ADVENTURES in Computational Collective Behavior

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Sample robot team scenario

- Consider an MRS engaging in a search & rescue task
- Group splits up to cover more ground
- Subgroup enters a building that requires a larger group
- Another subgroup decides to merge with the first to help
- All subgroups merge as they return home

Image available at http://d2rormqr1qwzpz.cloudfront.net/photos/2014/08/07/66095-swarm.jpg

Current state-of-the-art

- Existing approaches for artificial systems:
  - Tend to search for optimal sub-groups
  - Focus on multi-agent systems, not multi-robot systems
- Emergent coordination doesn't make these assumptions
  - Only focuses on the macro and not individual decision-making

Hyena society

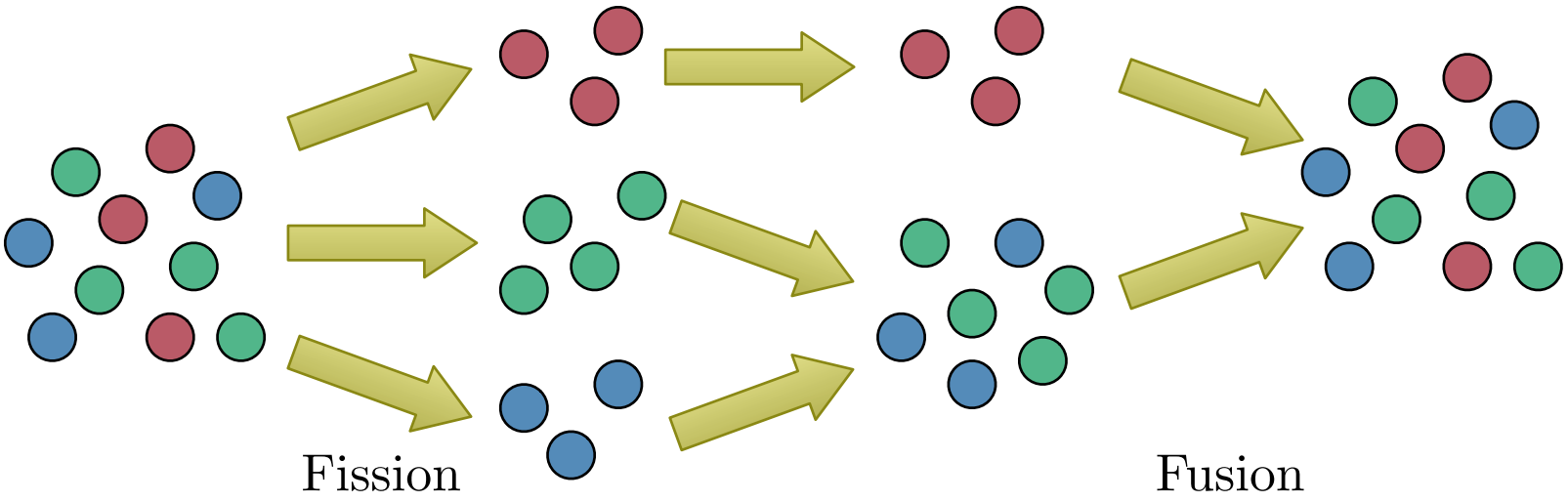
Fission-fusion society

Definition

“‘A society consisting of casual groups of variable size and composition, which form, break up and reform at frequent intervals.” [1]

- Group splits (fission) when costs $>$ benefits
- Groups merge (fusion) when costs $<$ benefits
- Dynamic process - size & composition change frequently
- Relieves tension caused by conflicts of interest

Fission-fusion society (*cont'd*)



Motivation

- Read more biology research papers than computer science
- Minimal formal training in biology
- Biological perspective into collective behavior
- Practical experience in collective behavior research

Iain Couzin

Couzin Lab Overview

Konstanz, Germany

Image available at http://ontheworldmap.com/germany/germany-political-map.jpg

Konstanz, Germany (Zoomed)

