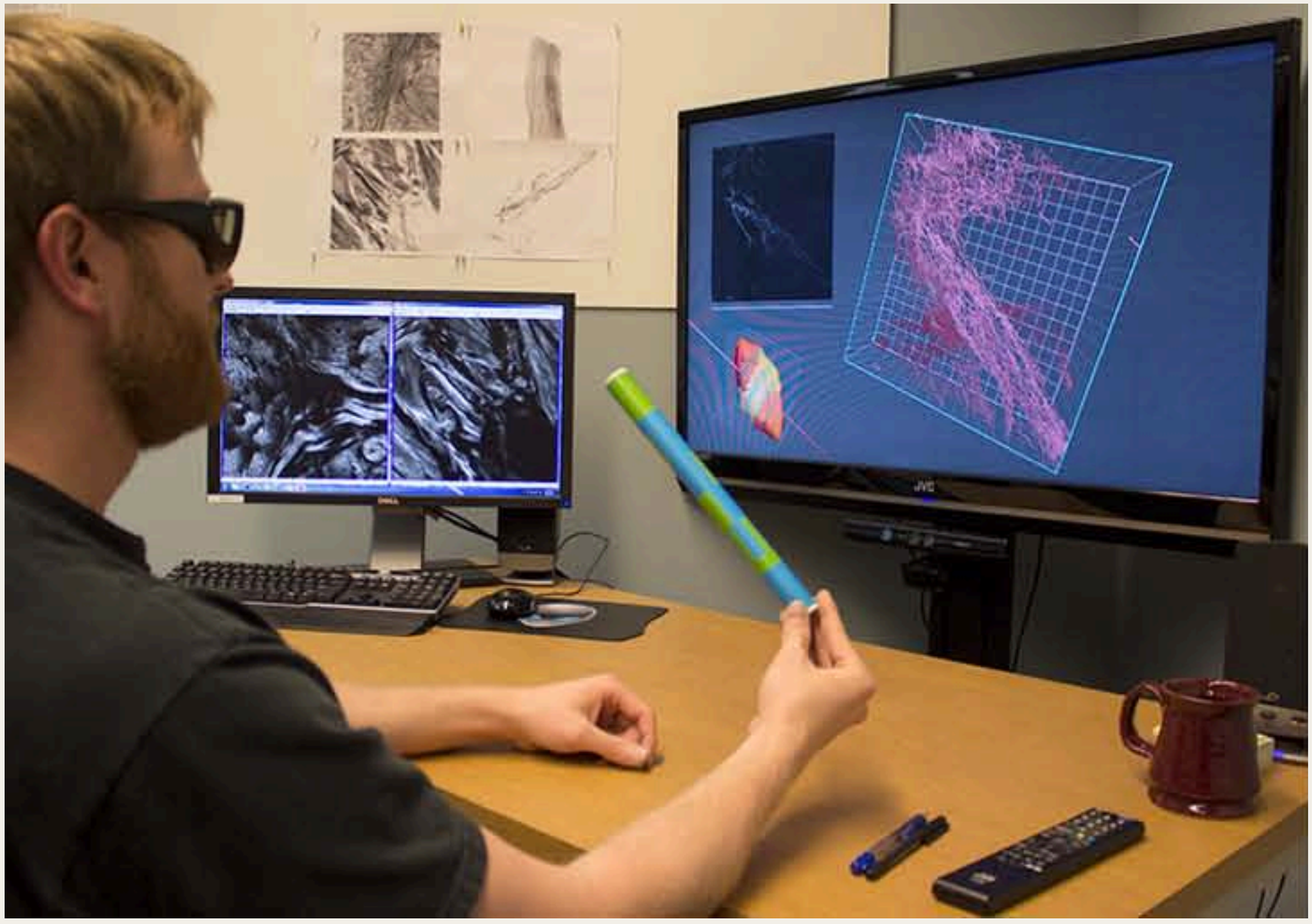
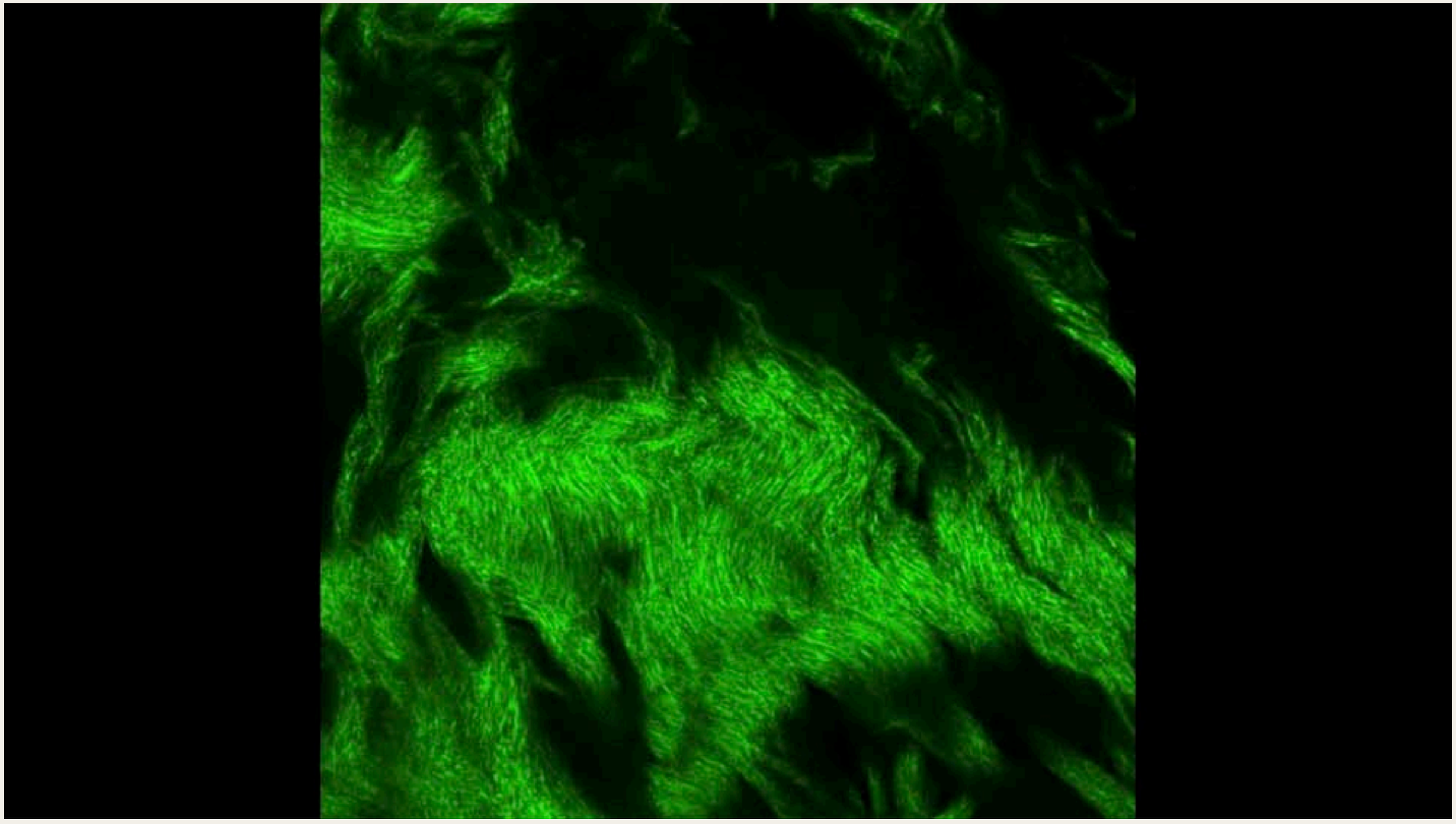
Bret Jackson, David Schroeder, and Daniel F. Keefe. Nailing Down Multi-Touch: Anchored Above the Surface Interaction for 3D Modeling and Navigation. Graphics Interface 2012., 2012.

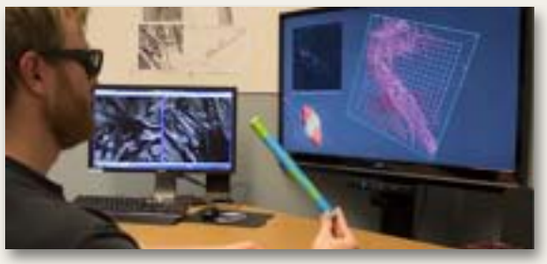
Wednesday, September 4, 2013

The future: Spatial user interfaces at your desk





Hands-on, data-driven medical device design



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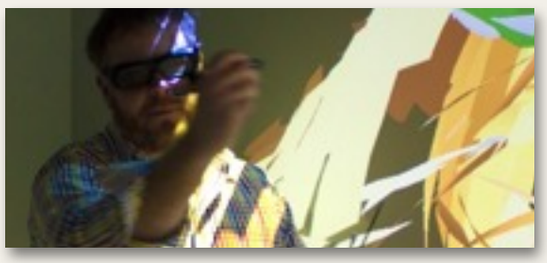

Visual computing for science and art

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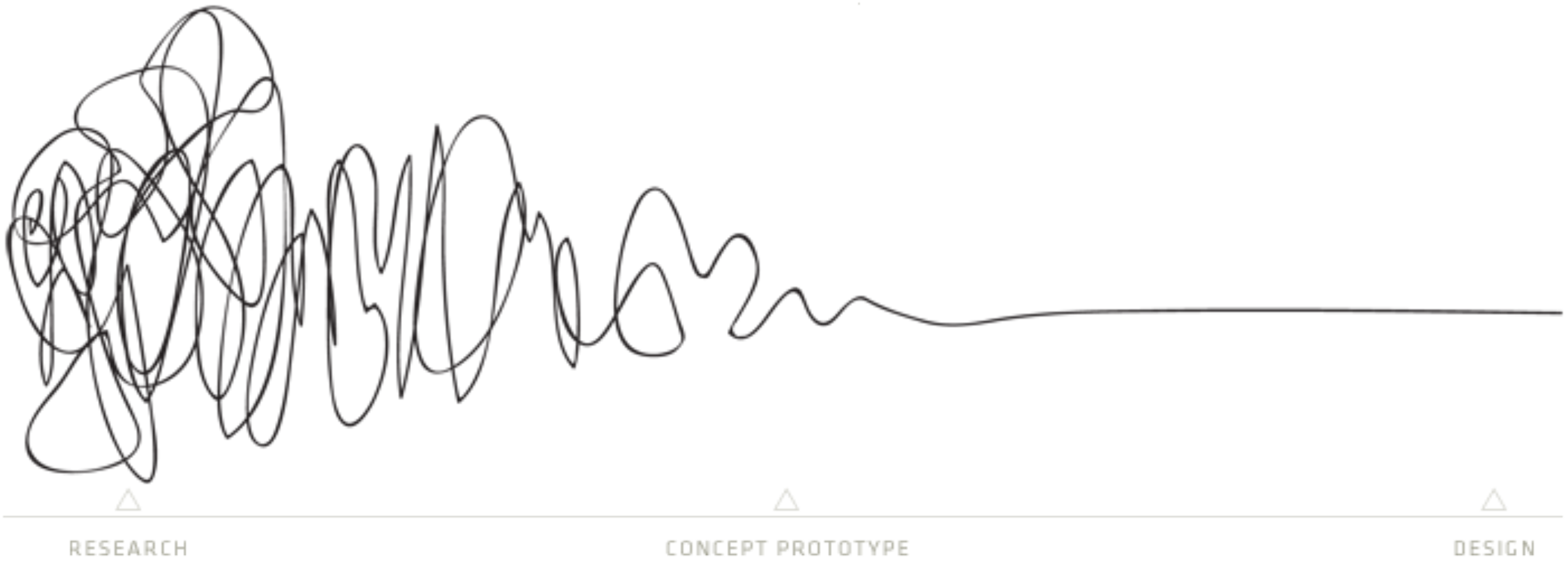


Damien Newman's "Design Process Squiggle"

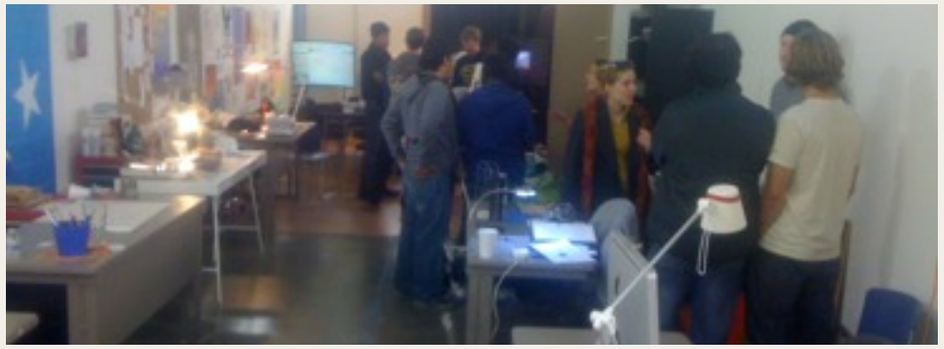
CavePainting & Making la Guitarrista Gitana
I3D 2001, SIGGRAPH Art Gallery 2002, ...

How Art and CS research intersect for me:
form through movement, the expressiveness of the hand in virtual space

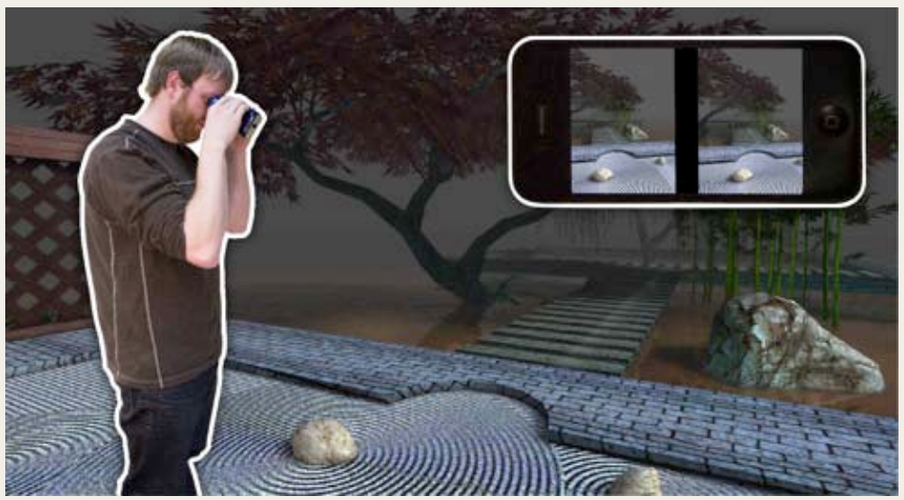
Hiding Spaces with Cynthia Beth Rubin
SIGGRAPH 2002, ISEA 2002.

Art/Design Collaborations in Courses and Research

University of Minnesota / Minneapolis College of Art and Design



“Advanced Virtual Environments” course / research paper now in press:



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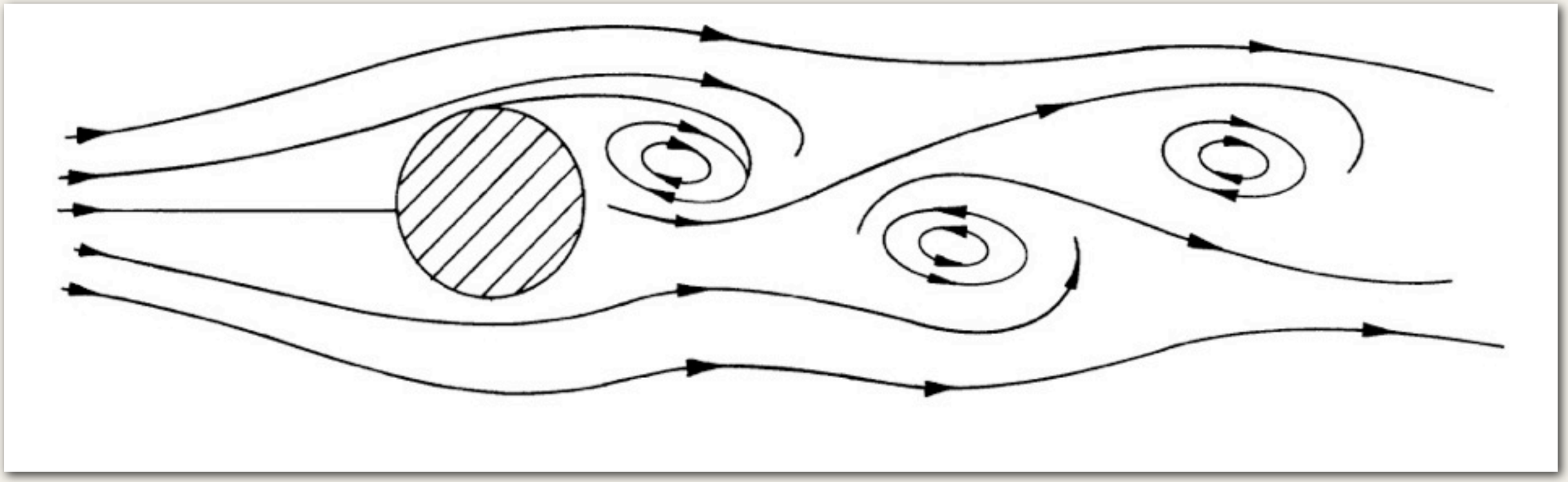

Turk et al. SIGGRAPH 1996

Scientific visualization tools for artists and designers

- Use hardware and metaphors familiar to visual designers.
- Leverage existing research in gestural user interfaces.
- Develop methods of linking input to underlying datasets.
- Use automation to simplify tedious and repetitive design tasks.

