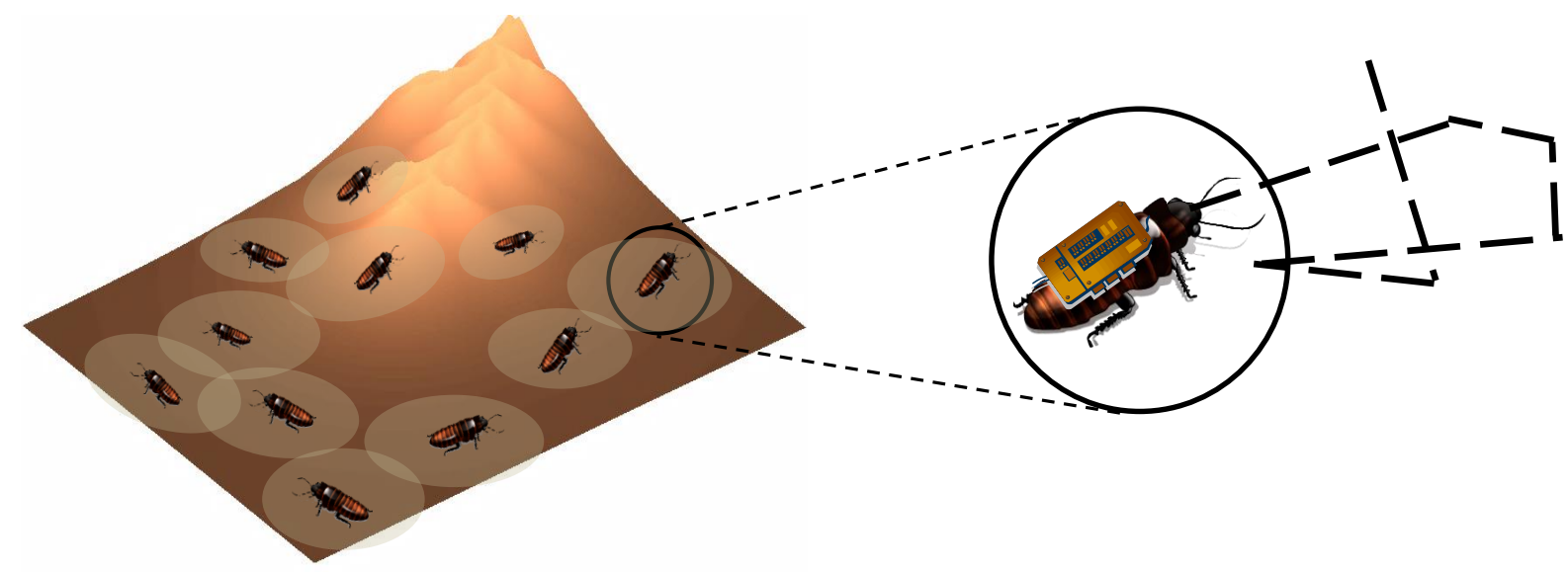


Motivation



- Cyborg insect networks
 - Existing biological networks + small instrumented payloads for sensing and control
- Applications:
 - Search and rescue, surveillance and monitoring, ...
- Tasks:
 - Mapping and exploration
- Examples:
 - disaster zone response scenario after earthquakes, tsunamis, hurricanes, etc.
- Limitations:
 - Reachability, power constraints, rough terrain conditions, weak sensory information
- Rough terrain conditions:
 - High uncertainty in odometry information
 - Requirement of complex locomotion capabilities
 - Energy



- Swarm systems
 - Randomness tolerated by collective performance
 - Randomness may offer solutions
 - Swarms of biologically inspired robots equipped with complex locomotion capabilities



- Insects**
- Complex navigational problems
 - Optimized locomotion
 - Survive in harsh environments