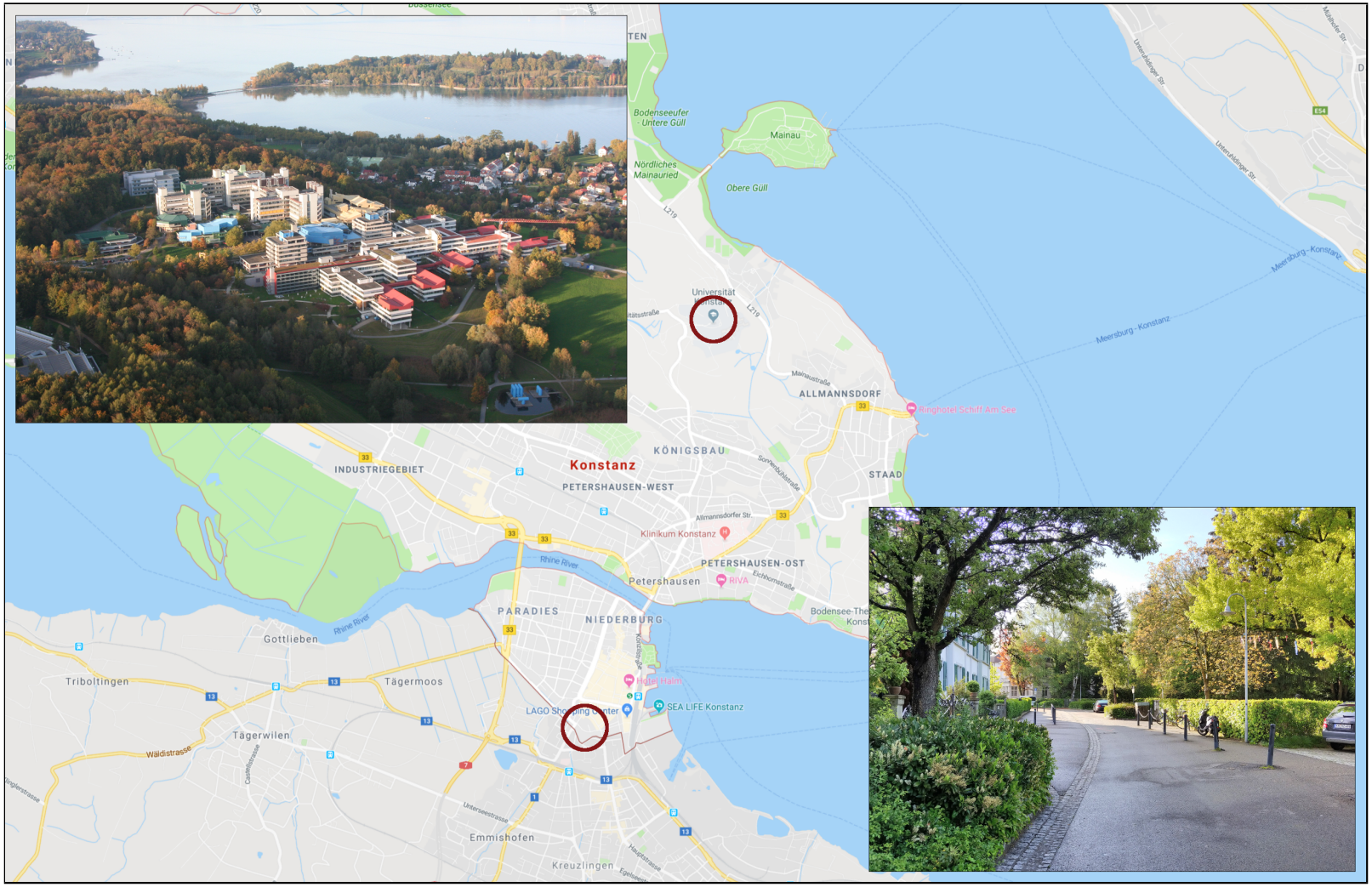
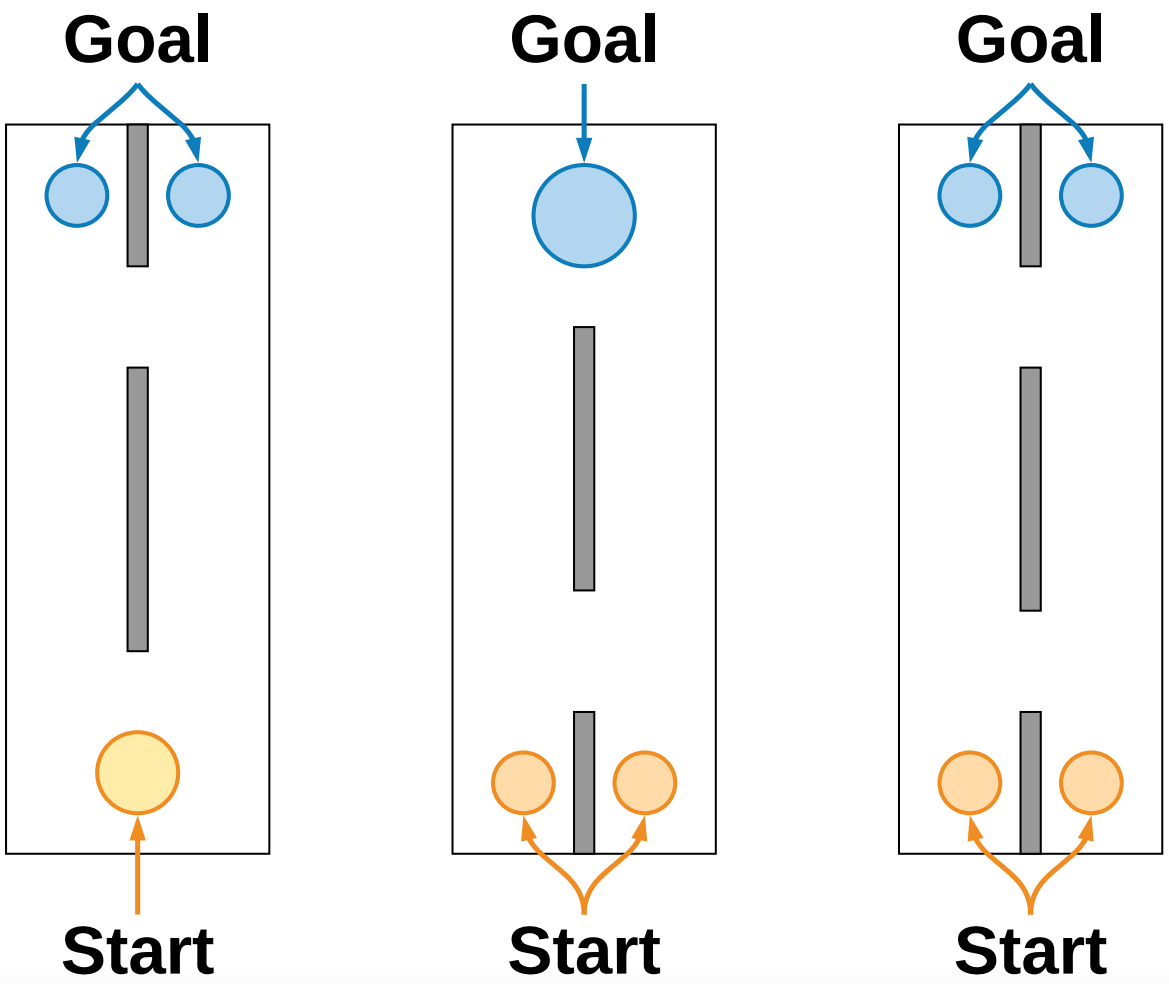