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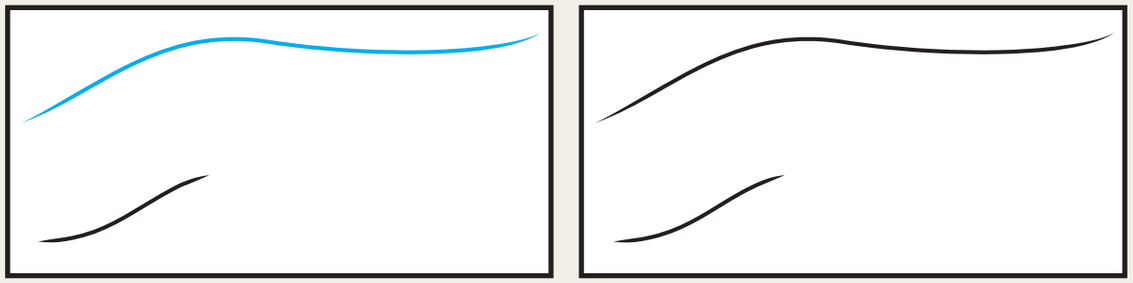
David Schroeder, Dane Coffey, Daniel F. Keefe. Drawing with the Flow: A Sketch-Based Interface for Illustrative Visualization of 2D Vector Fields In Proceedings of ACM SIGGRAPH/ Eurographics Sketch-Based Interfaces and Modeling 2010, 2010.

Data: Thanks to Mike Kirby and David Laidlaw

Streamline Gesture Set

Streamline Gesture Set

New



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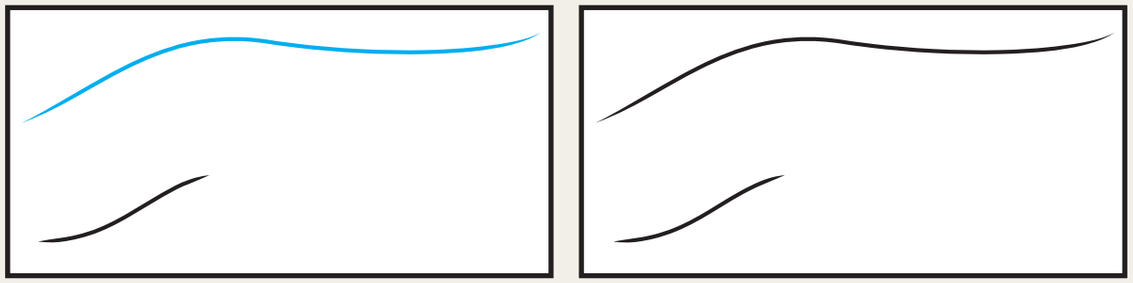
Streamline Gesture Set

New



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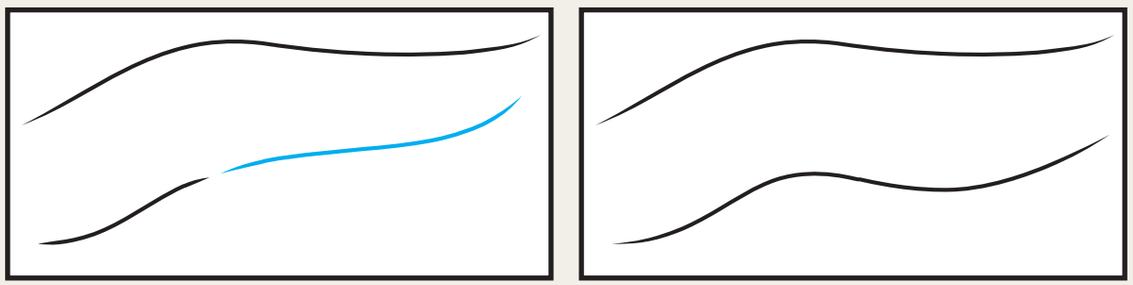
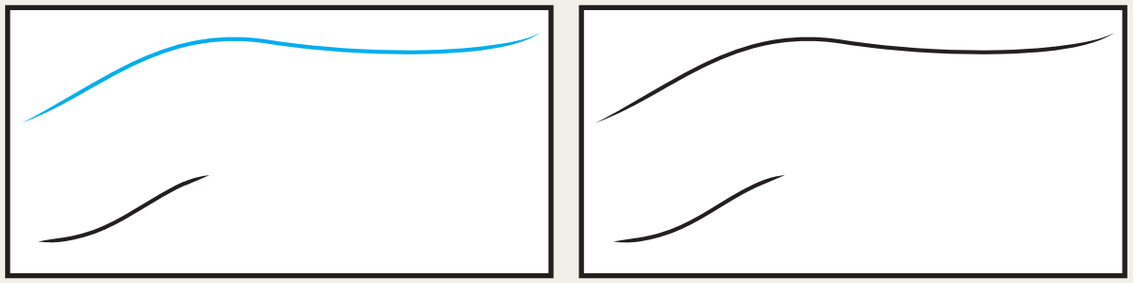


Streamline Gesture Set

New



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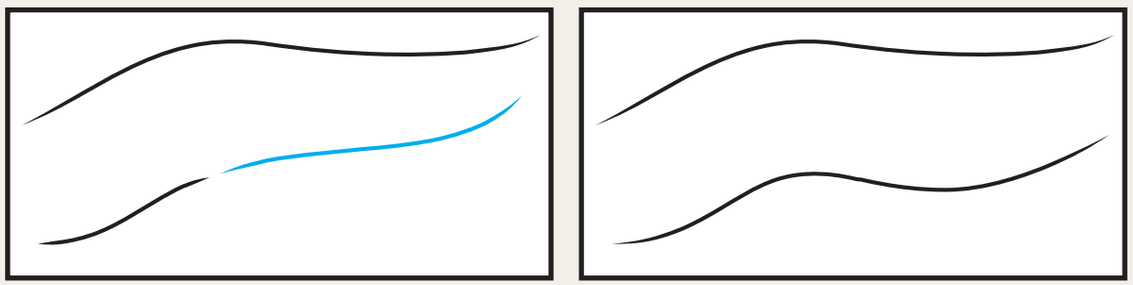

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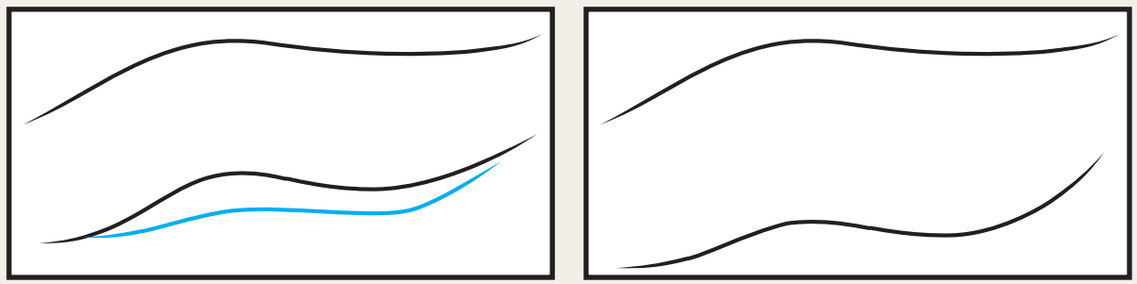

Streamline Gesture Set

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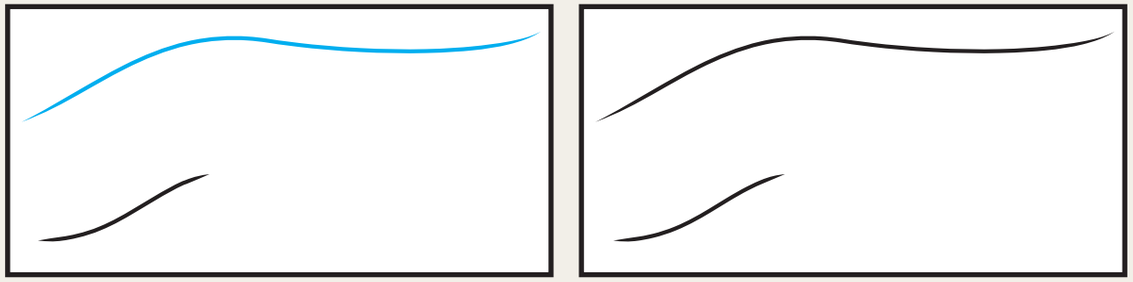

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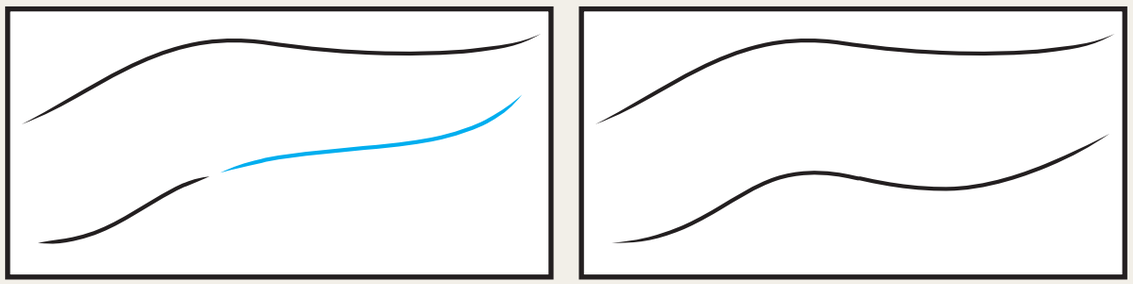

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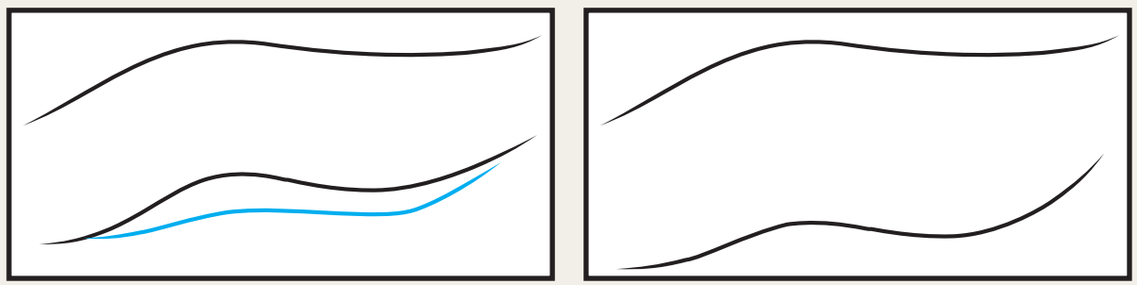
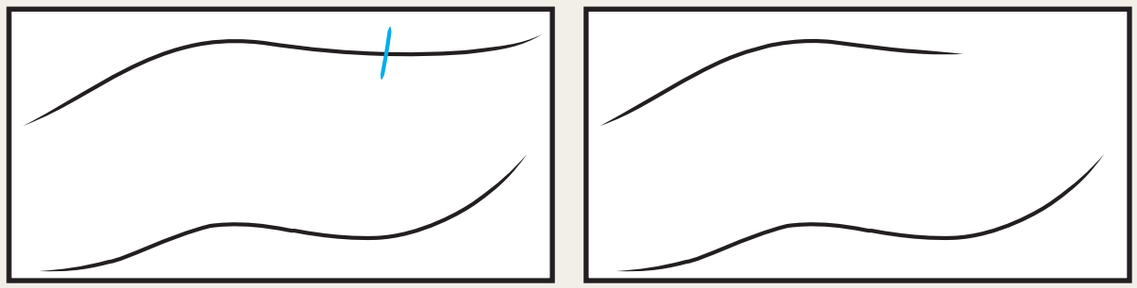


Crop



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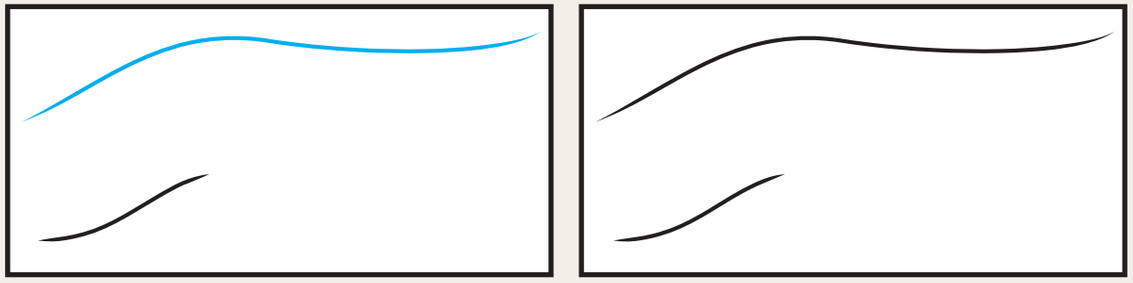
Streamline Gesture Set

New



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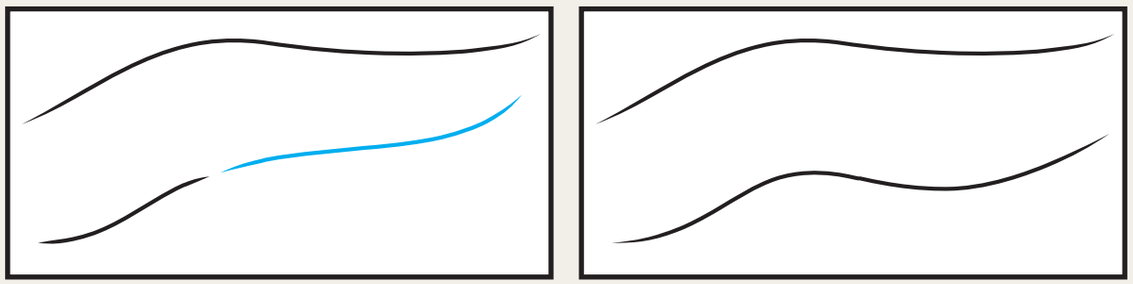

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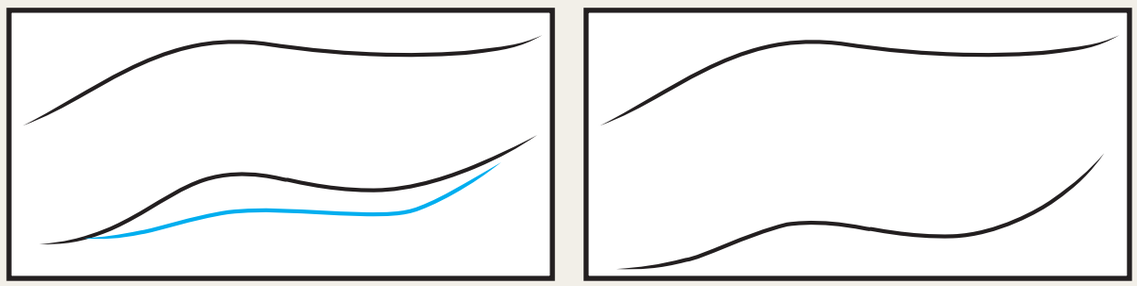

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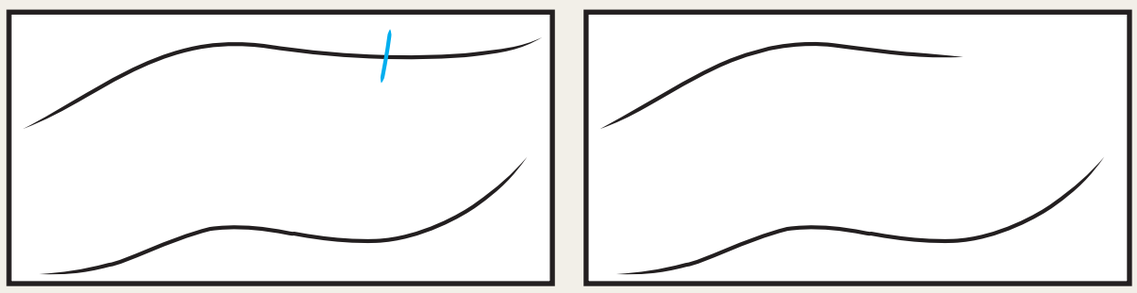