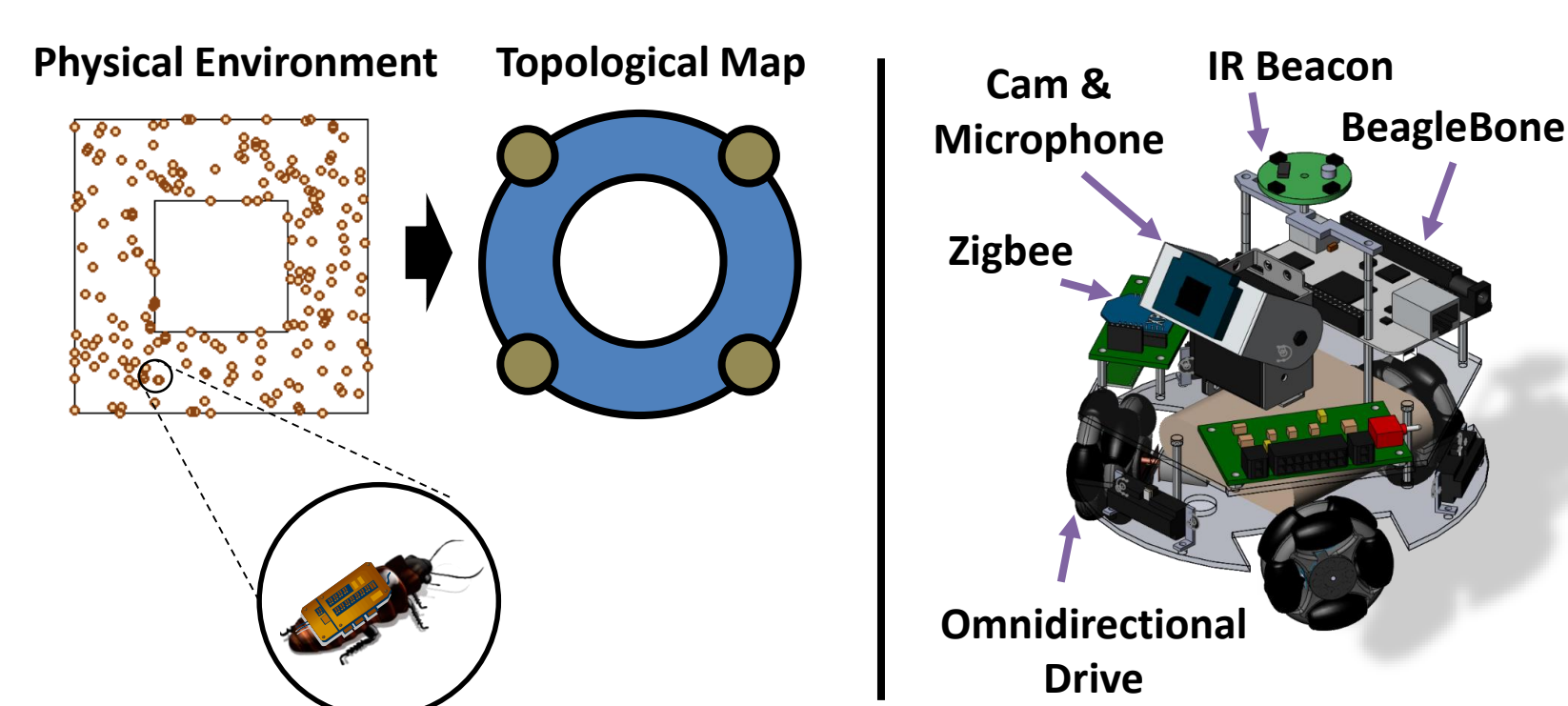
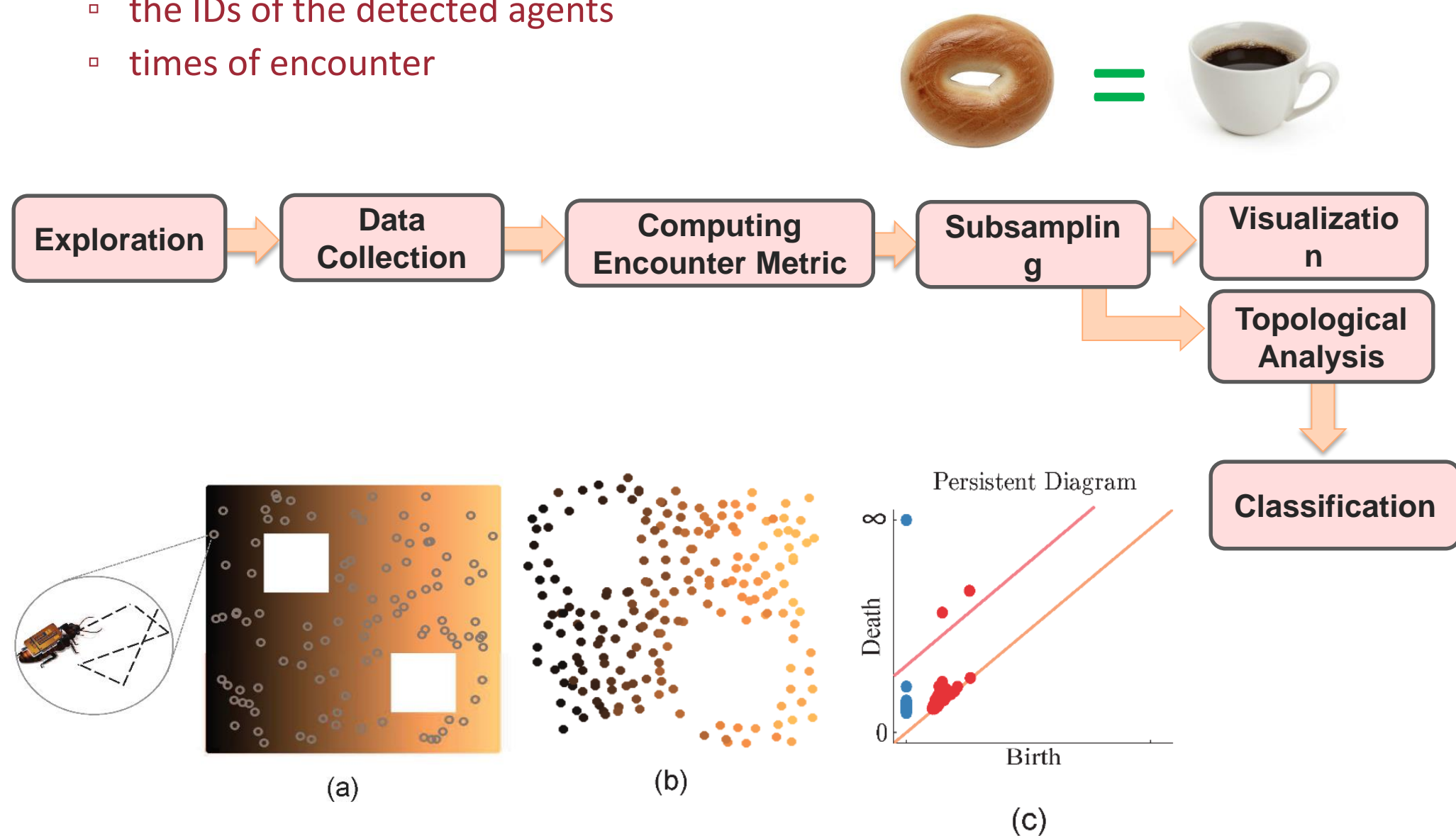
Topological Mapping of the Environment