Image available at Google Maps

Promoting Fission-fusion Events

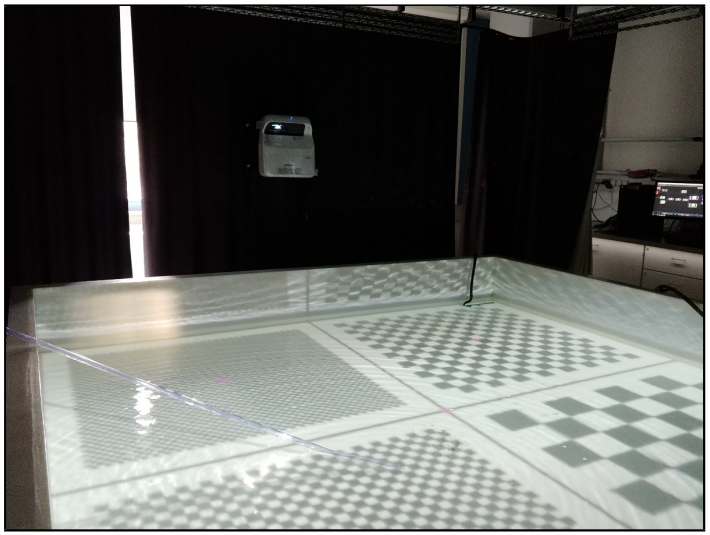


Experimental Setup

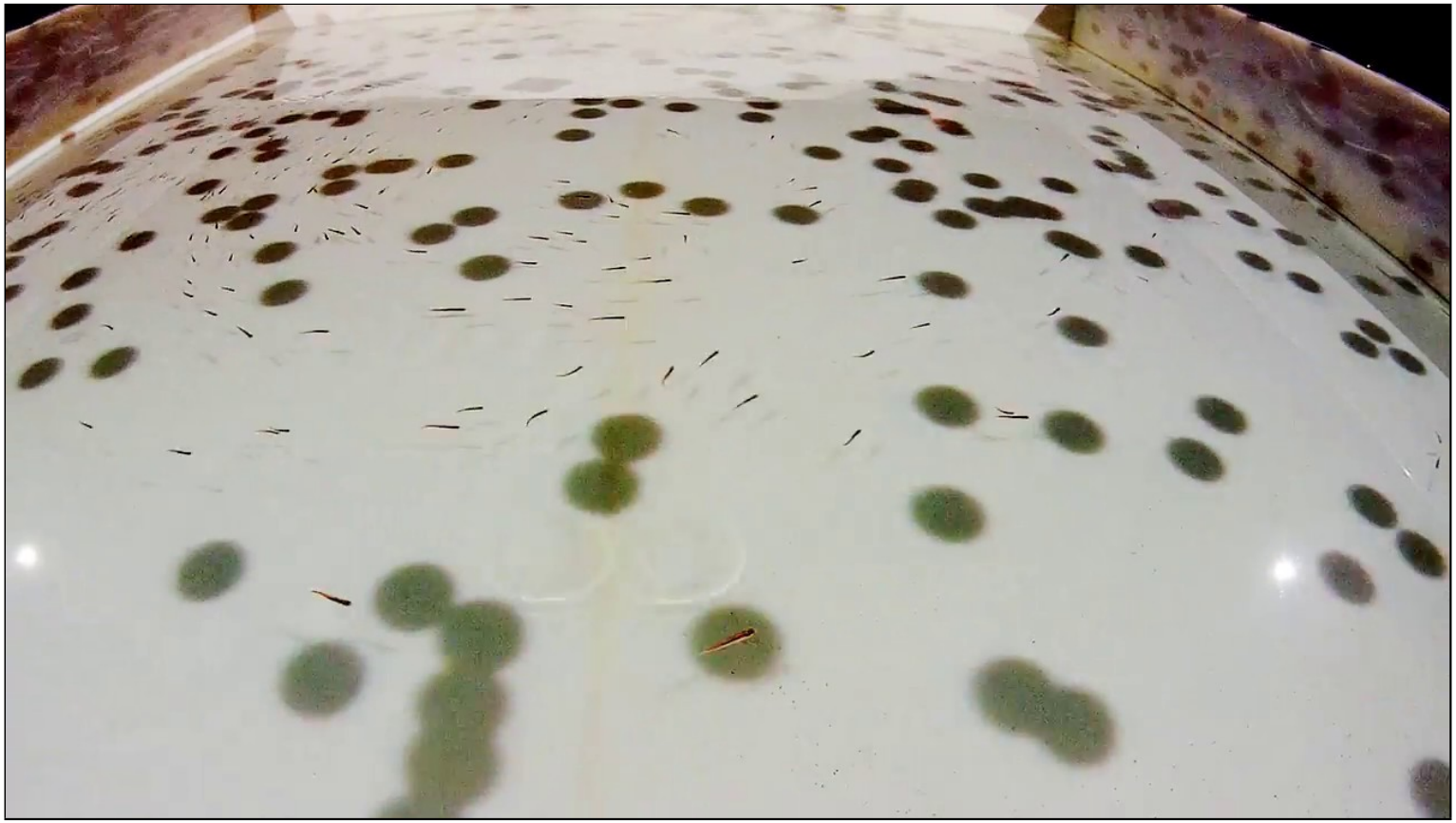
- Lab designed and operated by Dan Bath
- Sunbleaks (*Leucaspius delineatus*)
- Observation tanks
  - One 3x3m tank
  - Multiple 1x1m tanks
- IR lighting and cameras
- Moving patterns projected on tank bottom