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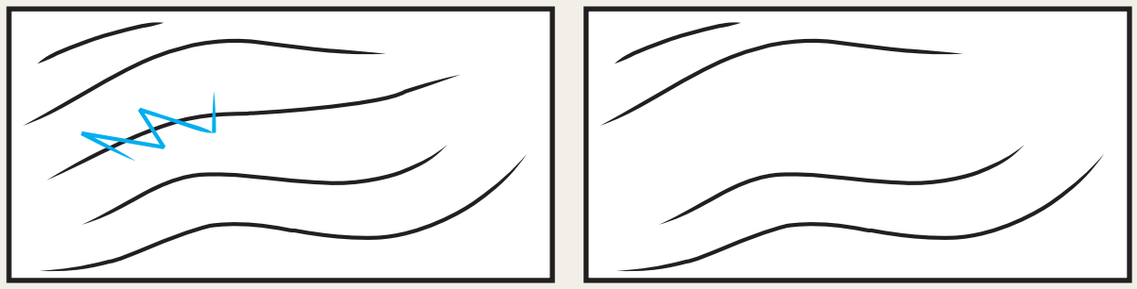

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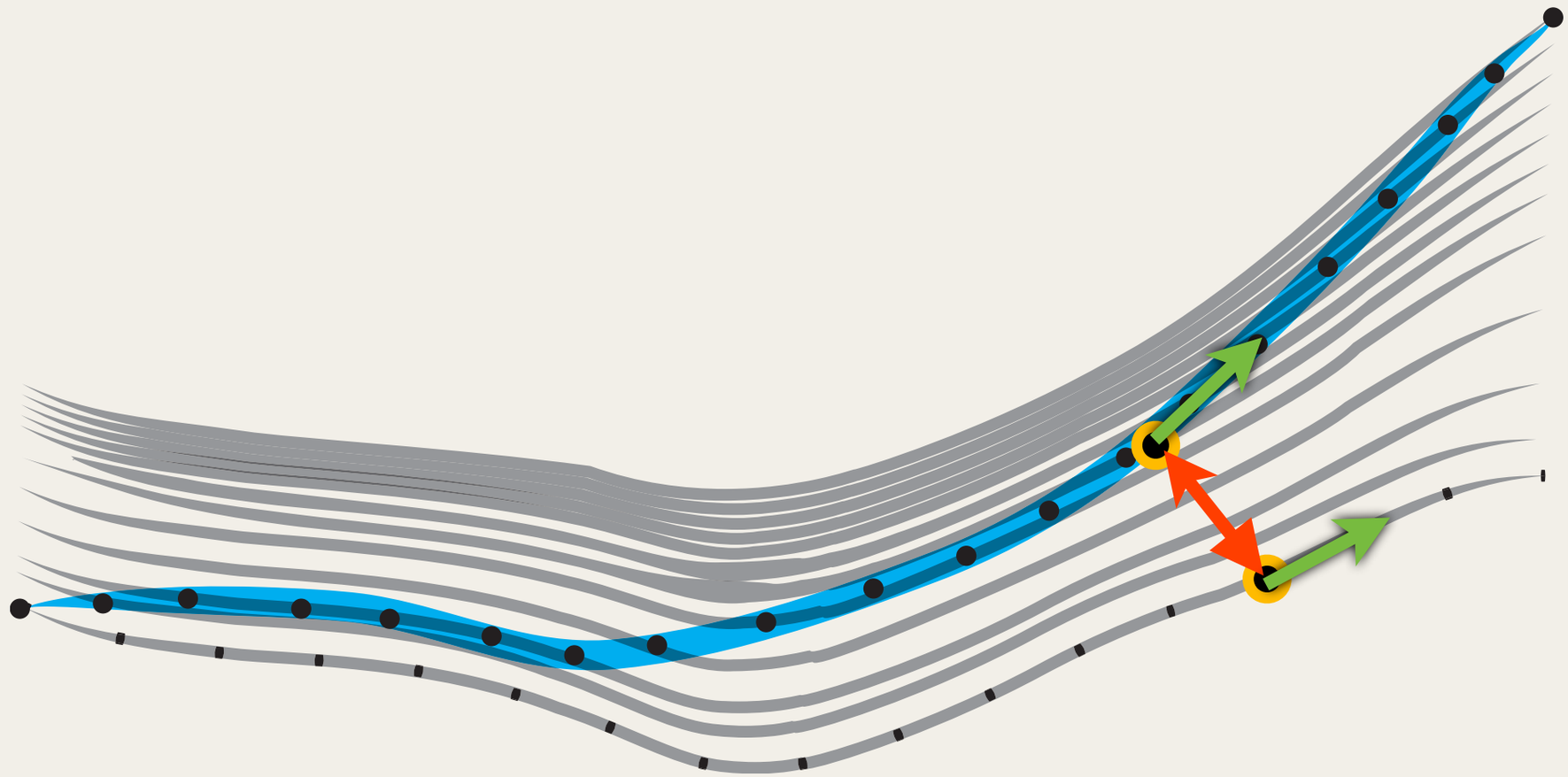
Ink-Data Settling



Similarity metric =

w_p(positional similarity) + w_d(directional similarity)

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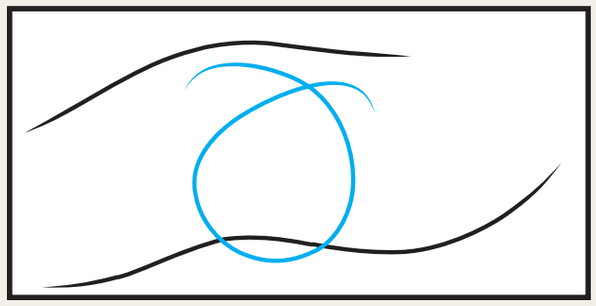
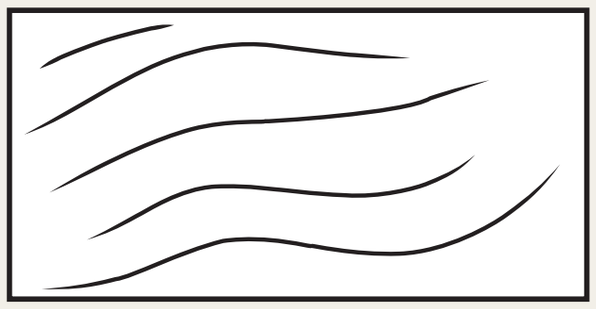
Interpreting User Intent Relative to Data

The “more” gesture





Interpreting User Intent Relative to Data

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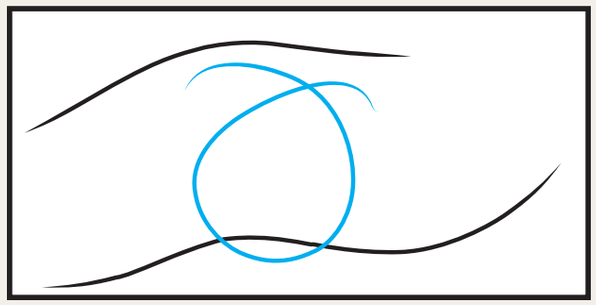

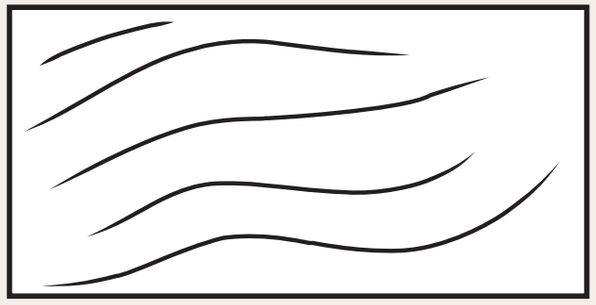

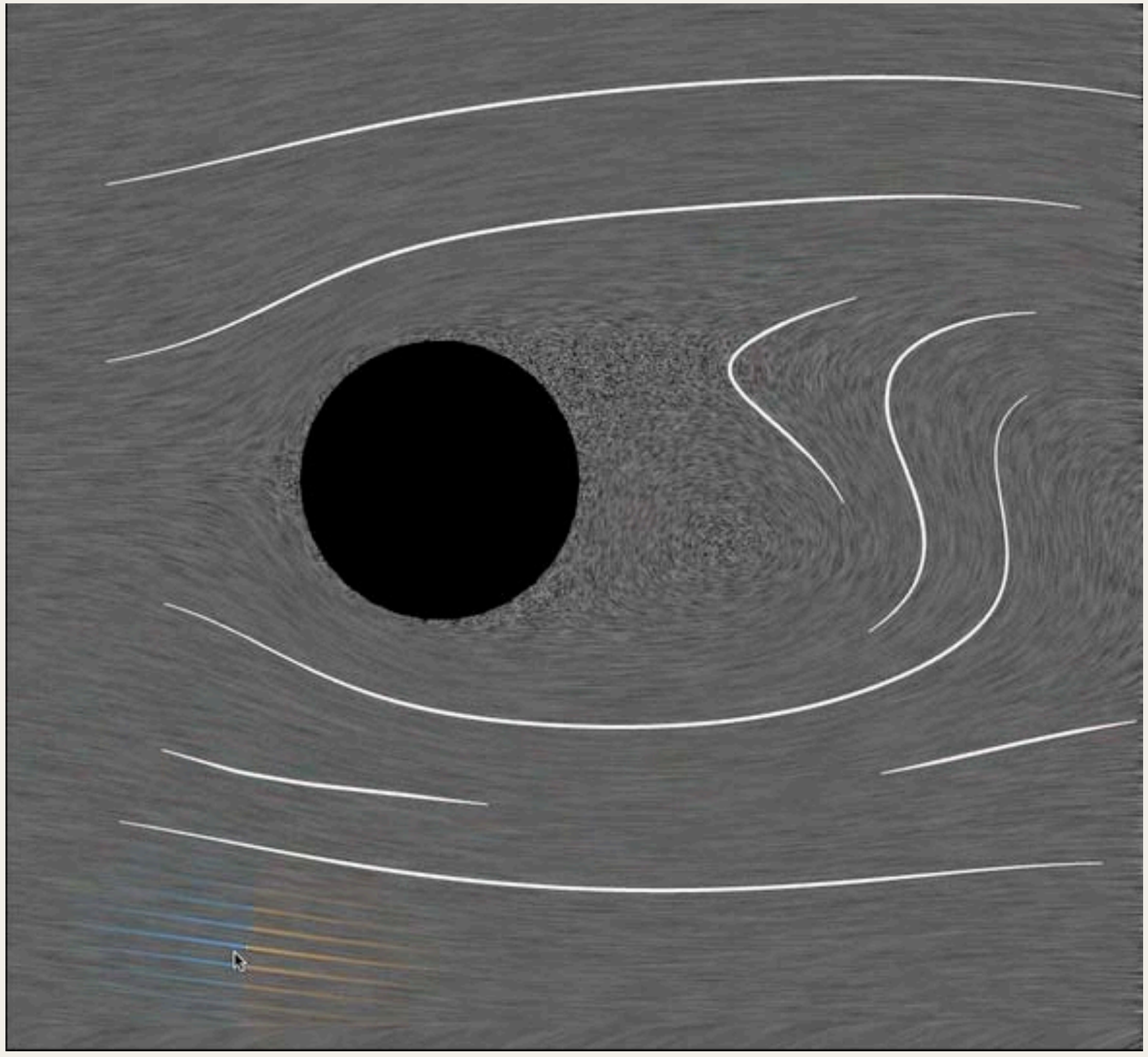

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Results: Fluid Exploration of Design Alternatives

Results: Fluid Exploration of Design Alternatives

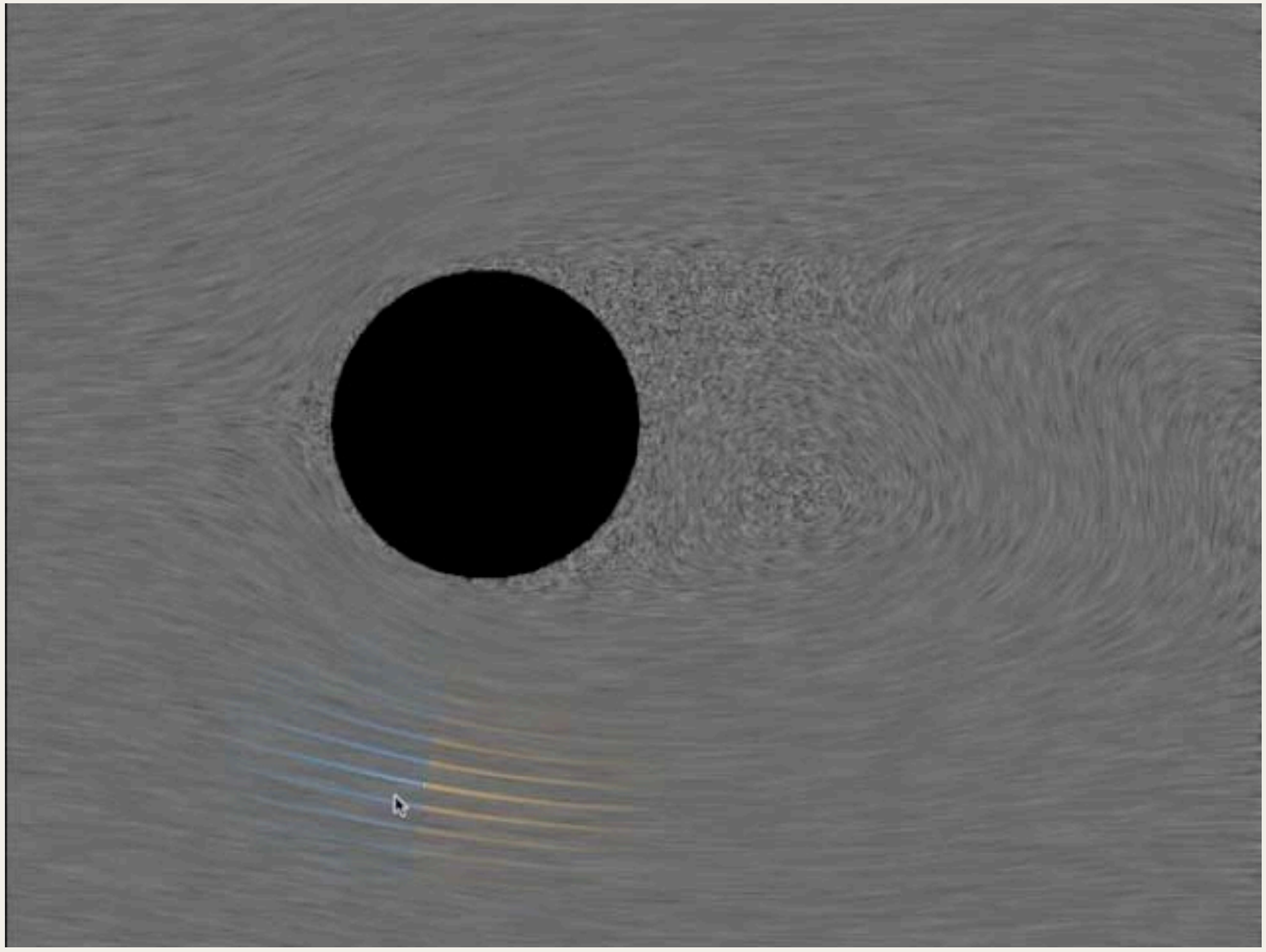
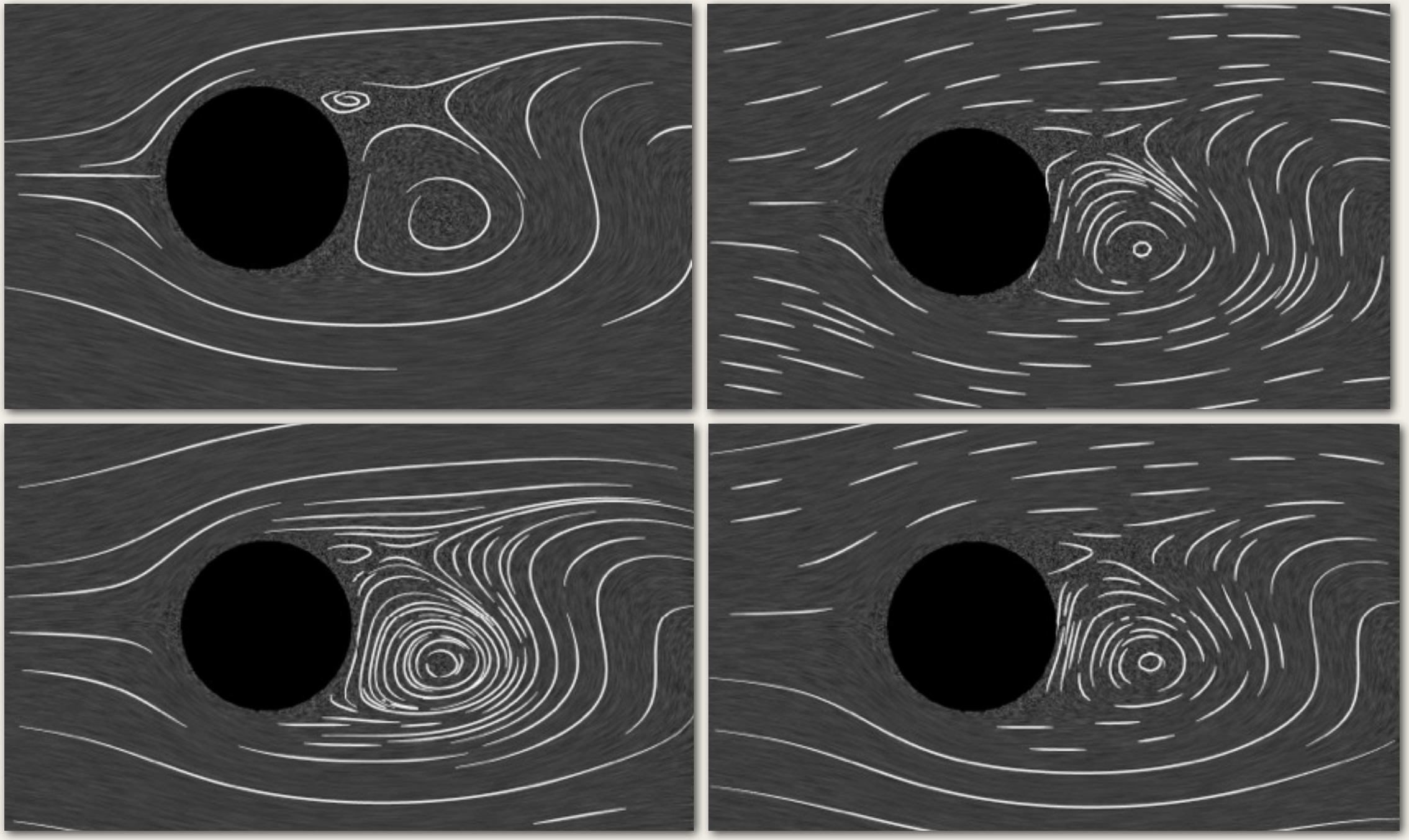