- Weak odometry capacities
- Bandwidth constraints
- Power Constraints
- Weak localization information

Topological Mapping

- Extract topological features of a domain
- Do not require strong localization information
- Use of methods from computational topology

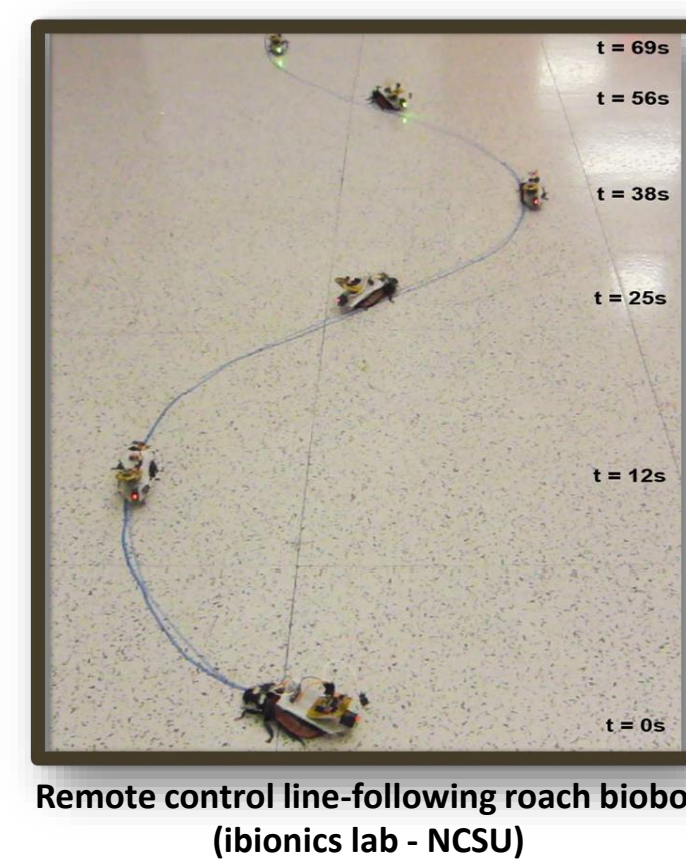
- Agents can detect the other agents in their proximity
- Agents can record:
 - the IDs of the detected agents
 - times of encounter



Biobotic Agents

Cockroaches

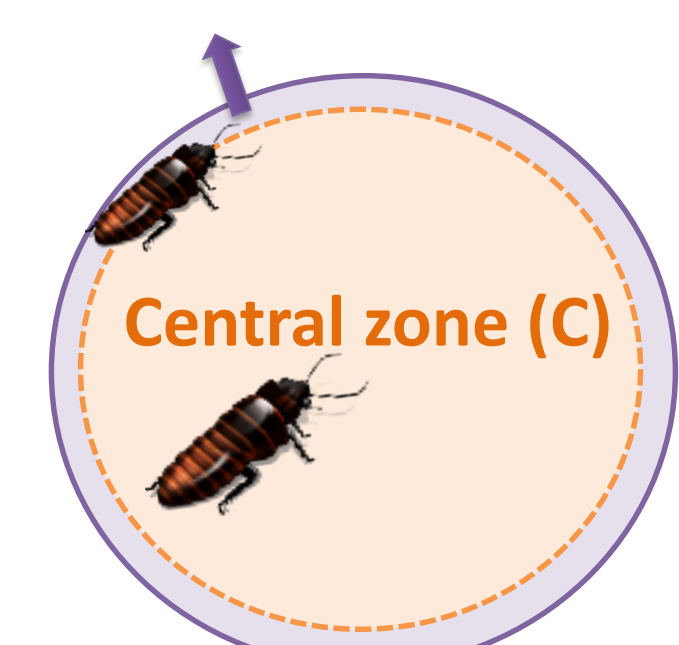
- non-eusocial insects
- Interesting individual and group behaviors
- Control of their motion by employing biomechanical perturbations in the locomotory control system



Modeling

Individual Motion

Peripheral Zone (P)