Image available at https://en.wikipedia.org/wiki/Leucaspius_delineatus

Fish Observation Tanks

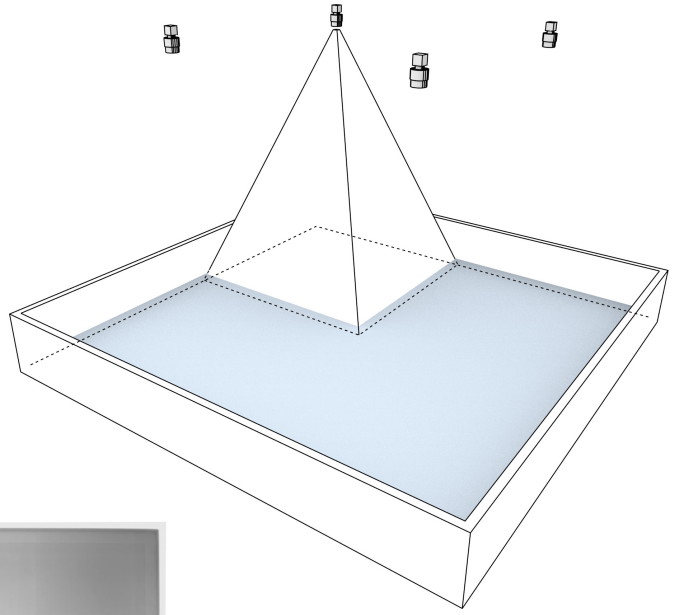


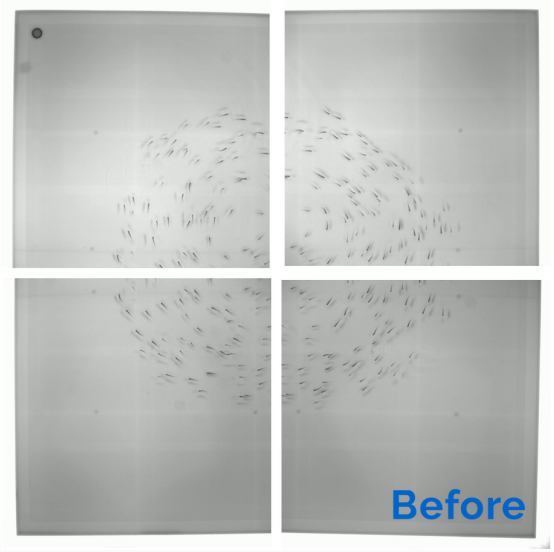
Visual Stimuli

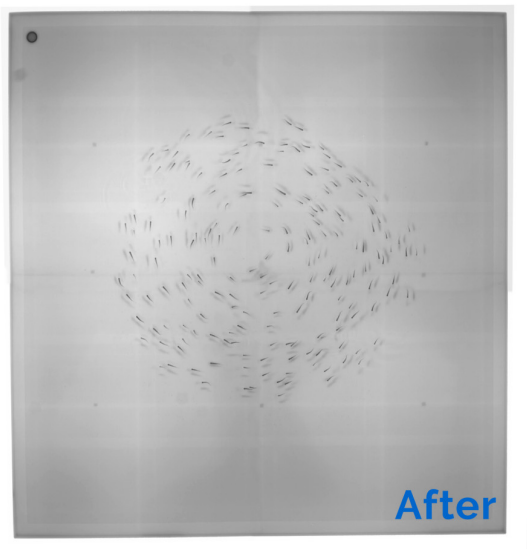


Stitching Videos

- 4 IR cameras record movement
- Must be stitched
- Different perspectives



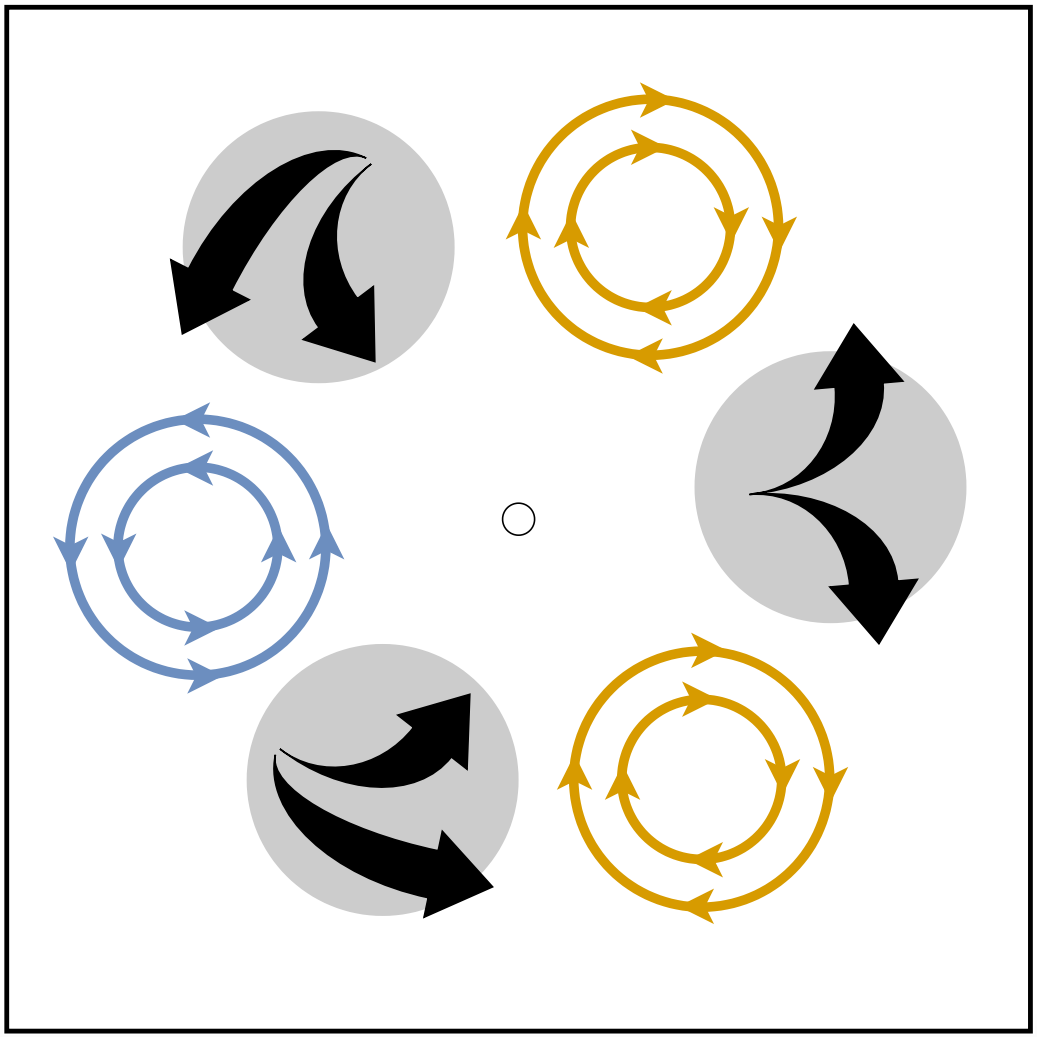




Experimental Protocol

- Approval for new protocols can take 6 weeks or more
- Research stay was a total of 7 weeks
- Unable to use original plan of introducing obstacles
- Had to find a way to use existing protocols