Illustration Possibilities



Additional Vector Fields

User Feedback

Minneapolis College of Art and Design instructors:

- “This is what all our students have on their desks” – interfaces in this style could expand technical possibilities for design students
- Illustrators and designers have incredibly controlled and deliberate technique – different styles of sketch-based interfaces might be possible

Mechanical Engineers who work with bio-flows (academic and industry)

- Forget illustrators, we want this!
- The level of interactivity is an exciting departure from standard practice

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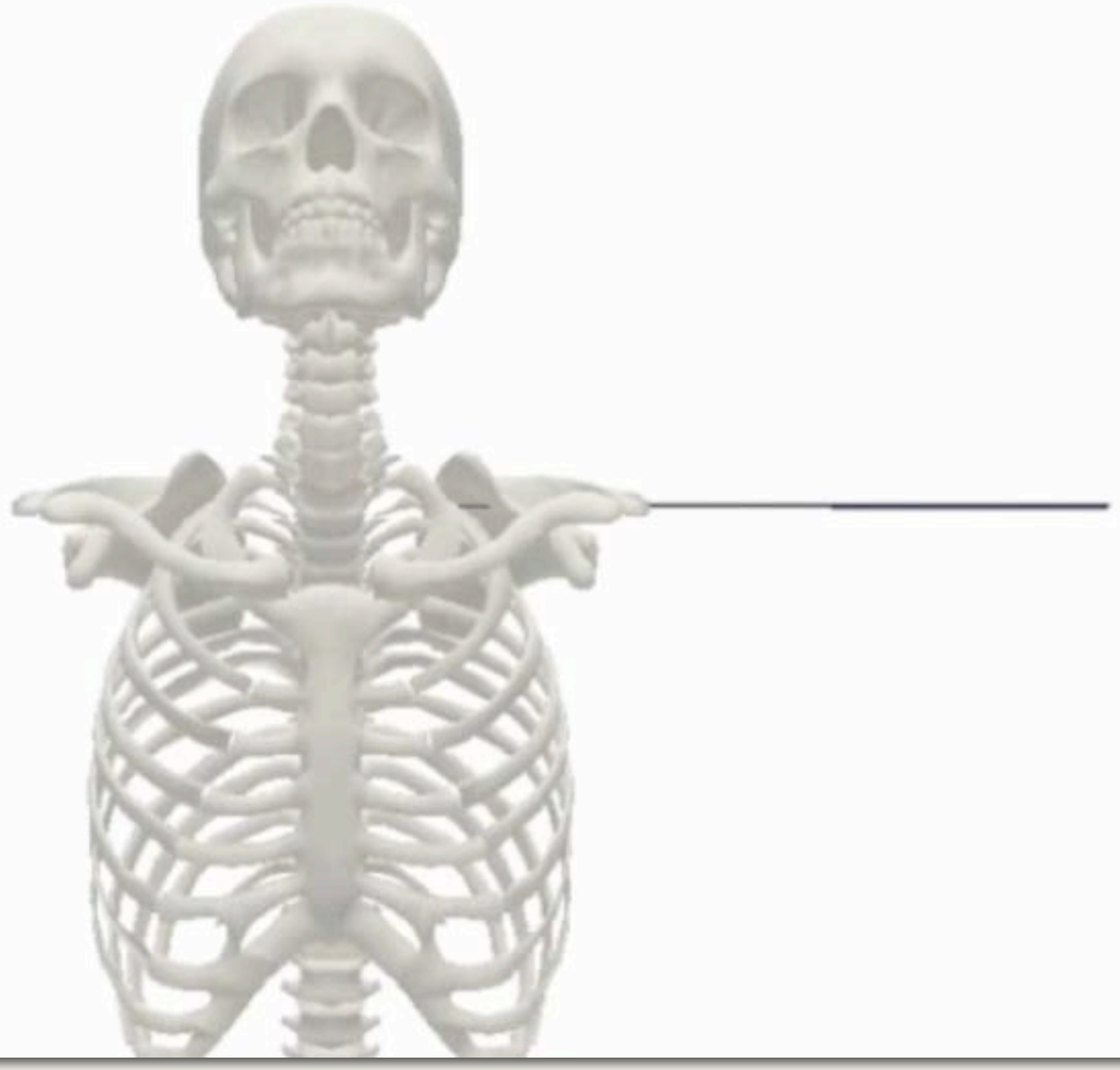
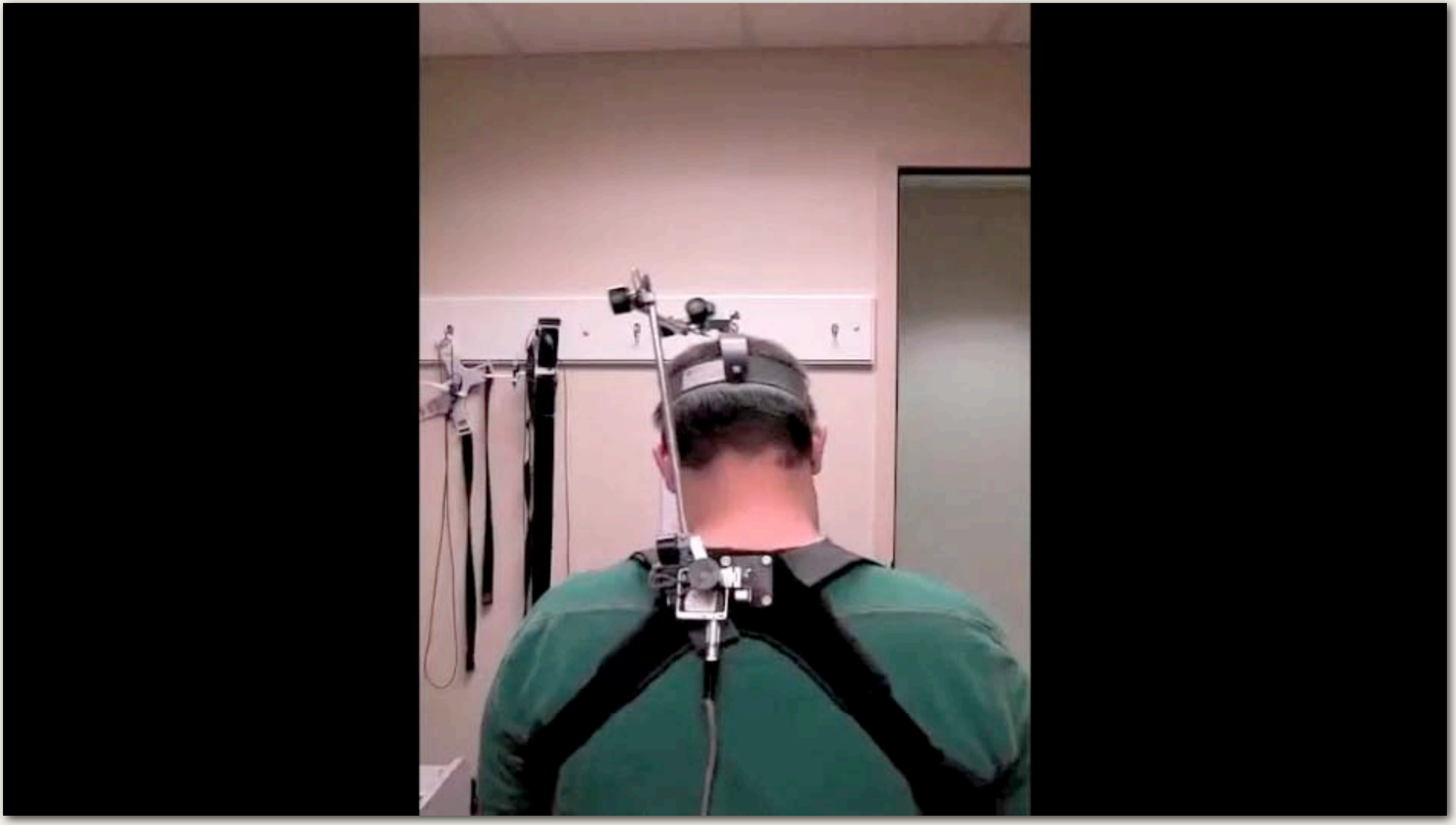
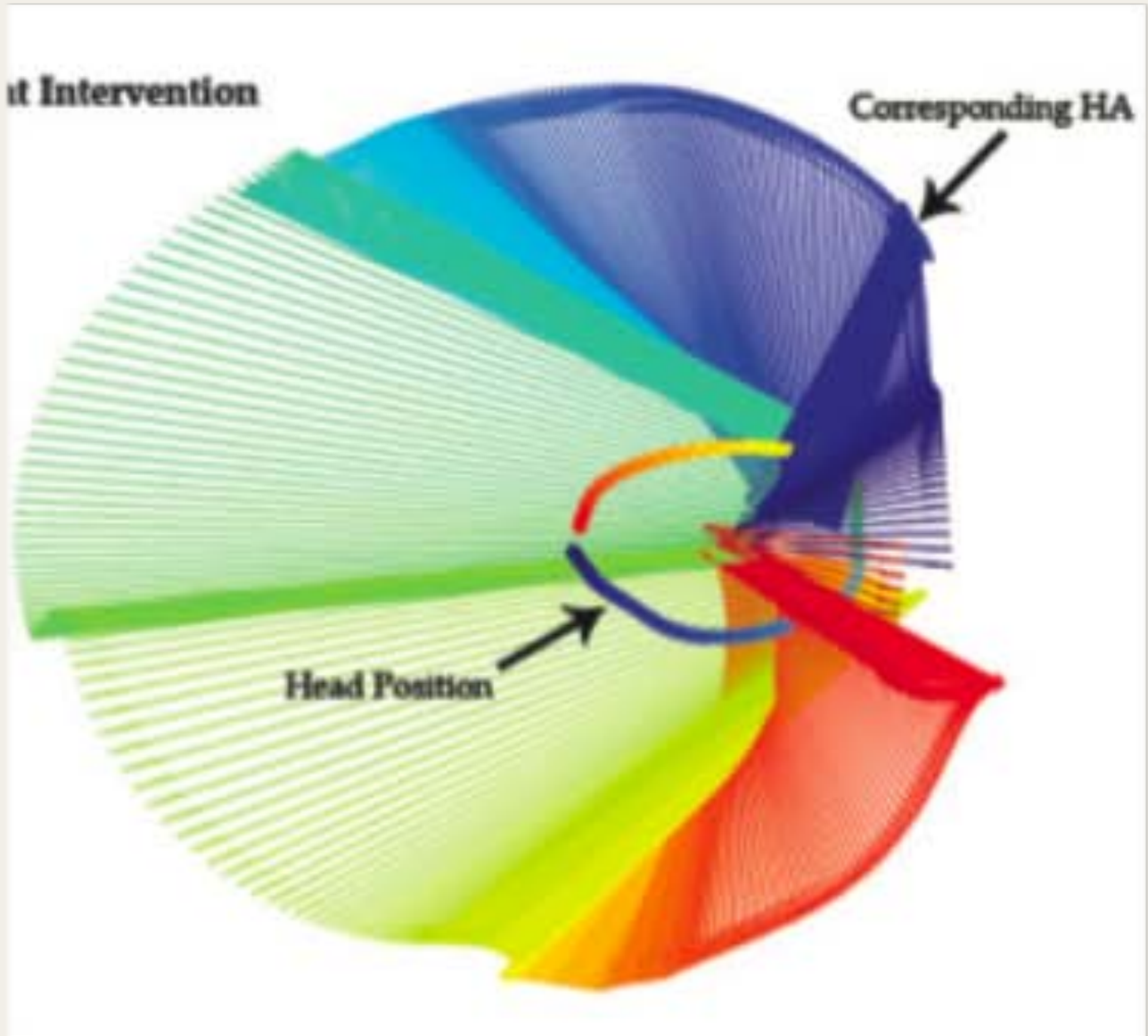
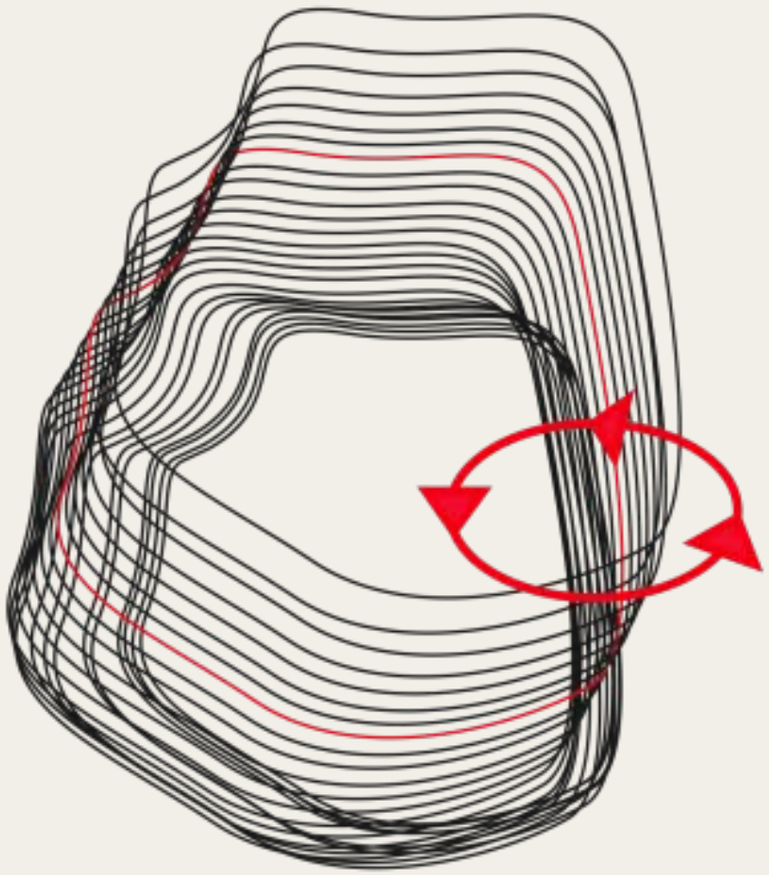
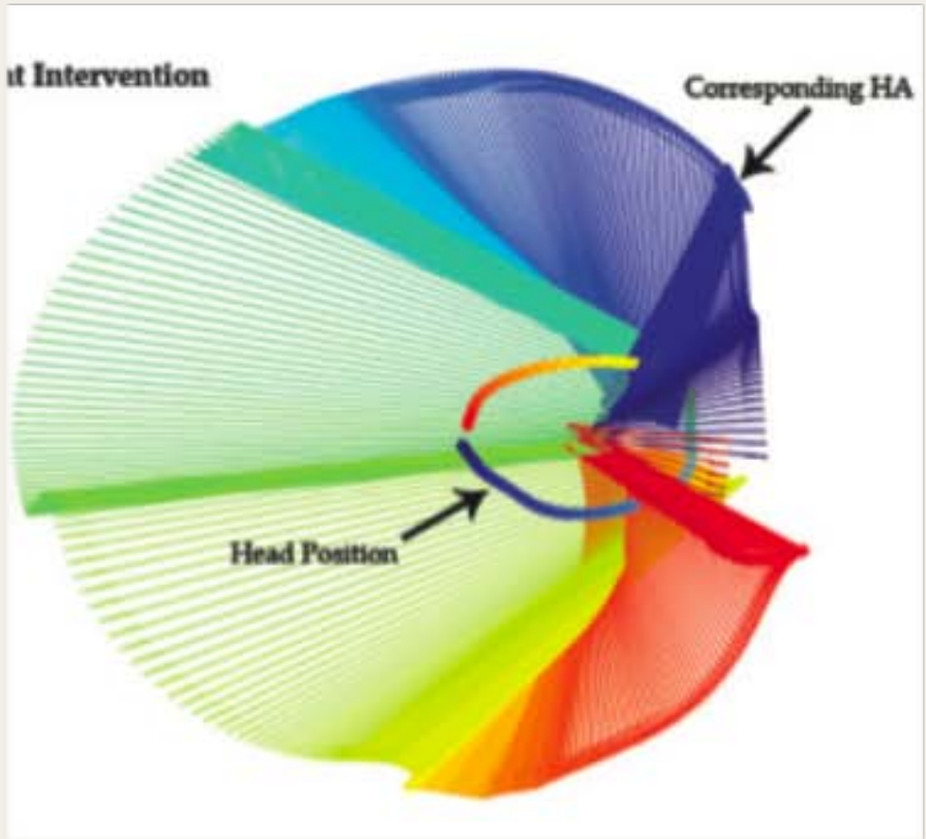