Wall Following

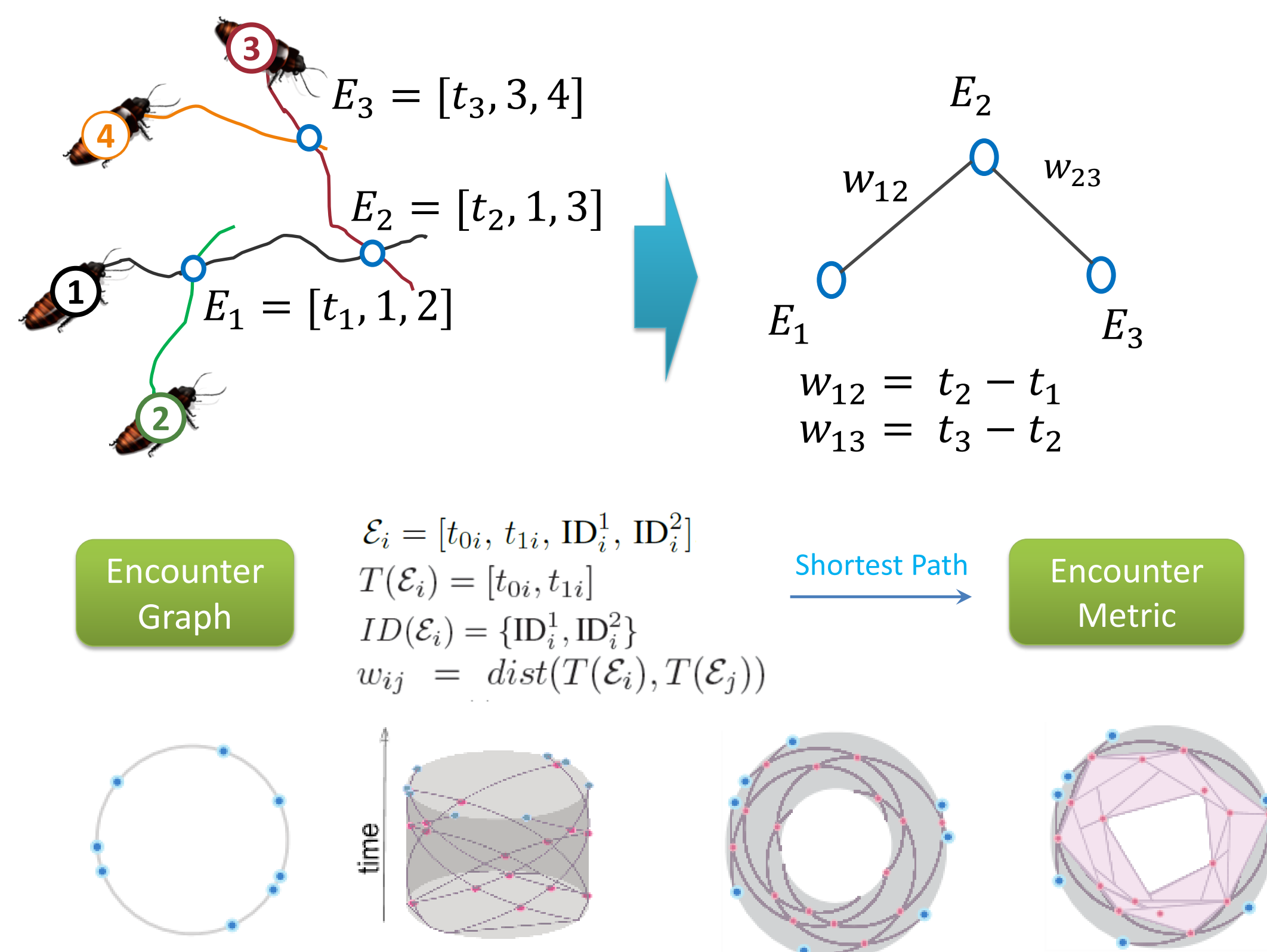
Random Walk

Collective Behavior

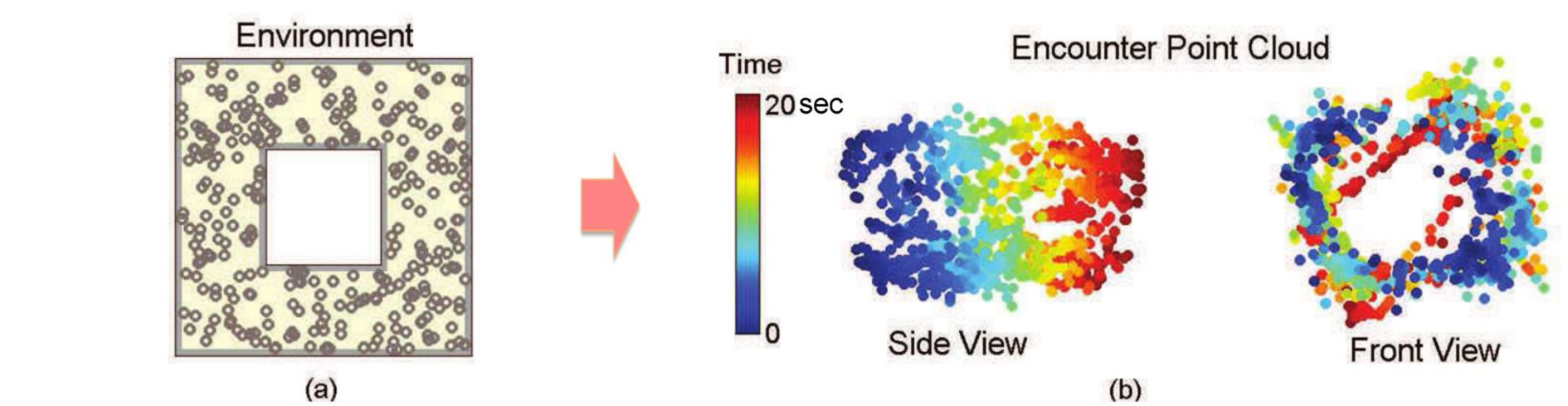
Aggregation

- Stop when encountering an aggregate
- Start moving after a collision
- Spontaneously start to move