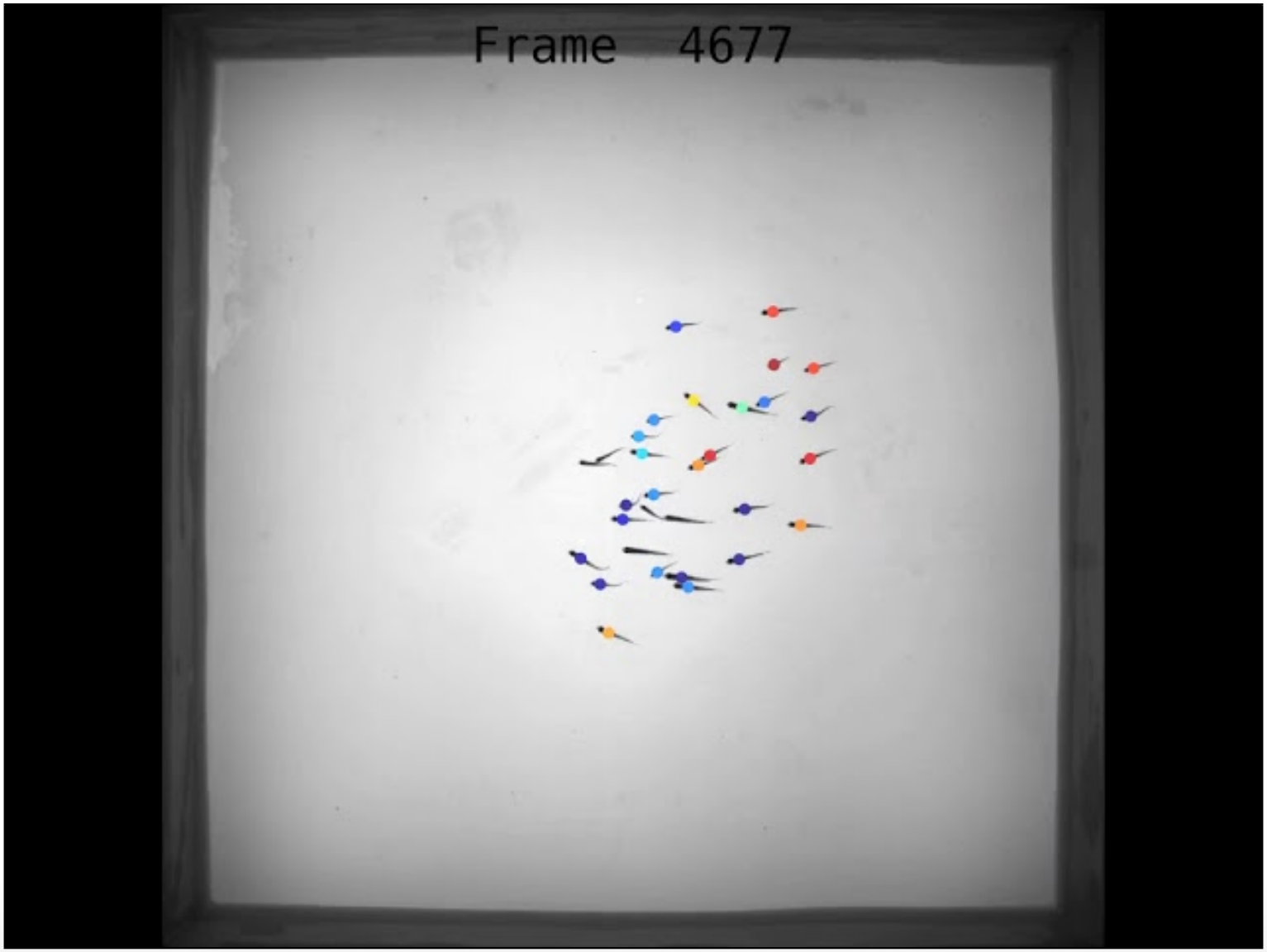
Complex Visual Stimuli Pattern



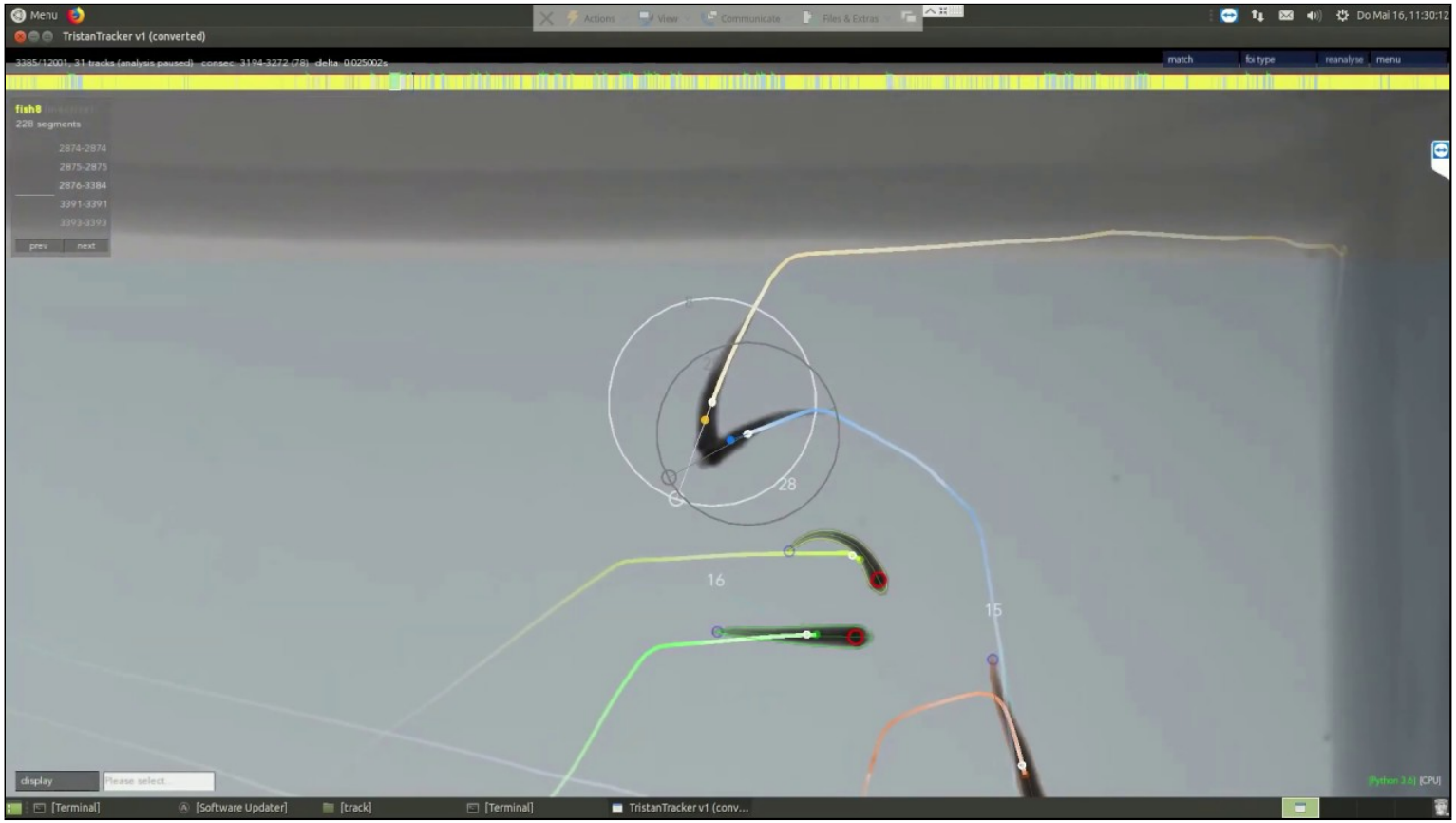
Stitching Problems

- Stitching is hard!
- Fish cast shadows
- Different angles for different cameras
- Light refracts in water

Position Tracking