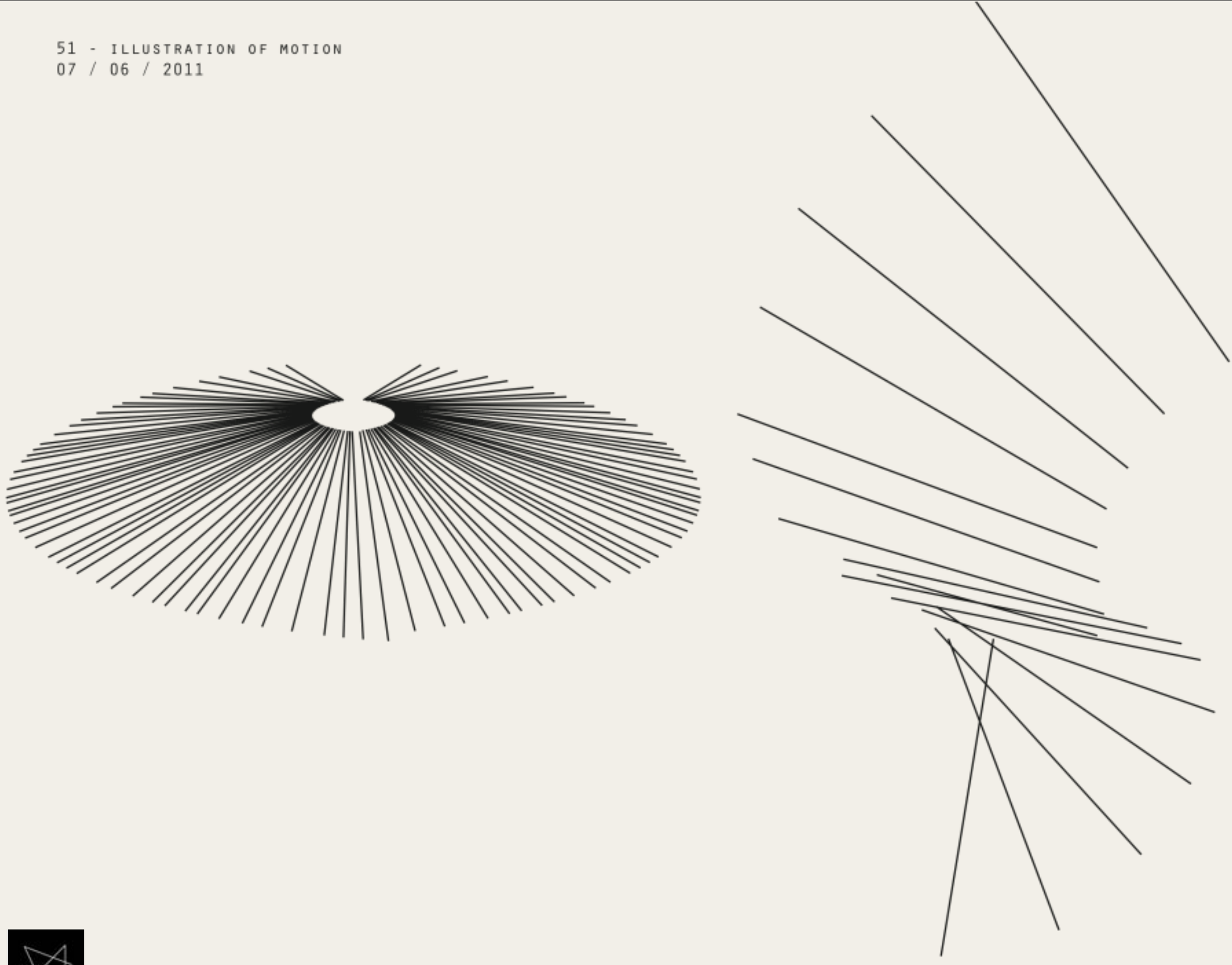

NEW APPROACH


ıt Intervention
Corresponding HA
Head Position




ut Intervention
Corresponding HA
Head Position

51 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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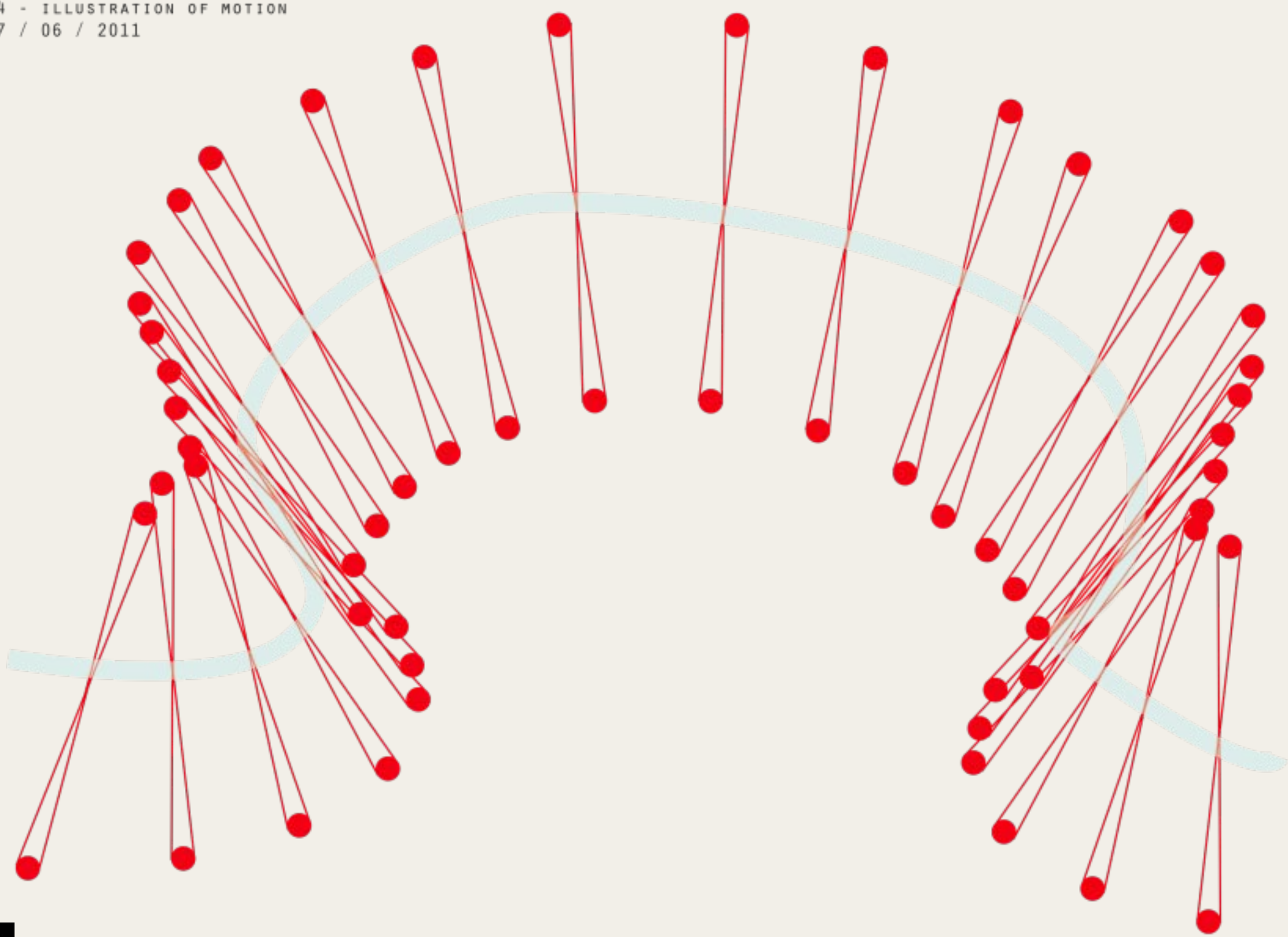
44 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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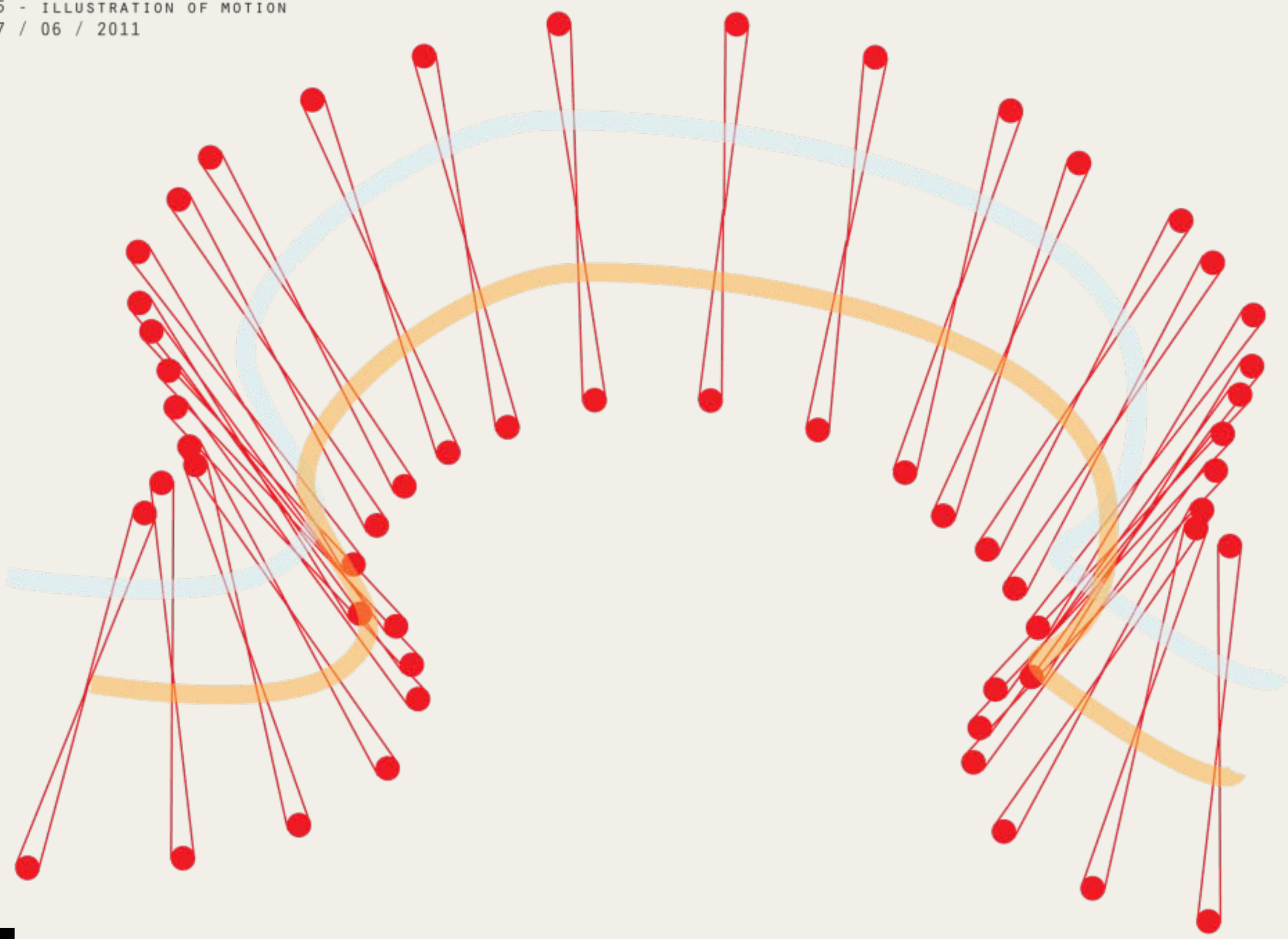
45 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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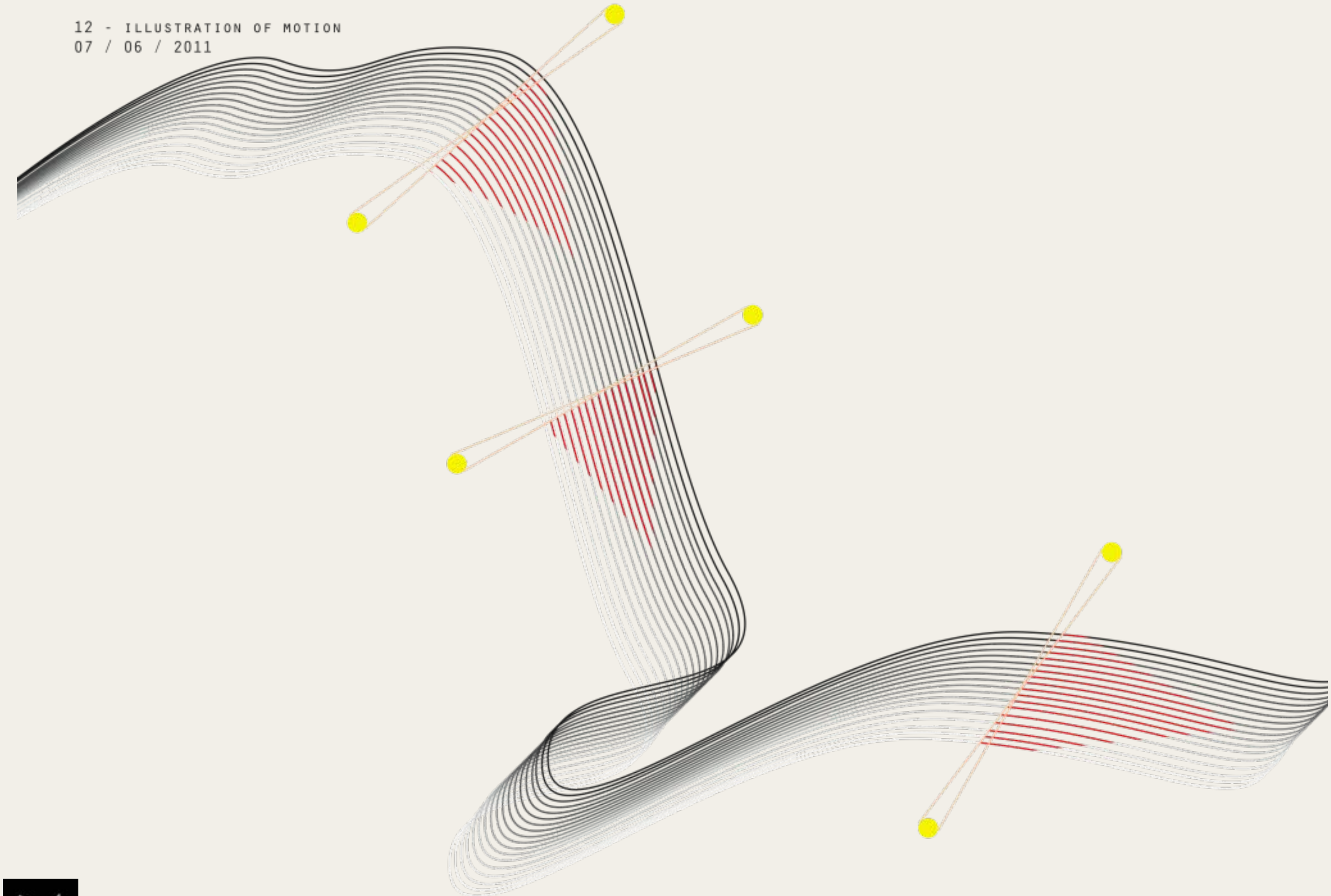
12 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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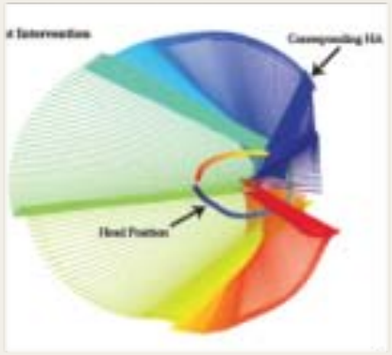
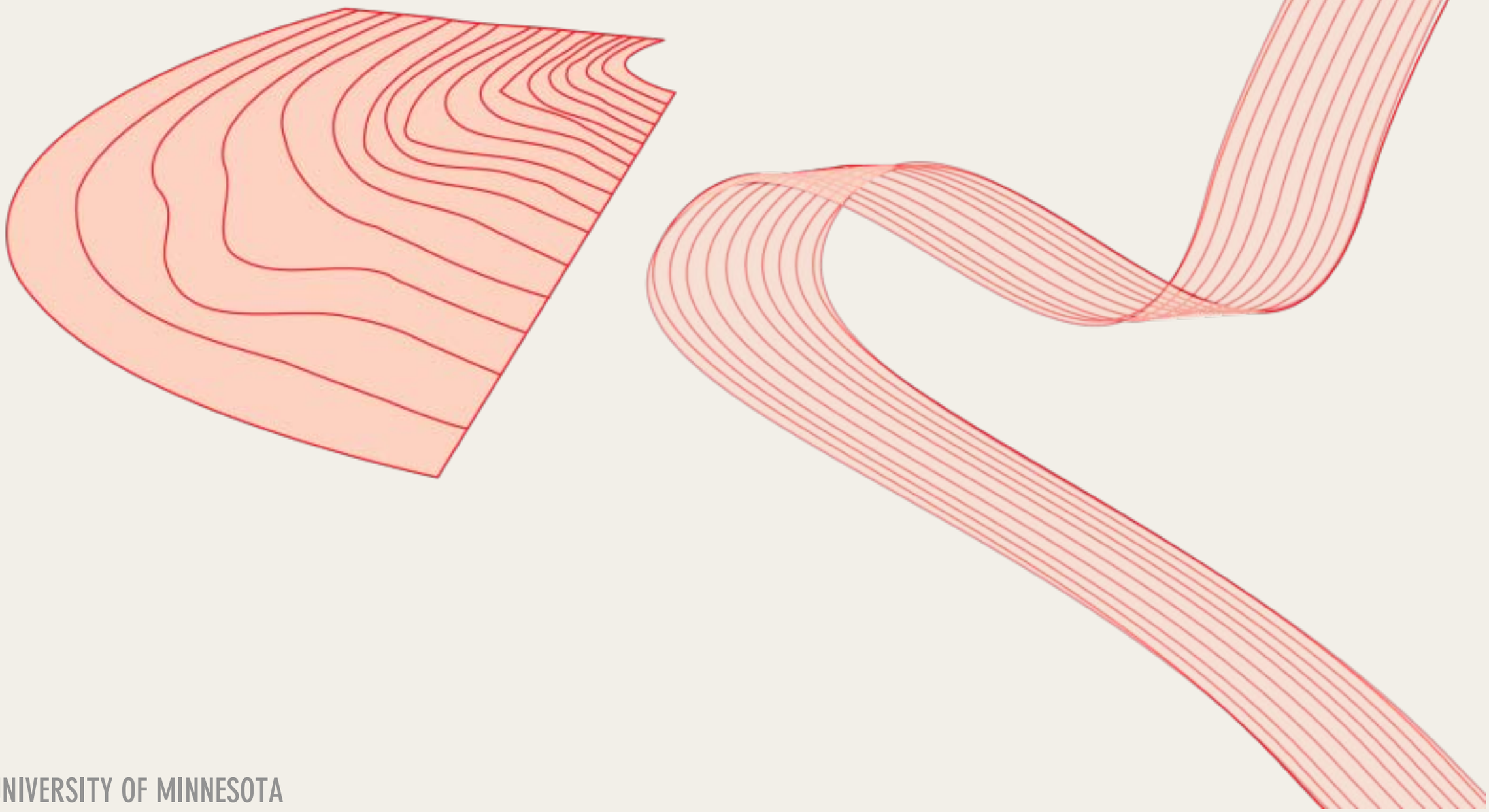
59 - ILLUSTRATION OF MOTION
07 / 12 / 2011