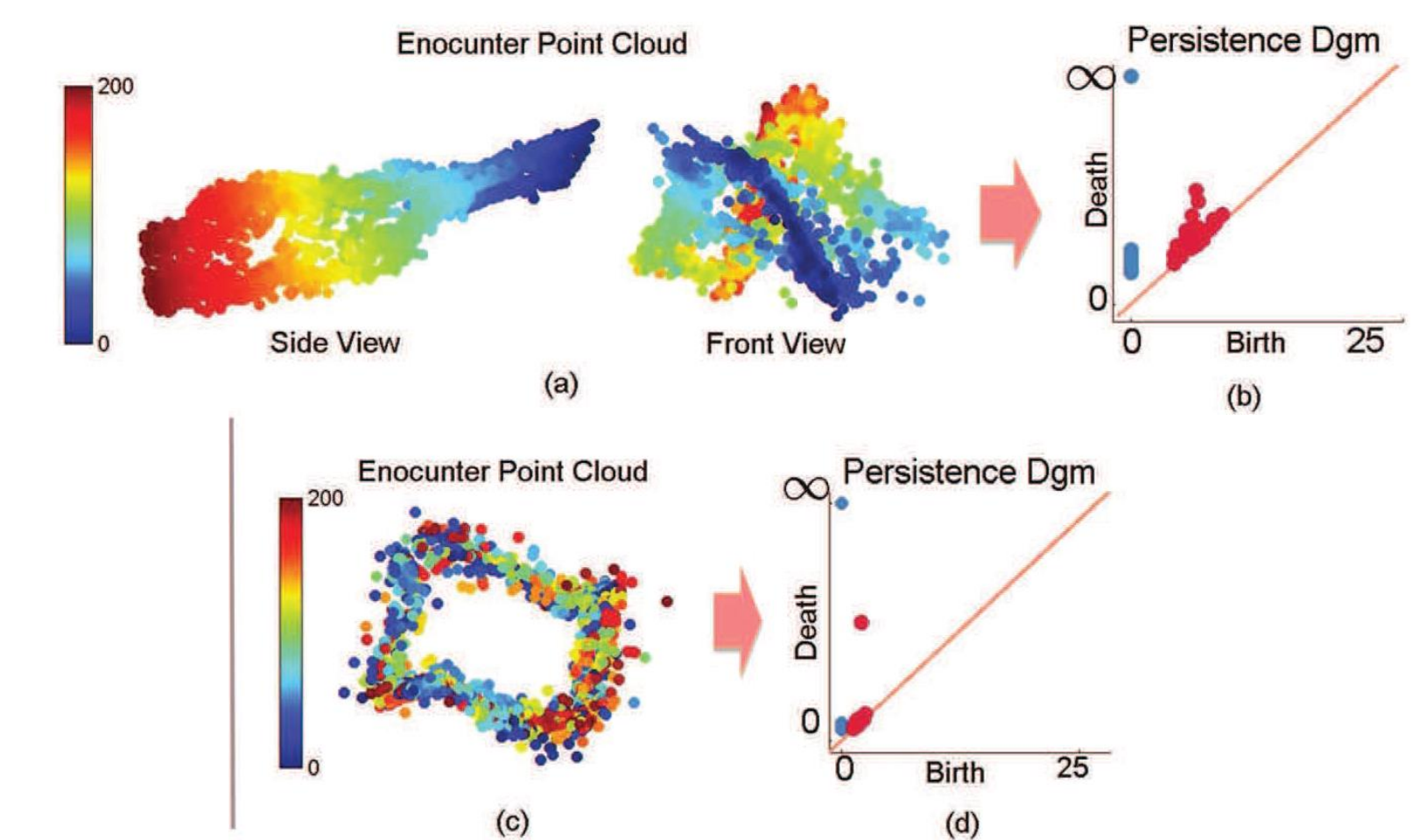
Encounter Metric



A hybrid network

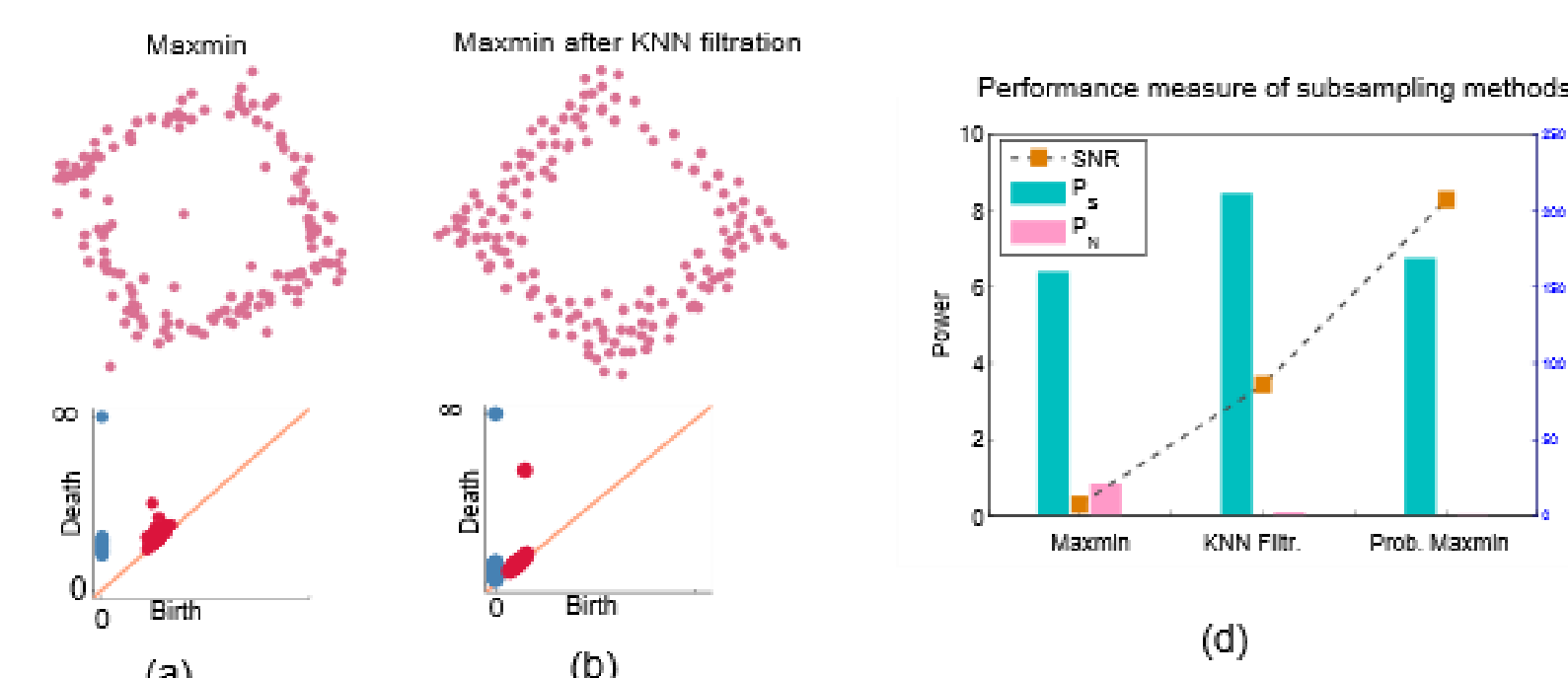


- Idea: Insert a small percentage of static landmark nodes S
- Modify our distance metric as follows:
 - $w_{ij} = 0$ for $ID(\mathcal{E}_i) \cap ID(\mathcal{E}_j) \in S$