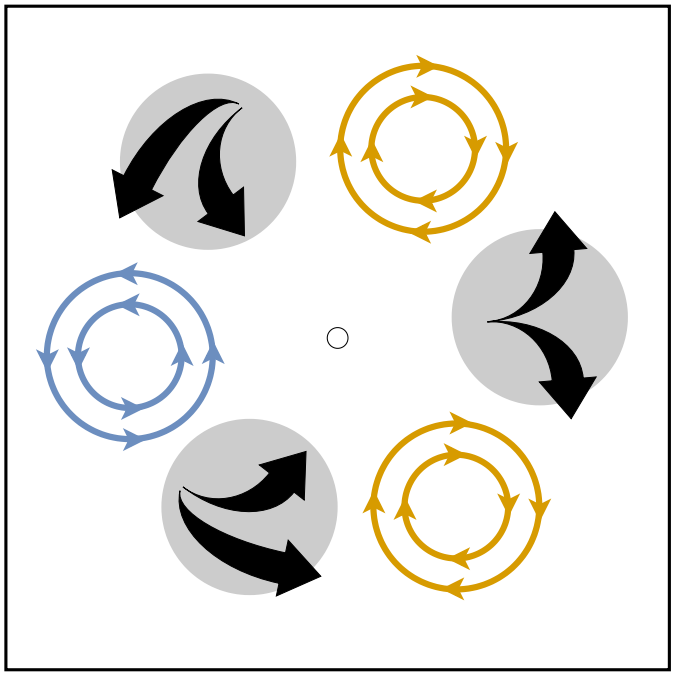


Deep Learning



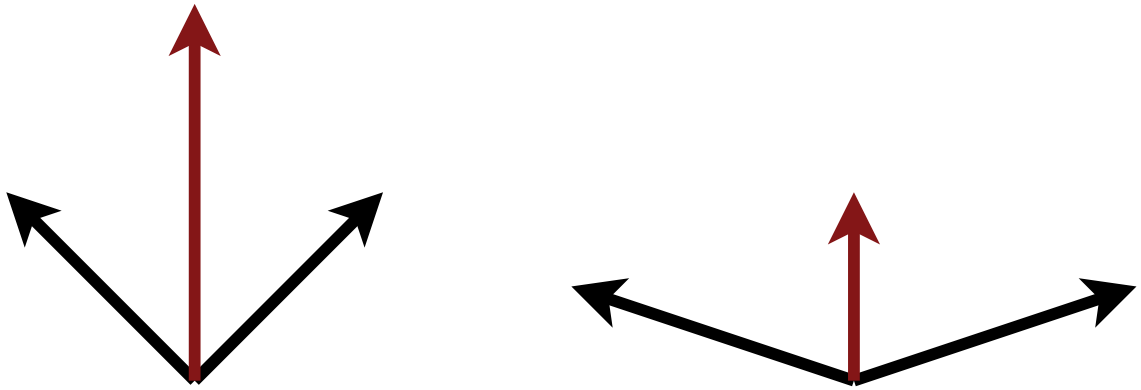
Incorrect Behavior

- Lot's of downtime due to challenges
- Tried using data we had
- Nothing made sense
- Movement was nothing like we predicted

