POST PROCESSING OF OCCUPANCY GRID MAPS USING PERSISTENT HOMOLOGY

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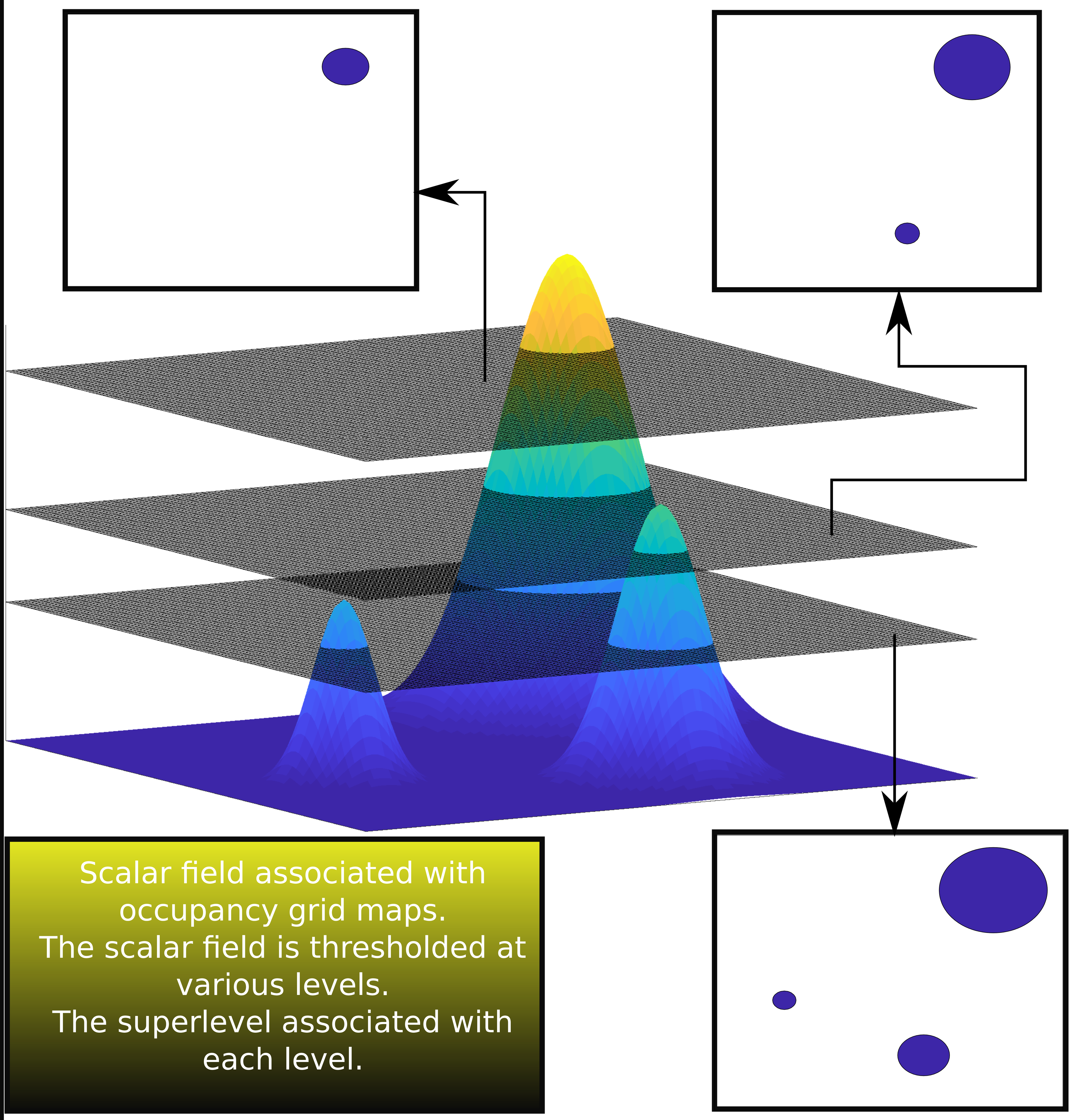
MOTIVATION

- A common approach to post-processing an occupancy grid map is by solving an inference problem referred to as the Maximum A Posterior(MAP) mapping procedure.
- MAP computes the occupancy grid map with the maximum probability of occurrence based on the occupancy probability of each grid cell in the map.
- MAP procedure is posed as an optimization problem, and the solution is computed using gradient-based hill climbing methods.
- This approach is computationally expensive since gradient ascent must be performed from different initial conditions to escape local minima and the search space is exponential in the number of grid cells.
- An assumption used in solving this inference problem through MAP is the independence of grids in the occupancy grid map.
- This assumption is definitely not true for any occupancy grid map modeling a realistic environment, primarily because environments in real world have a structure.
- We present an alternative approach that is based on techniques from topological data analysis (TDA), which exploit the idea that real world environments have a definite structure.