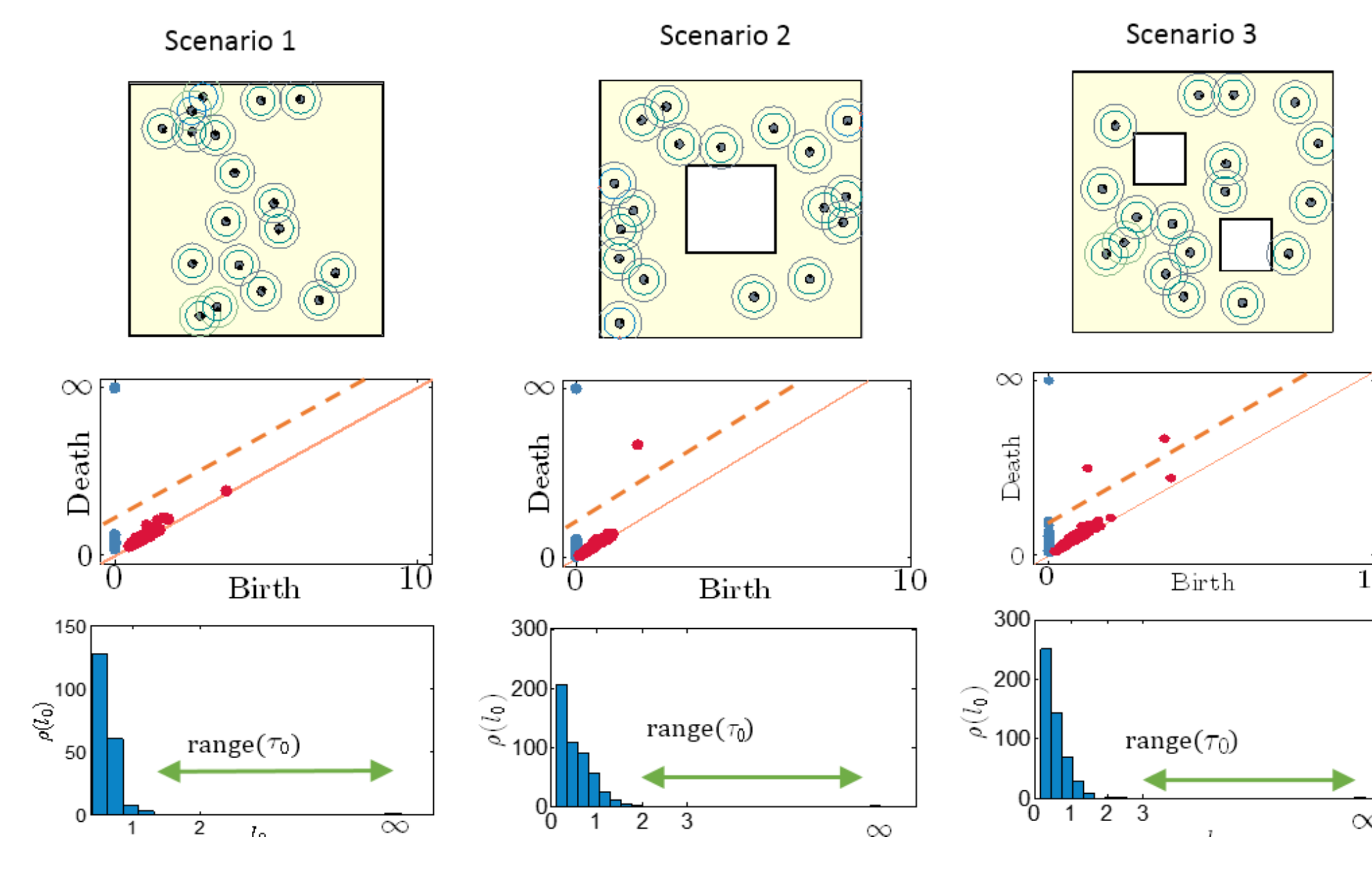


Subsampling

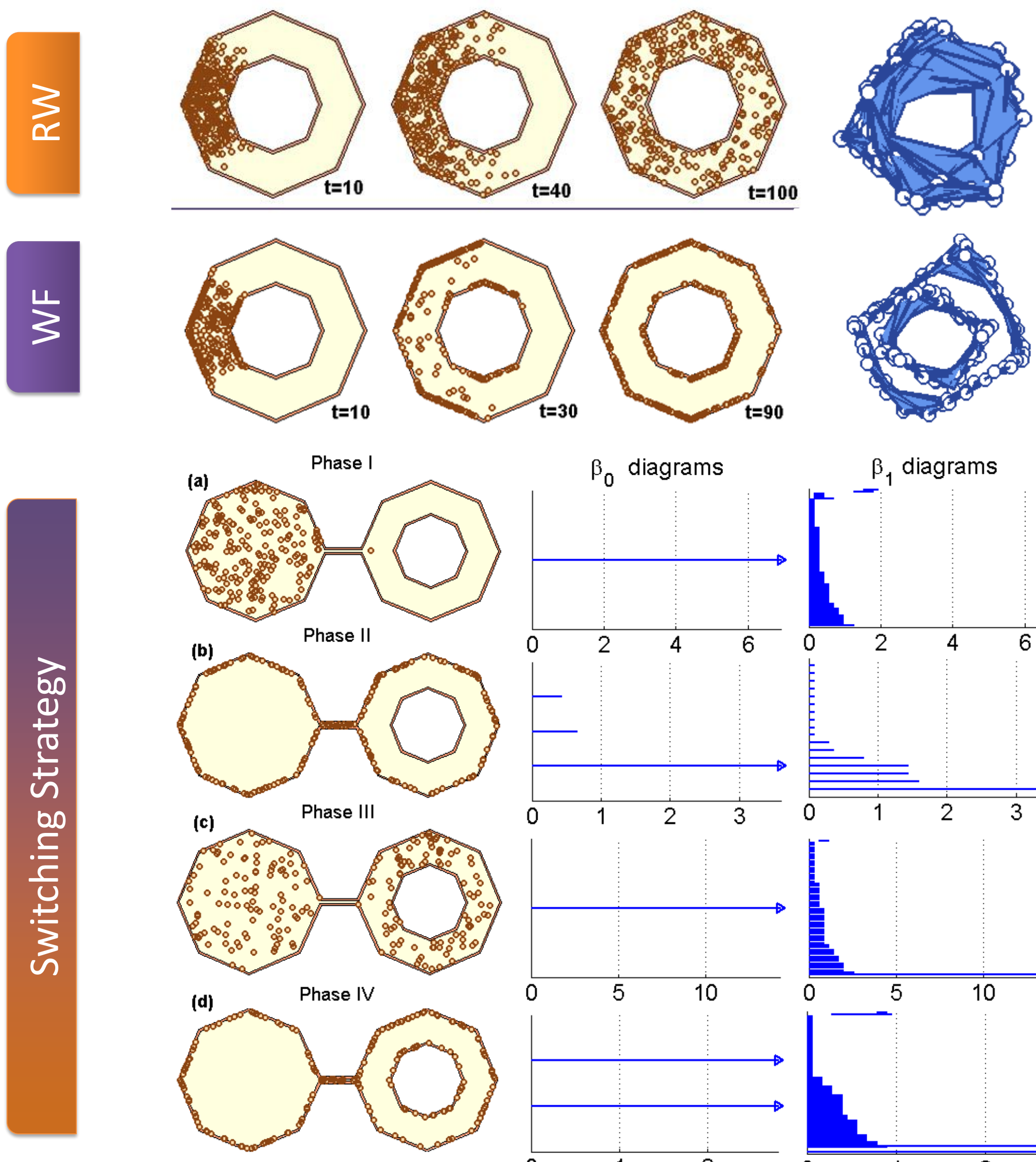
- Computational complexity
- Outliers due to uncertainties in estimation