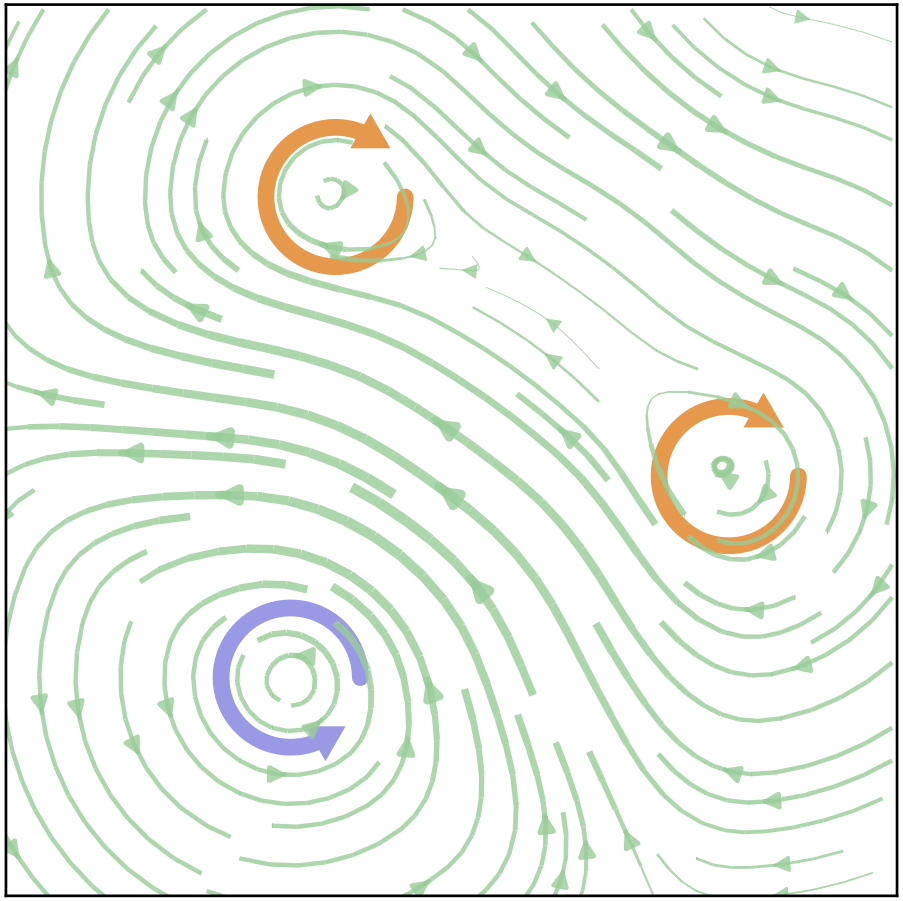


Fly Movement

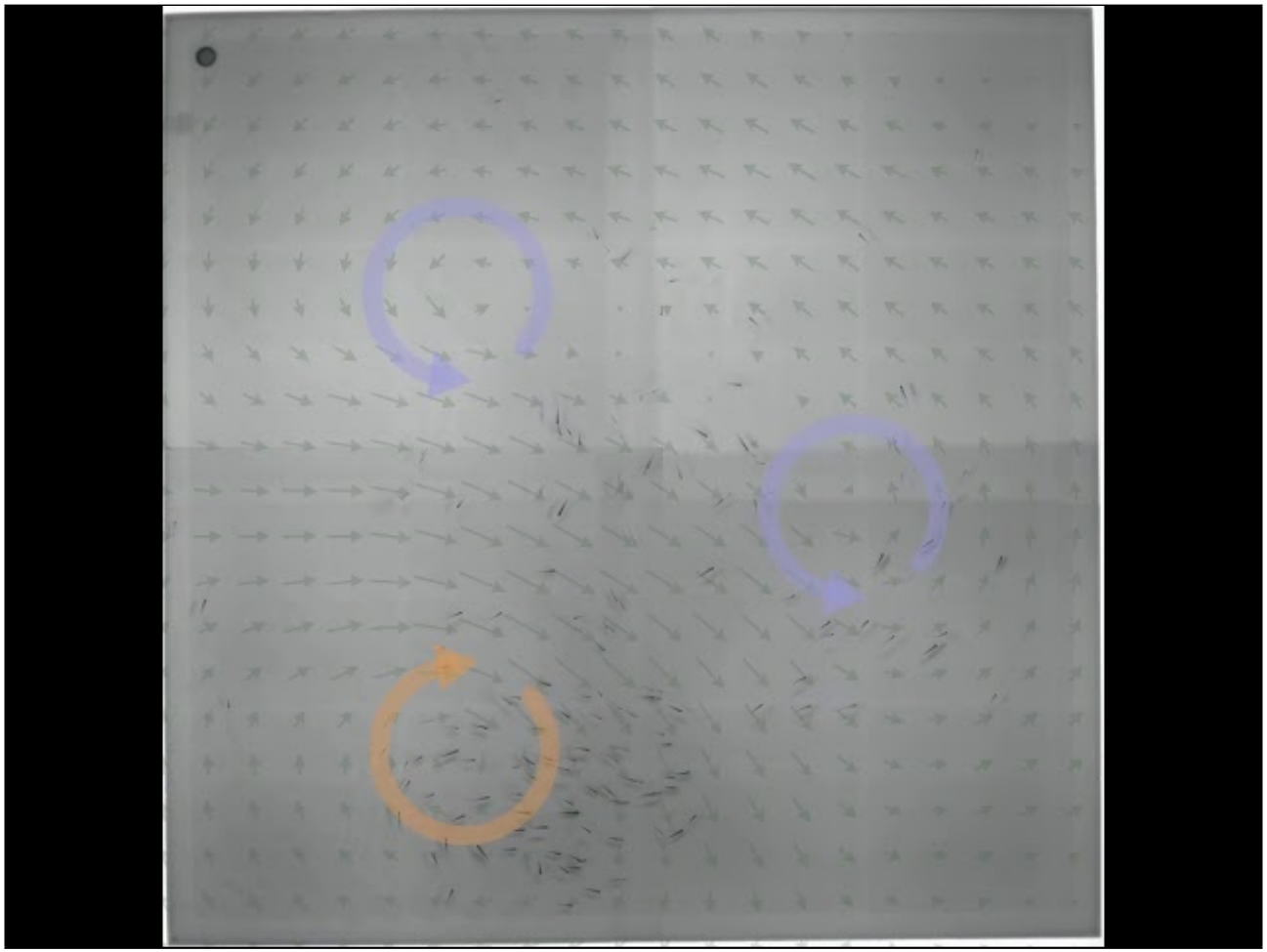
- Vivek Sridhar is researching fly movement
- Presents two targets
- When angle is small, flies add vectors
- When angle is large, flies choose one