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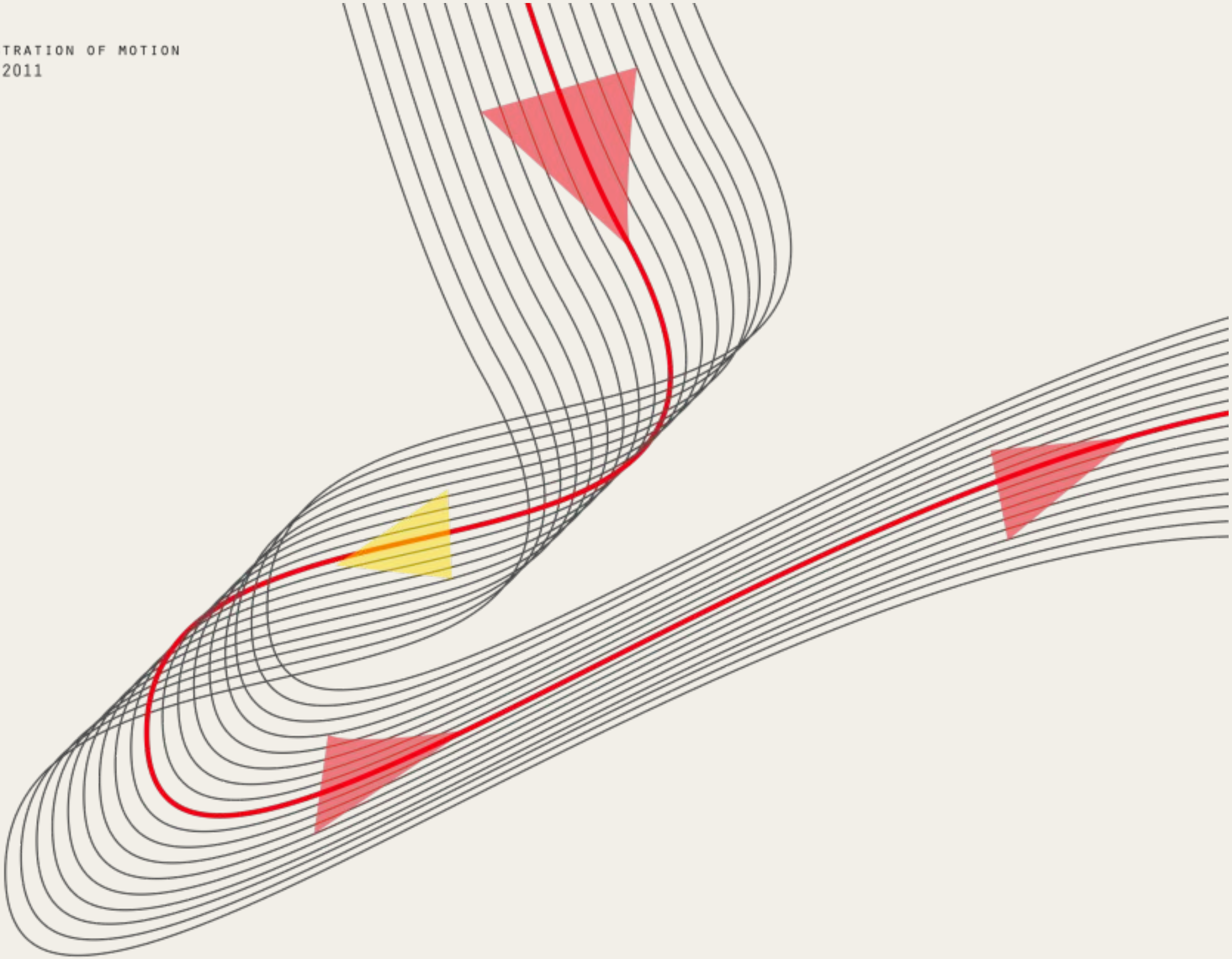
17 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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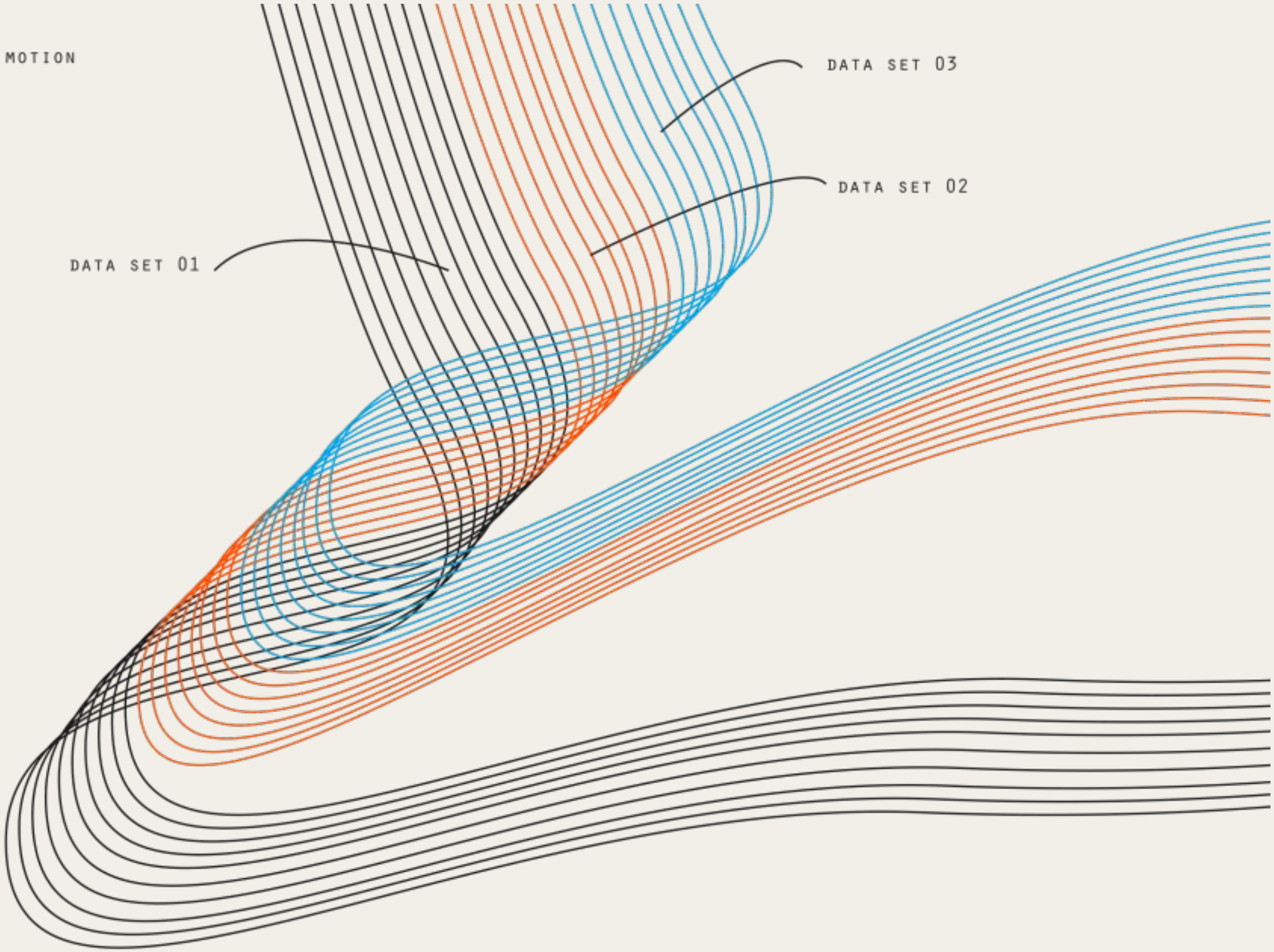
25 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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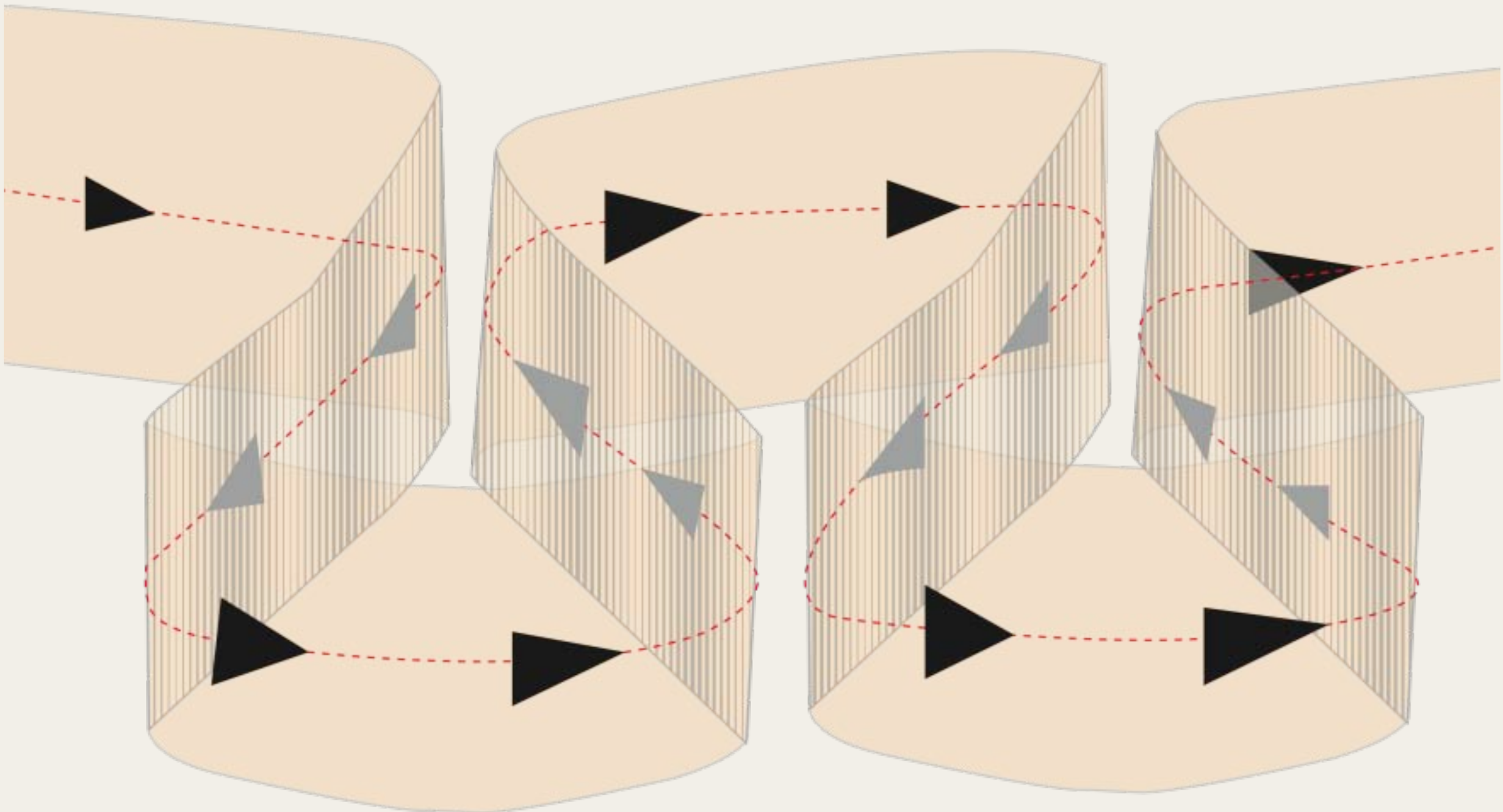
41 - ILLUSTRATION OF MOTION
07 / 06 / 2011