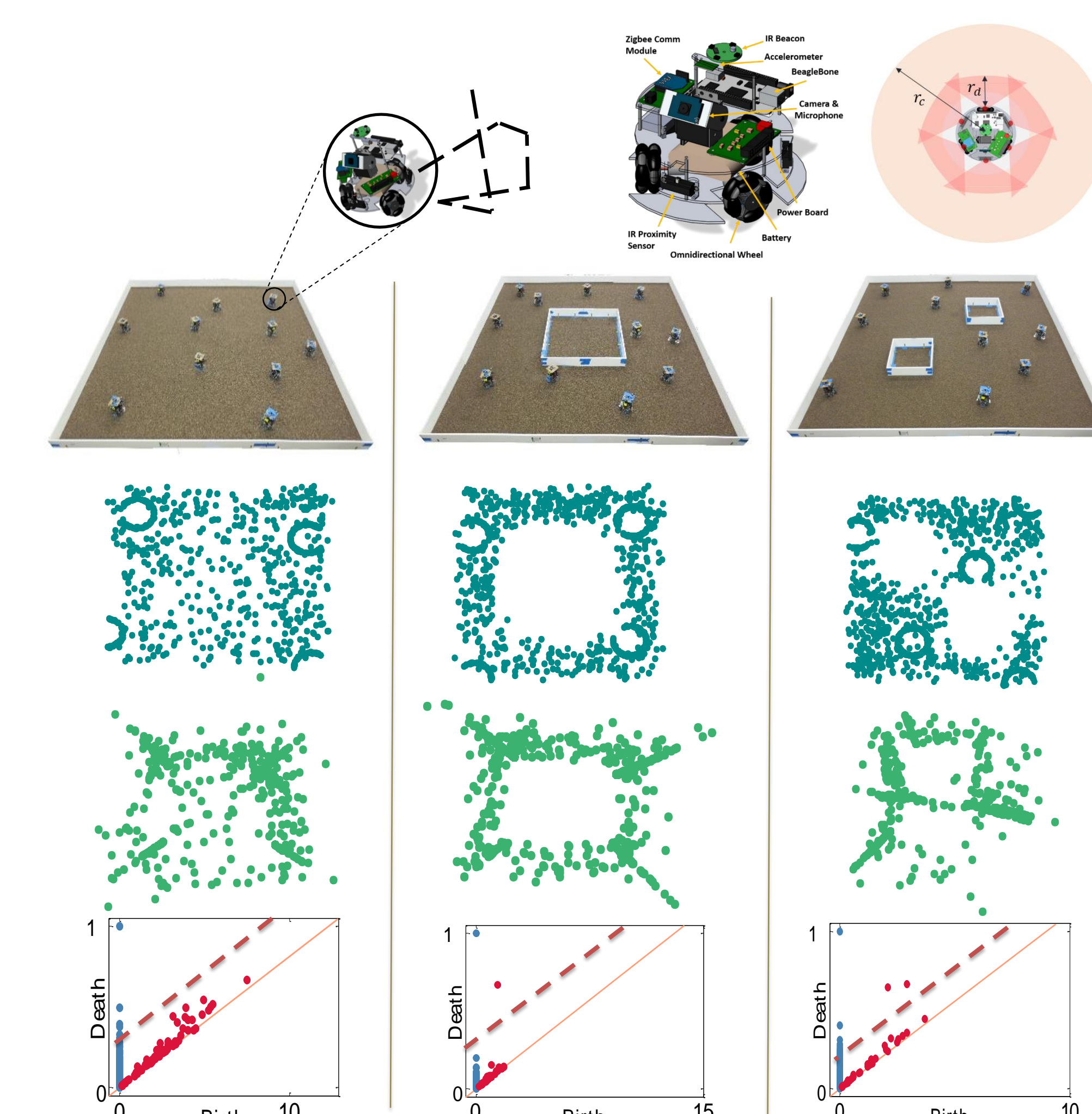
Simulations



Switching Control



Robotic Experiments



References:

1. A. Dirafzoon and E. Lobaton, "Topological Mapping of Unknown Environments using an Unlocalized Robotic Swarm," International Conference on Intelligent Robots and Systems (IROS), 2013.
2. A. Dirafzoon, et al, "Mapping of Unknown Environments using Minimal Sensing from a Stochastic Swarm," IROS 2014.