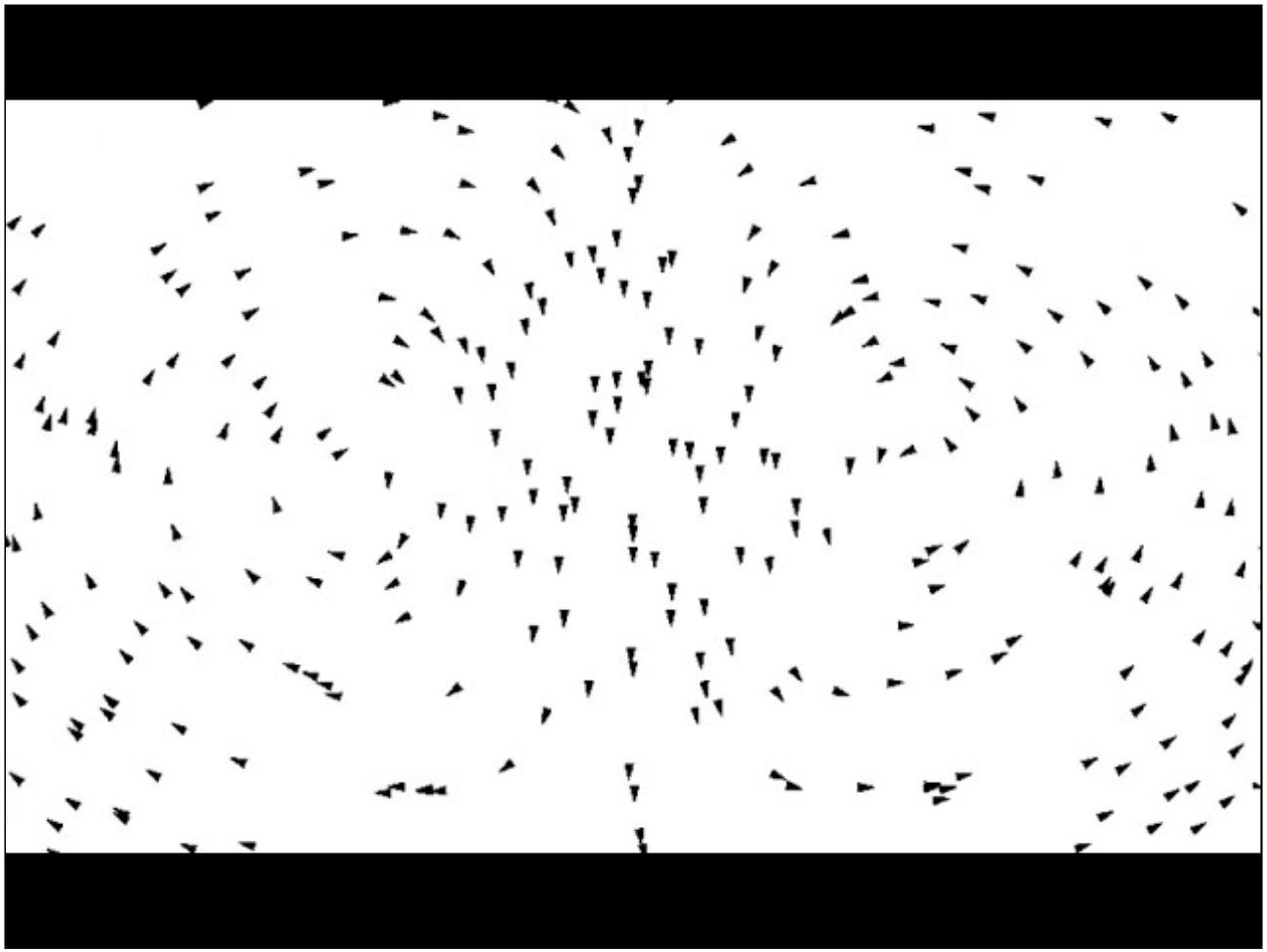
Flow Following



Flow Following - Complex



Visual Stimuli Rework



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Questions?

References

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Trends in Ecology & Evolution, 20(8):449–456, 2005.

Slideshow