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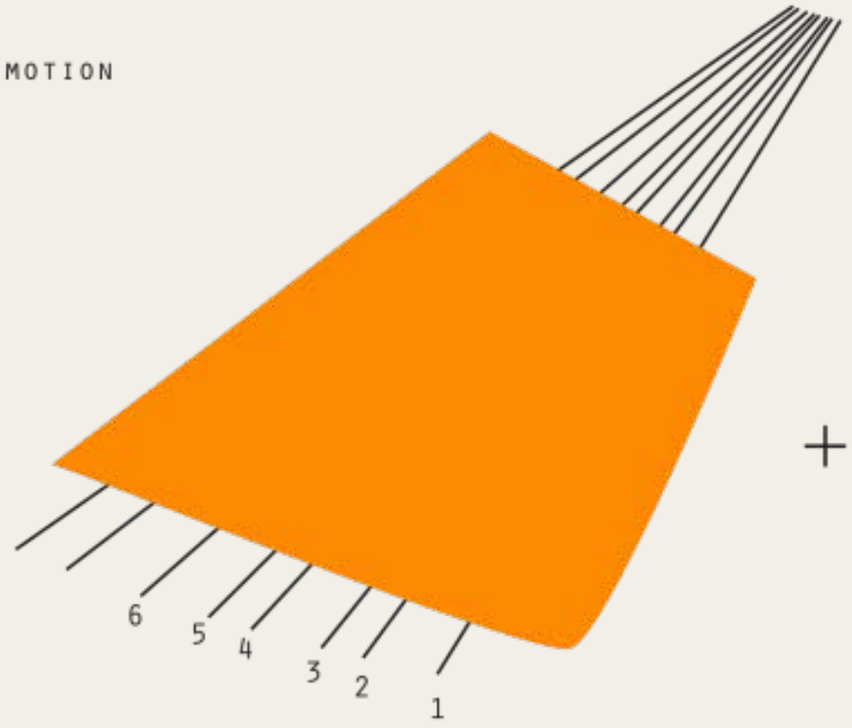
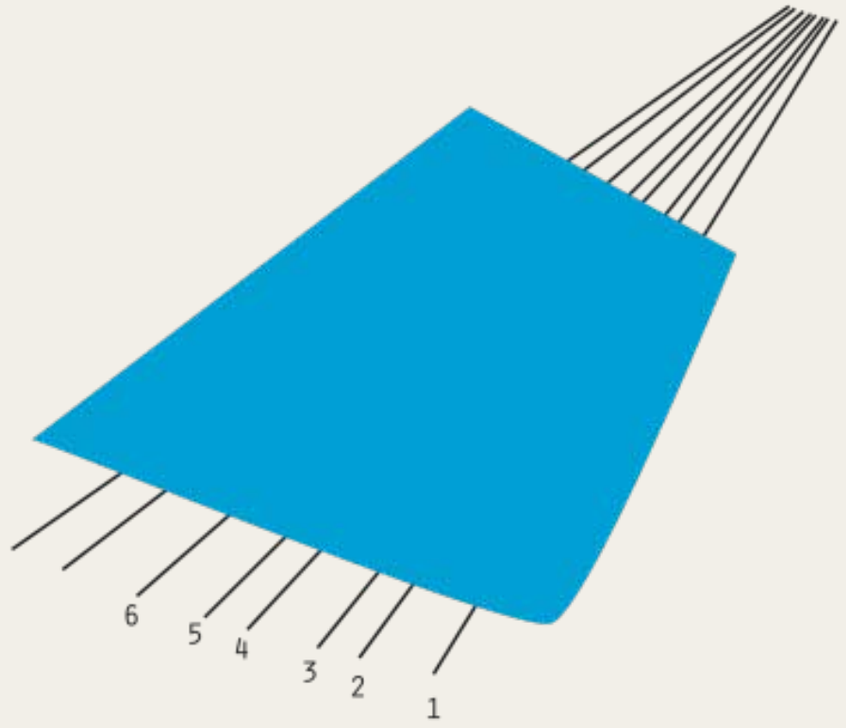
14- COMPARITIVE MOTION
10 / 12/ 2011



BEFORE

+



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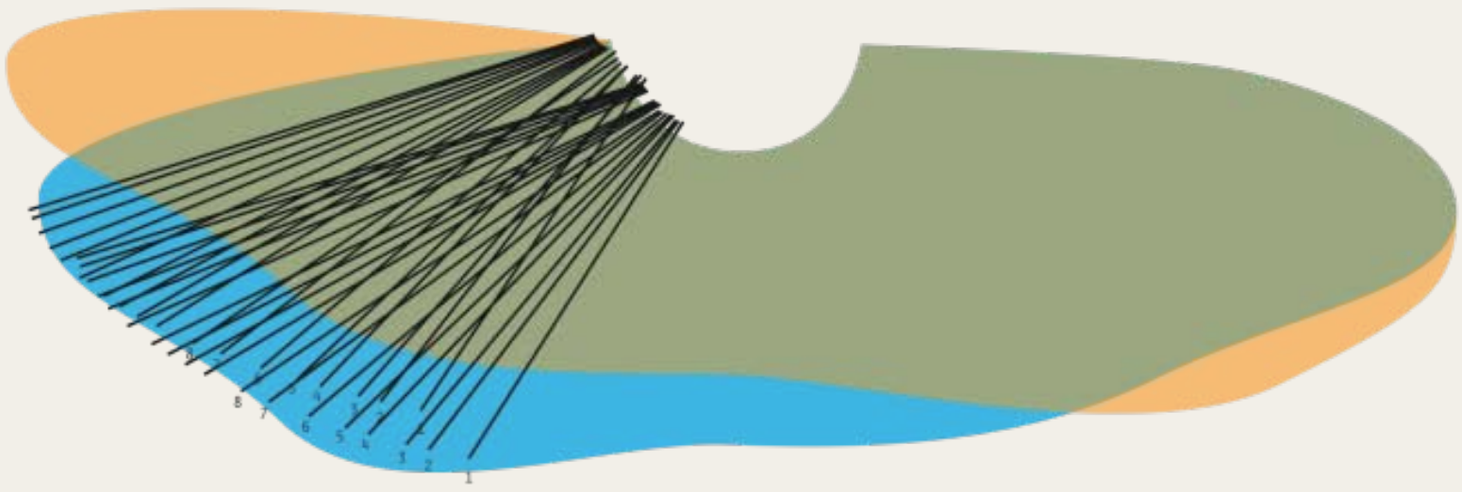
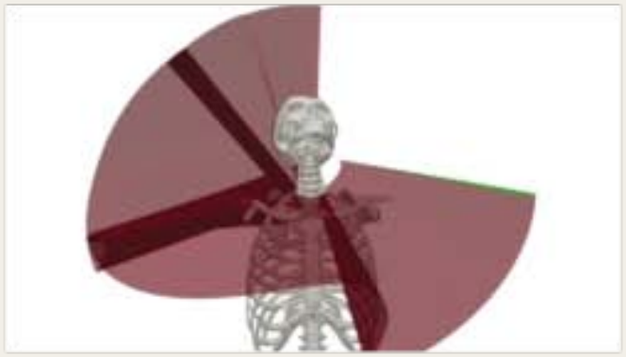


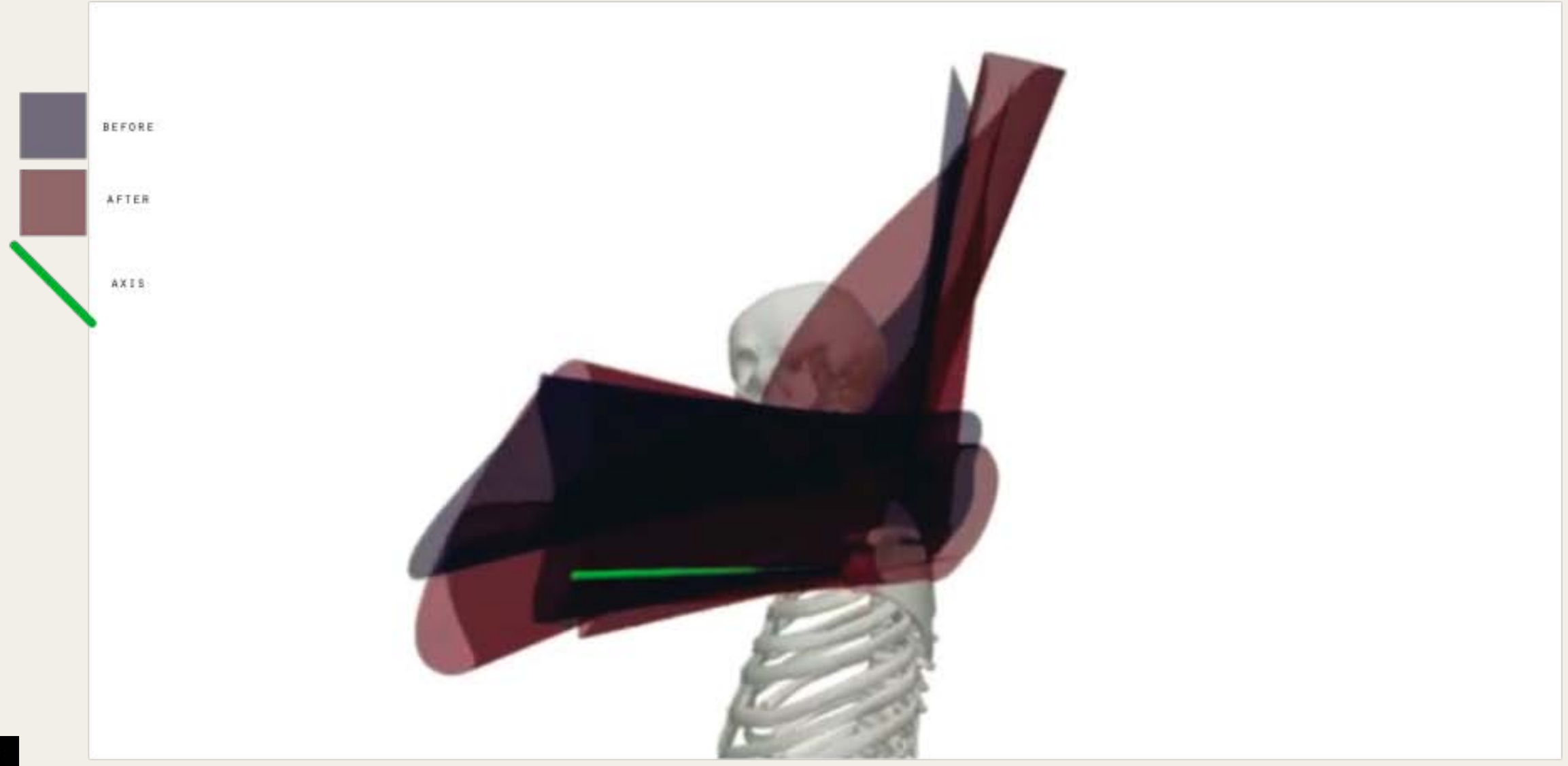
EXAMPLE OF COMBINATION

18- COMPARITIVE MOTION
10 / 12/ 2011



BEFORE

AFTER



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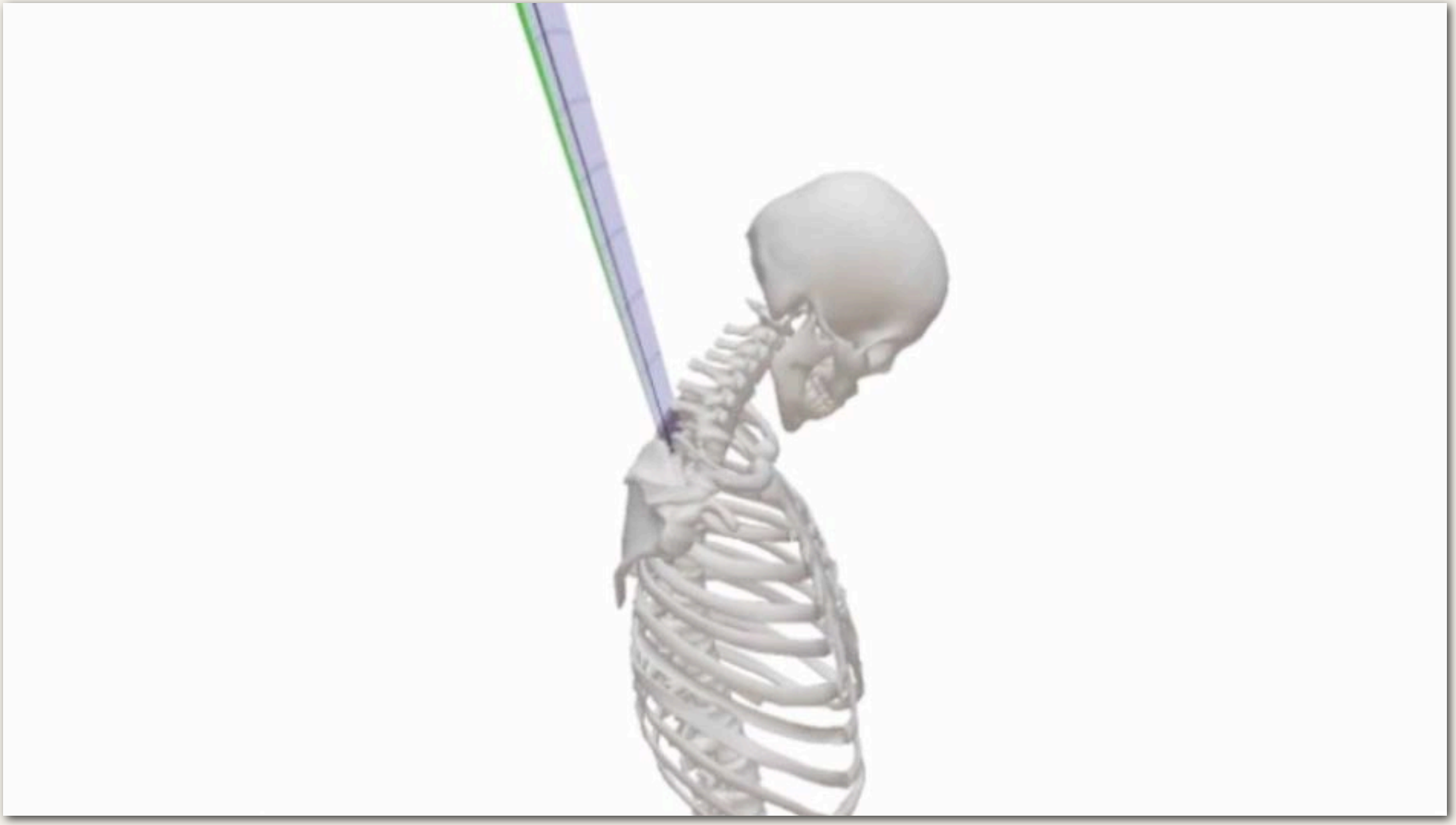
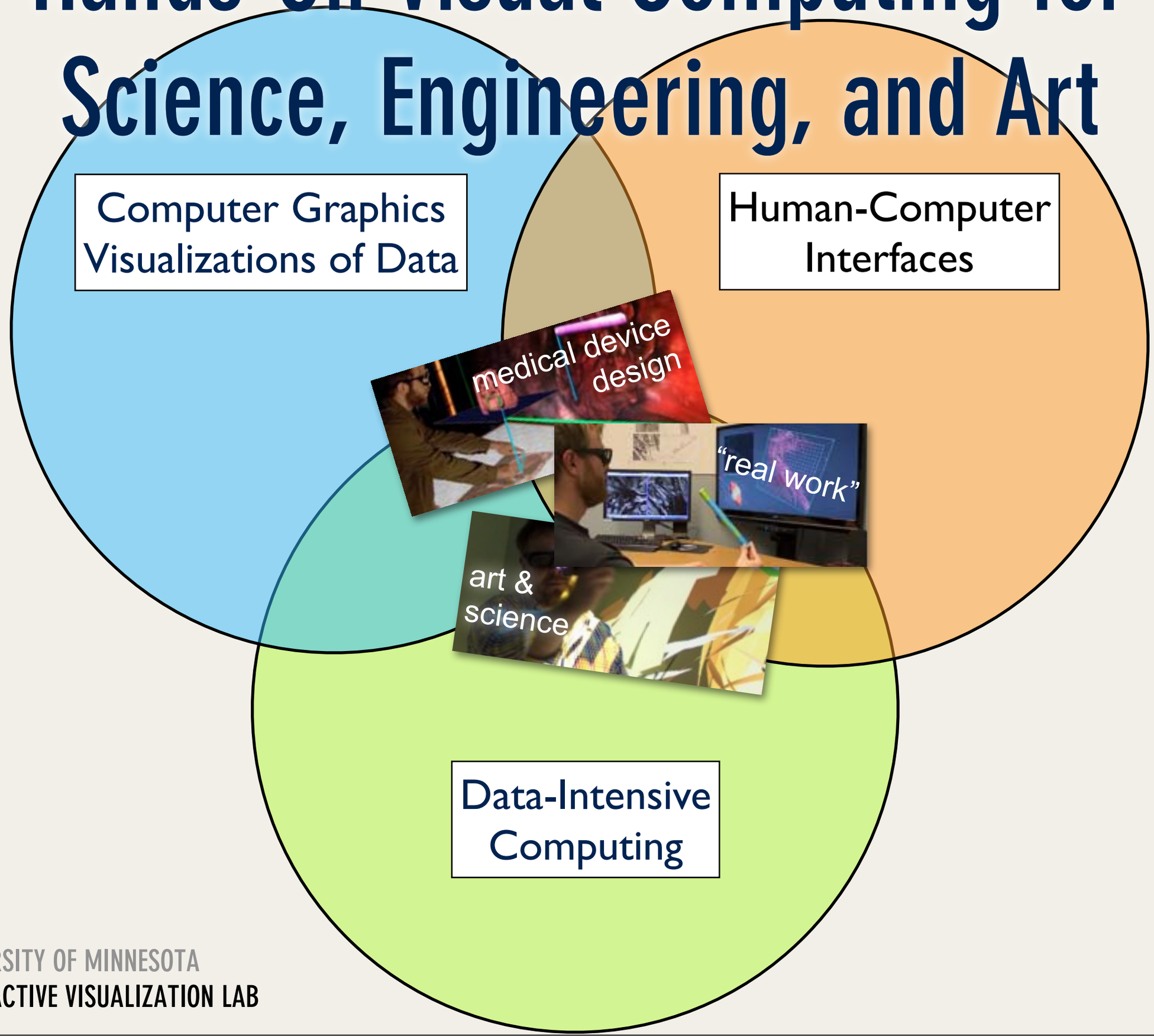


Hands-On Visual Computing for Science, Engineering, and Art



IV/LAB
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INTERACTIVE VISUALIZATION LAB

Take aways for a next generation of hands-on visual computing

- Data-intensive computing is the future.
- You will create this future, opening up many new exciting applications of computing in the process.
- Even as this new paradigm takes hold, our most challenging data-intensive problems will still always involve people.
- A challenge: How do we help people move **from data to insight**?