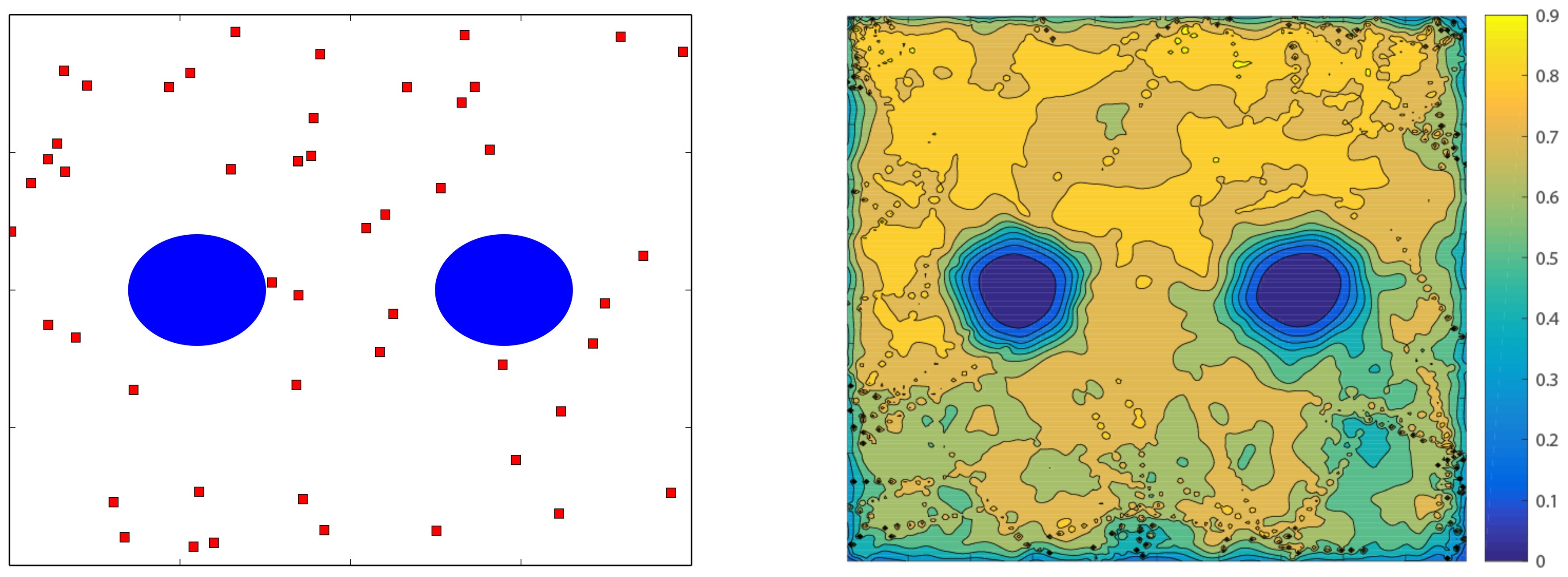
METHODOLOGY



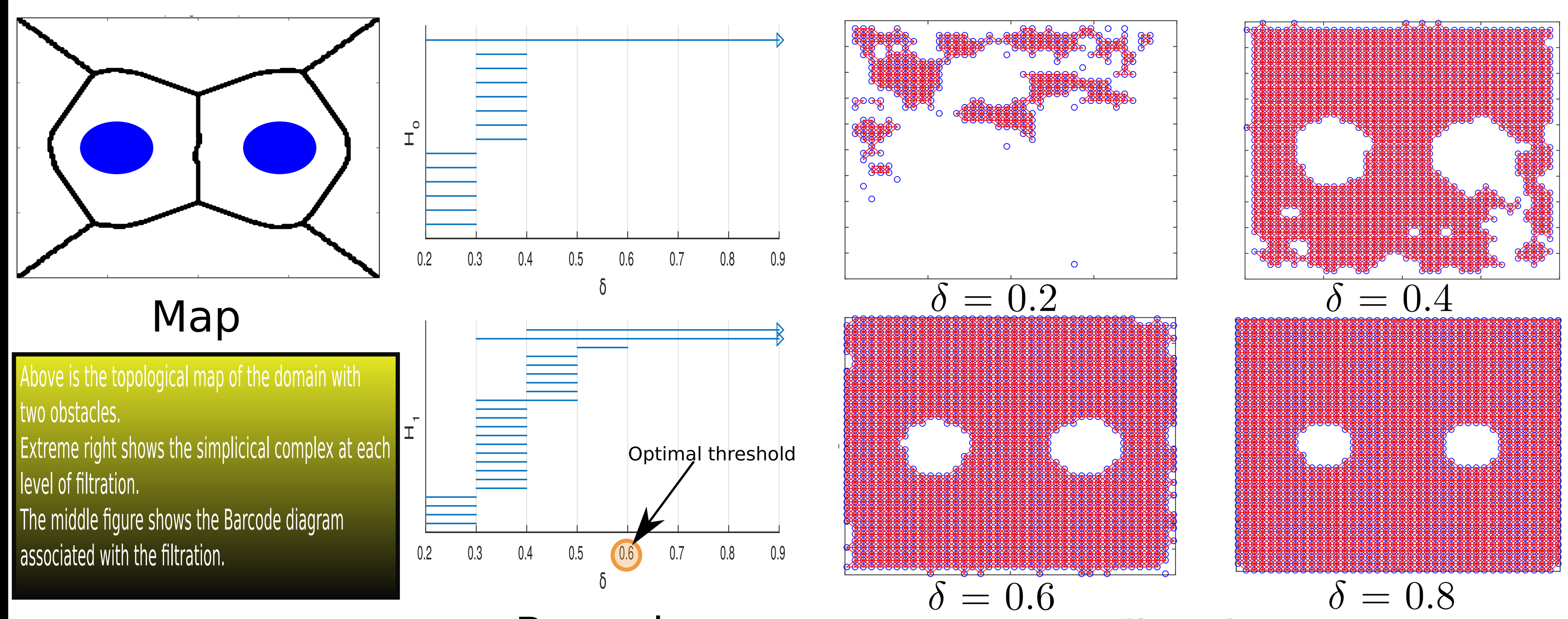
Scalar field associated with occupancy grid maps.
The scalar field is thresholded at various levels.
The superlevel associated with each level.

- Given an occupancy grid map compute the best possible map of the domain.
- We identify the persistent topological features in the domain and find the optimal threshold '*a*' for which all grid cells with probability more than '*a*' belong to an obstacle.
- We generate superlevel sets at various levels of the occupancy grid map.
- We then construct a simplicial or cubical complex at each level.
- Next, the zero homology and one homology of the super level sets are computed.
- Finally, the value above which the topological features are consistent gives the optimal threshold value.

