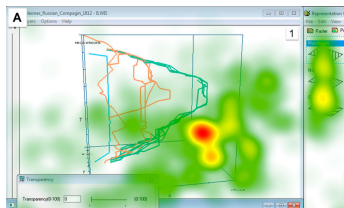
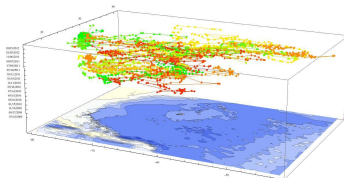


# Parallel Detection of Movement Patterns in Large Spatio-temporal Datasets

February 1, 2019

# Trajectory datasets

- ▶ Sensors, sensors everywhere!!!
- ▶ Anything that could move, will be tracked...
- ▶ Some applications:
  - ▶ Social behavior
  - ▶ Ecology (birds, sharks, ...)
  - ▶ Climate change (icebergs, cyclones, ...)
  - ▶ Software...



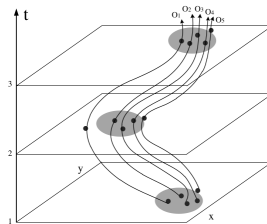
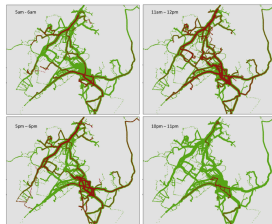
# Complex movement patterns

Previous works focus on traditional queries:

- ▶ Range, Nearest Neighbors, Similarity, ...

Recent works look for the aggregate behavior:

- ▶ Moving clusters, Convoys, **Flocks**, Swarms, Gatherings, ...

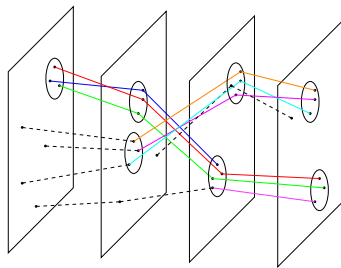


(b) Flock, convoy and swarm

# What is a flock???

## Definition $((\mu, \varepsilon, \delta) - \text{flock})$

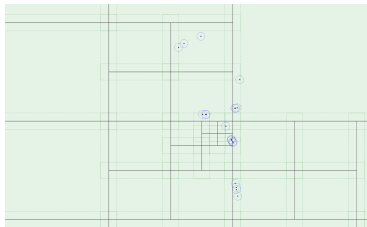
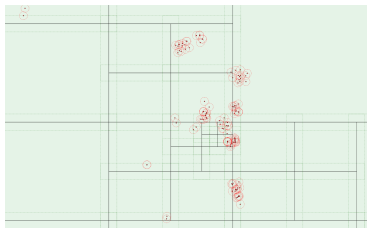
Sets of at least  $\mu$  objects moving close enough ( $\varepsilon$ ) for at least  $\delta$  time intervals (Benkert et al, 2008).



- ▶ Vieira et al. (2009) proposed BFE algorithm (first polynomial solution).
- ▶ Drawbacks:
  1. Find disks is costly. They can be at any place.
  2. Huge amount of duplicate and redundant disks.
  3. Join between time intervals was a Cartesian product.

# Contributions

1. Boost the detection of disks through a parallel approach (spatial partitioning + expansions).
2. Apply a frequent pattern mining approach to improve disk filtering (local + merge approach).
3. Use parallel distance joins to improve combination between consecutive time intervals (a Distance parameter).



# Preliminar results

- ▶ Implementation using GeoSpark. Synthetic datasets using SUMO (Simulation of Urban Mobility).
- ▶ Berlin network (OSM).  $\approx 20K$  points per timestamp, 10 timestamps. Varying  $\varepsilon$  ( $\mu = 3$  and  $\delta = 3$ ).