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- A challenge: How do we help people move **from data to insight**?
- Related challenge: How do we teach this?

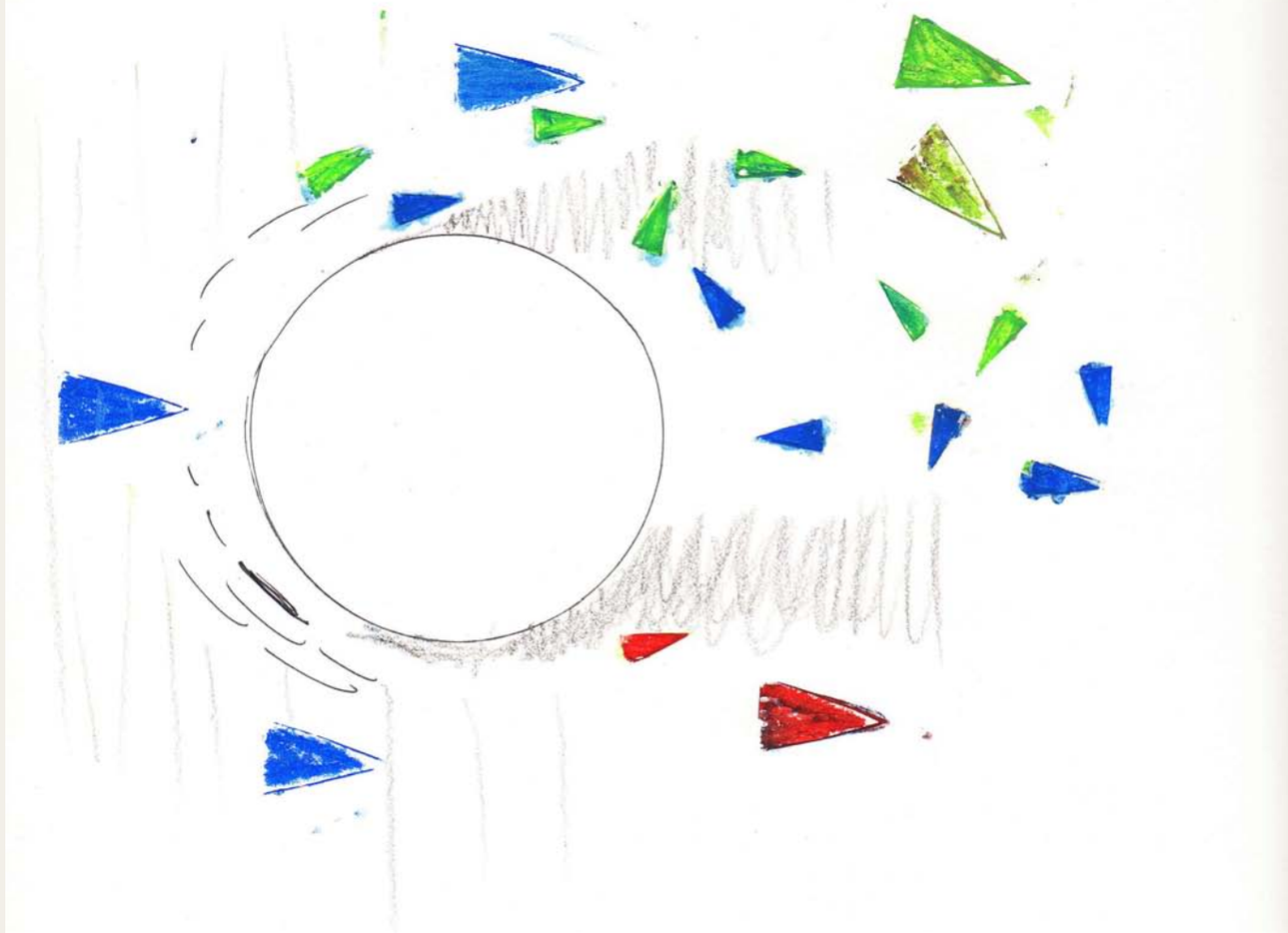
Velocity (arrow direction)

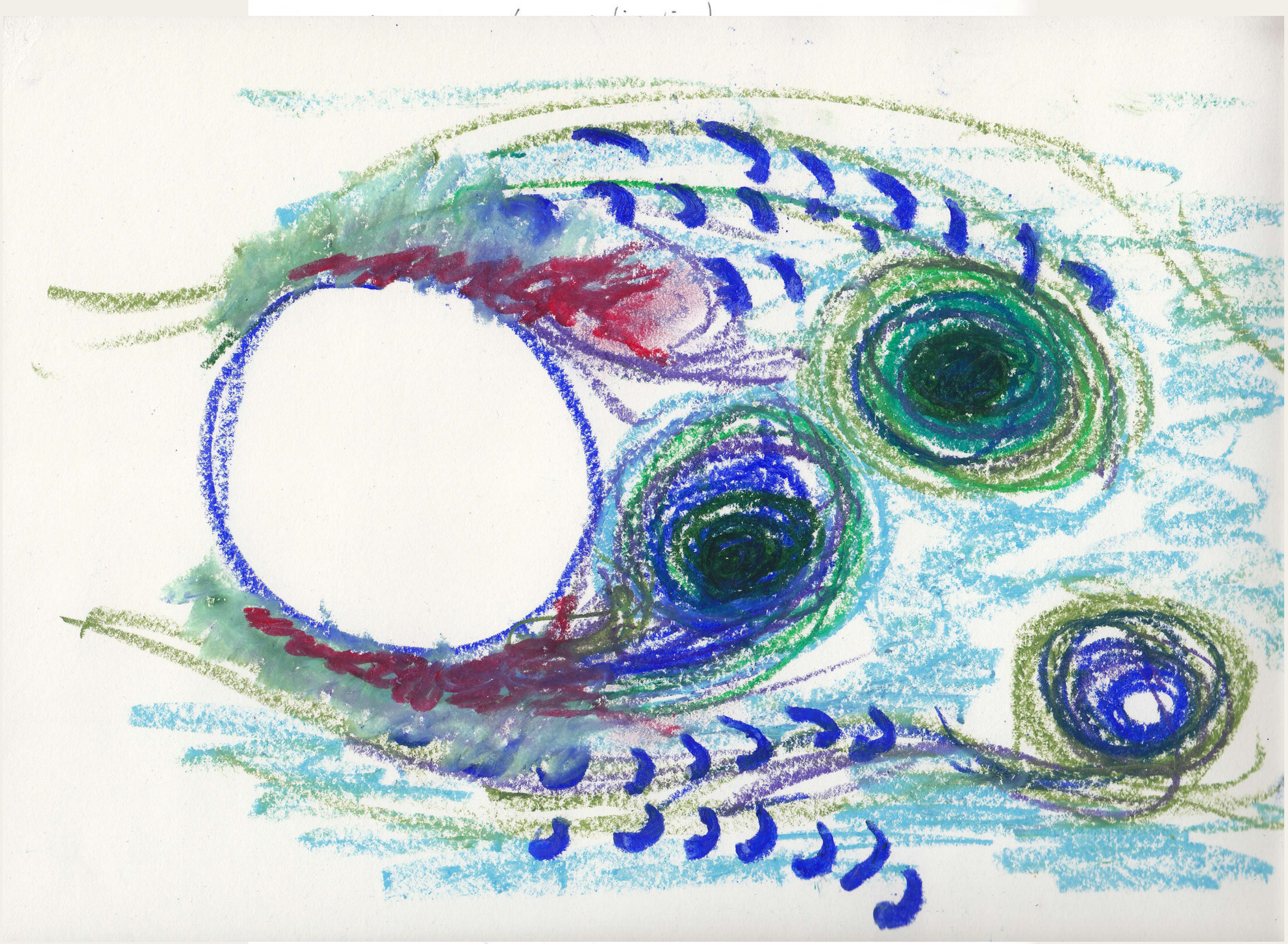
Speed

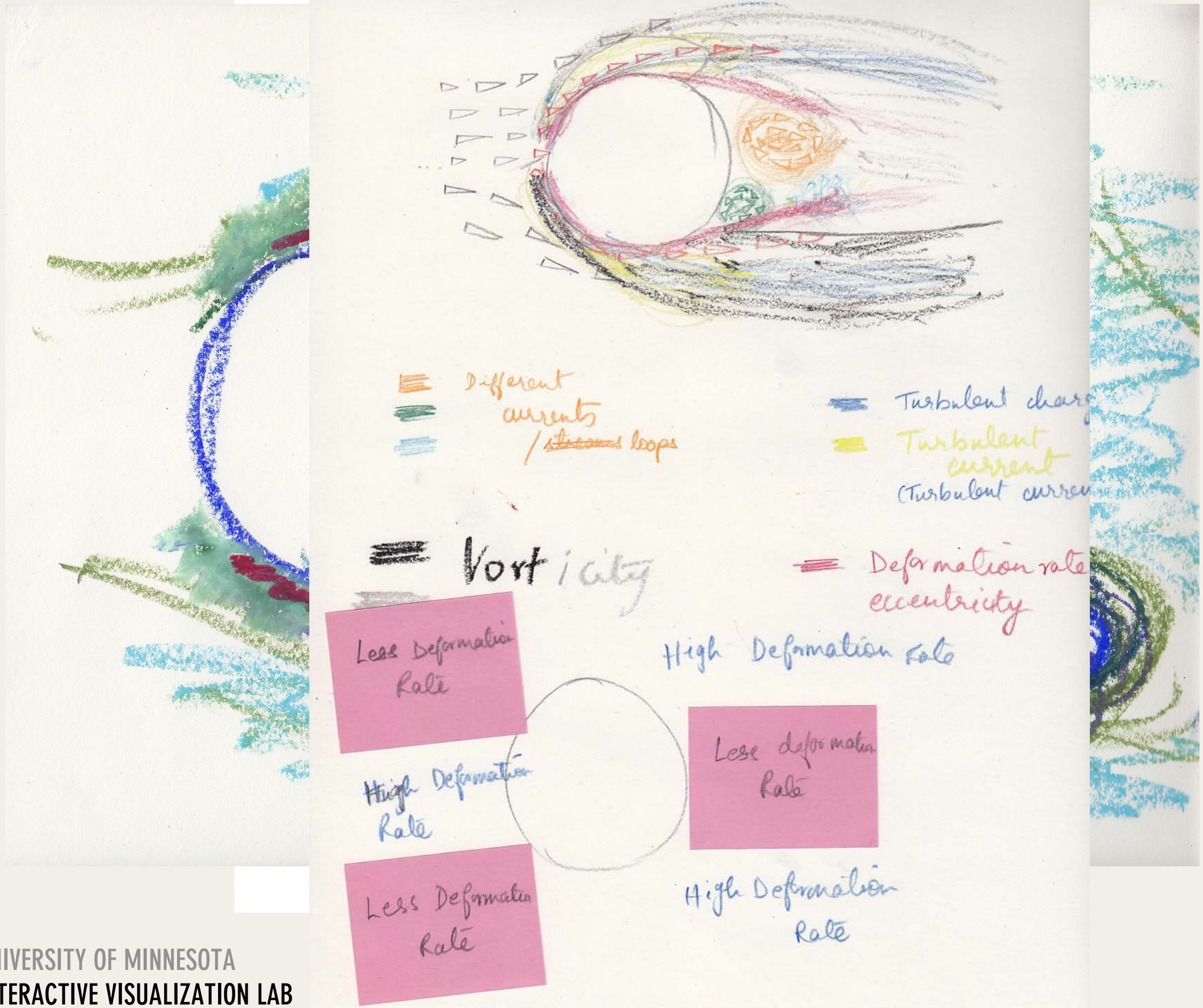
Vorticity

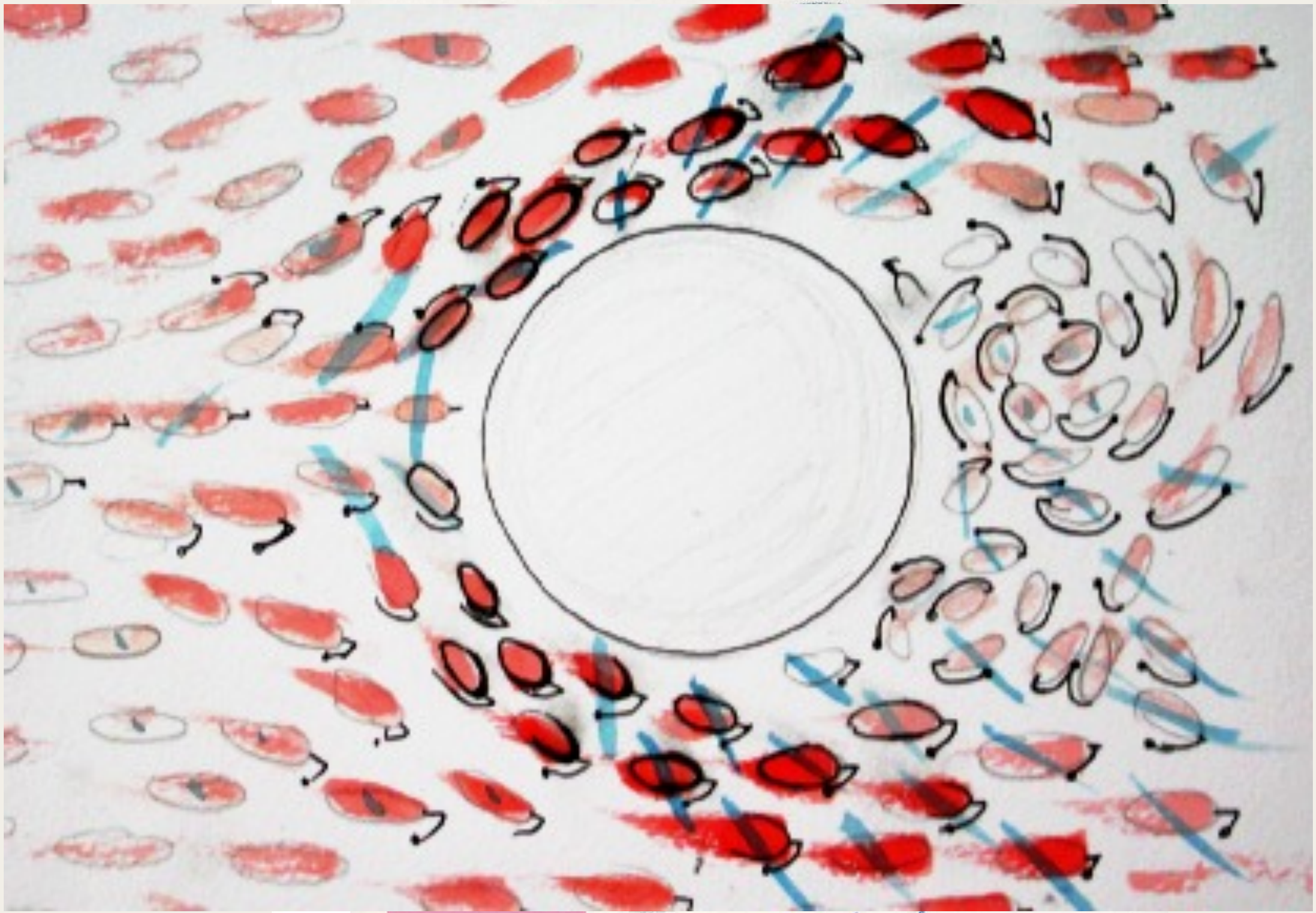
Turbulent charge (background)

Turbulent current






Different currents / ~~streams~~ loops
Turbulent chaos
Turbulent current
(Turbulent curren
Vorticity
Deformation rate eccentricity
Less Deformation Rate
High Deformation Rate
High Deformation Rate
Less deformation Rate
Less Deformation Rate
High Deformation Rate


Less Deformation Rate
High Deformation Rate

UNIVERSITY OF MINNESOTA
INTERACTIVE VISUALIZATION LAB

University of Minnesota Interactive Visualization Lab (IV/LAB)

Students

Dane Coffey, Bret Jackson, Fedor Korsakov, Cyrus Lin, Cory Schaffhausen, David Schroeder, Lauren Thorson.

Interdisciplinary collaborators

Art Erdman (U. of Minnesota)
Kimani Toussaint and Tony Lau (U. of Illinois)

Data and driving problems

NCAR & NSF
NLM Visible Human

Research support for the IV/LAB

NSF (CAREER Award IIS-1054783 and Award IIS-1218058)
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IV/LAB

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IV/LAB

UNIVERSITY OF MINNESOTA
INTERACTIVE VISUALIZATION LAB

Wednesday, September 4, 2013