SIMULATION AND EXPERIMENTAL RESULTS

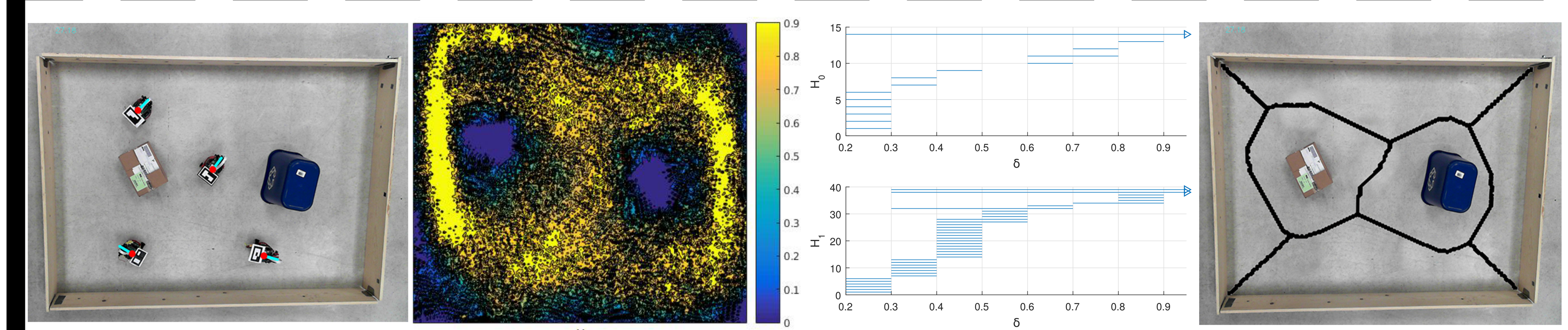


World with two obstacles | Unoccupancy map



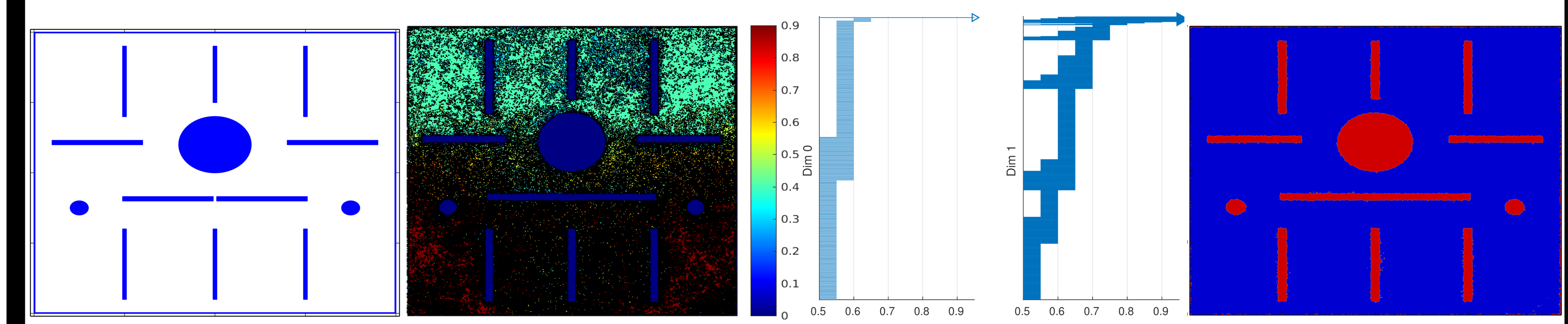
Map | Barcode | Filtration

Unoccupancy grid map from simulation data with unbounded localization noise [1]



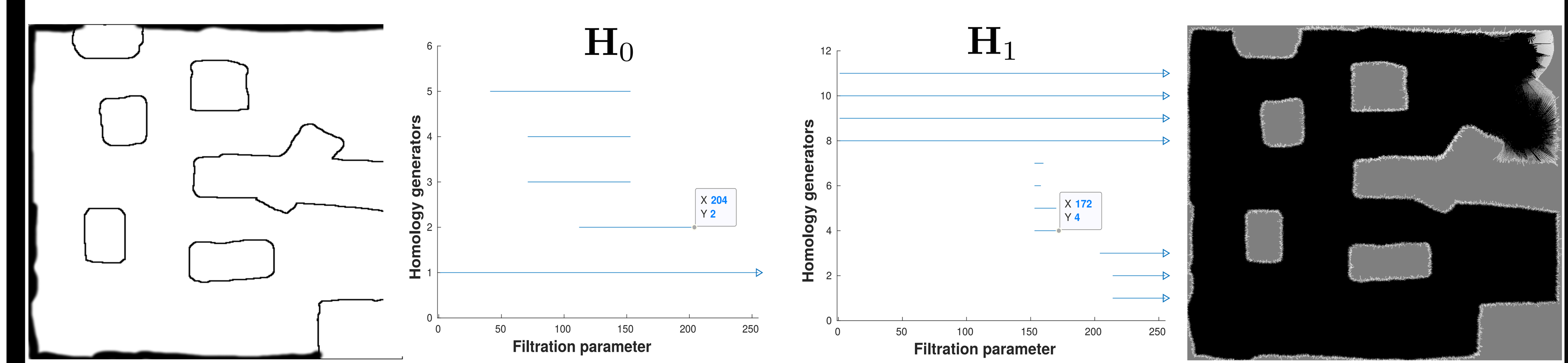
Setup | Unoccupancy map | Barcode | Map overlaid

Unoccupancy grid map from experimental data with unbounded localization noise [1]



Environment | Unoccupancy map | Barcode | Map

Unoccupancy grid map from simulation data with bounded localization noise [2]



Environment | Barcode | Map

Occupancy grid map from Stage simulator simulation data with no localization noise [3]

REFERENCES

[1] Ragesh. K. Ramachandran, S. Wilson, and S. Berman, "A probabilistic approach to automated construction of topological maps using a stochastic robotic swarm," IEEE Robotics and Automation Letters, vol. 2, no. 2, pp. 616–623, Apr. 2017.

[2] Ragesh K. Ramachandran and Spring Berman. "Automated construction of metric maps using a stochastic robotic swarm leveraging received signal strength". arXiv:1903.05392

[3] Ragesh K. Ramachandran, Zahi Kakish, and Spring Berman. Information correlated levy walk exploration and distributed mapping using a swarm of robots. IEEE Transactions on Robotics, 2019. [In revision].

This research was supported by NSF Award CMMI-1363499 & Arizona State University Global Security Initiative

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