A Processing Pipeline for Descriptive Underwater 3D Occupancy Mapping with Scanning Sonar

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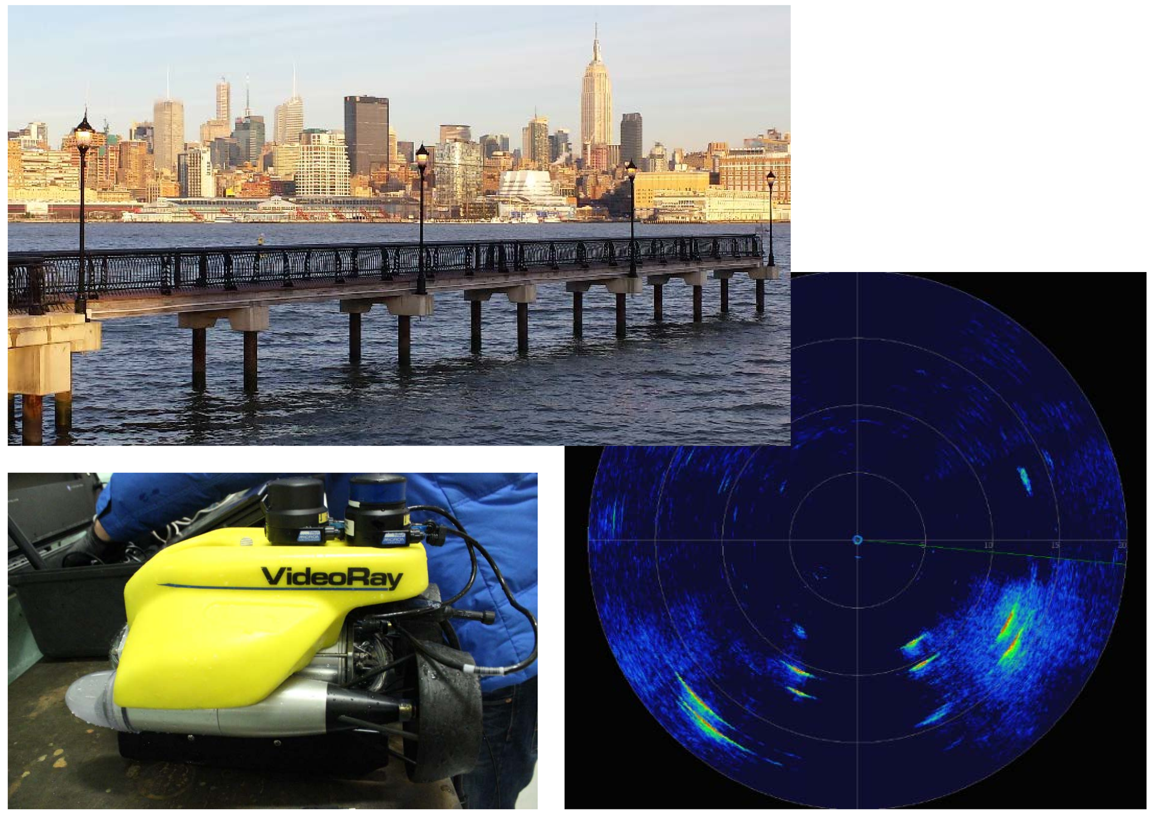
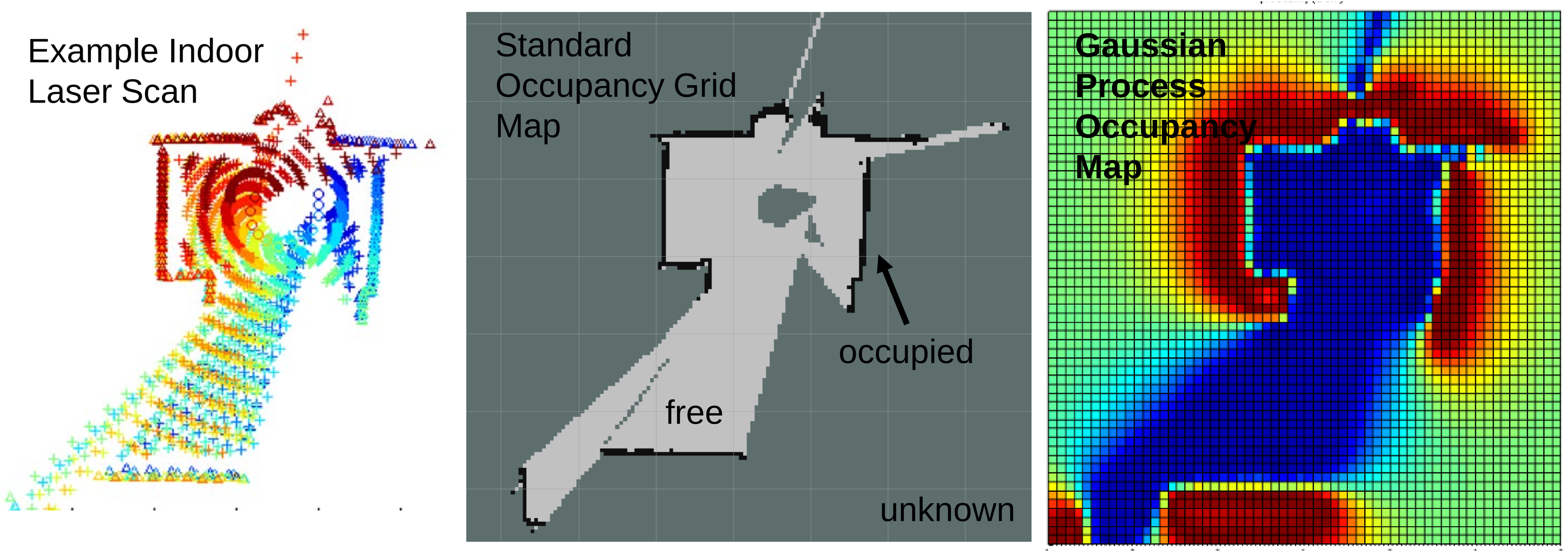
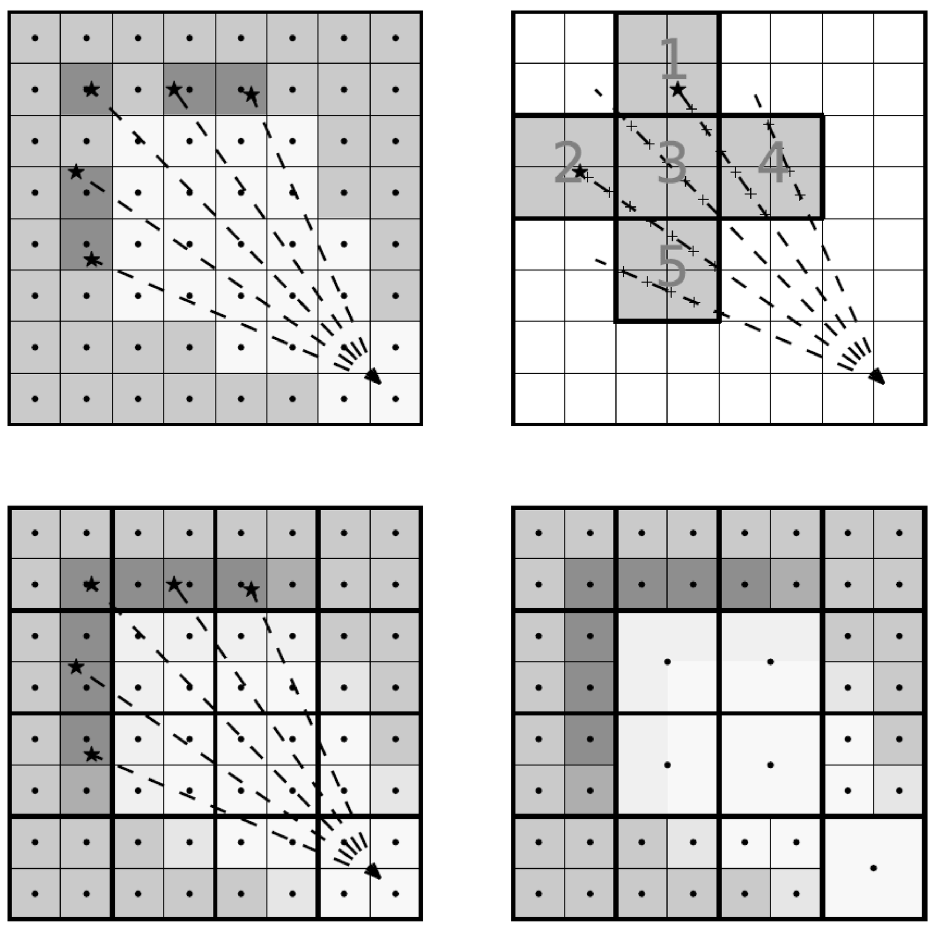


Goal: More seamless and efficient operation of ROVs for port and harbor infrastructure inspection tasks, by relieving the human operator of the need for low-level piloting of a robot, under poor situational awareness. Enable an ROV, under sparse and noisy data, to make robust exploration and maneuvering decisions.

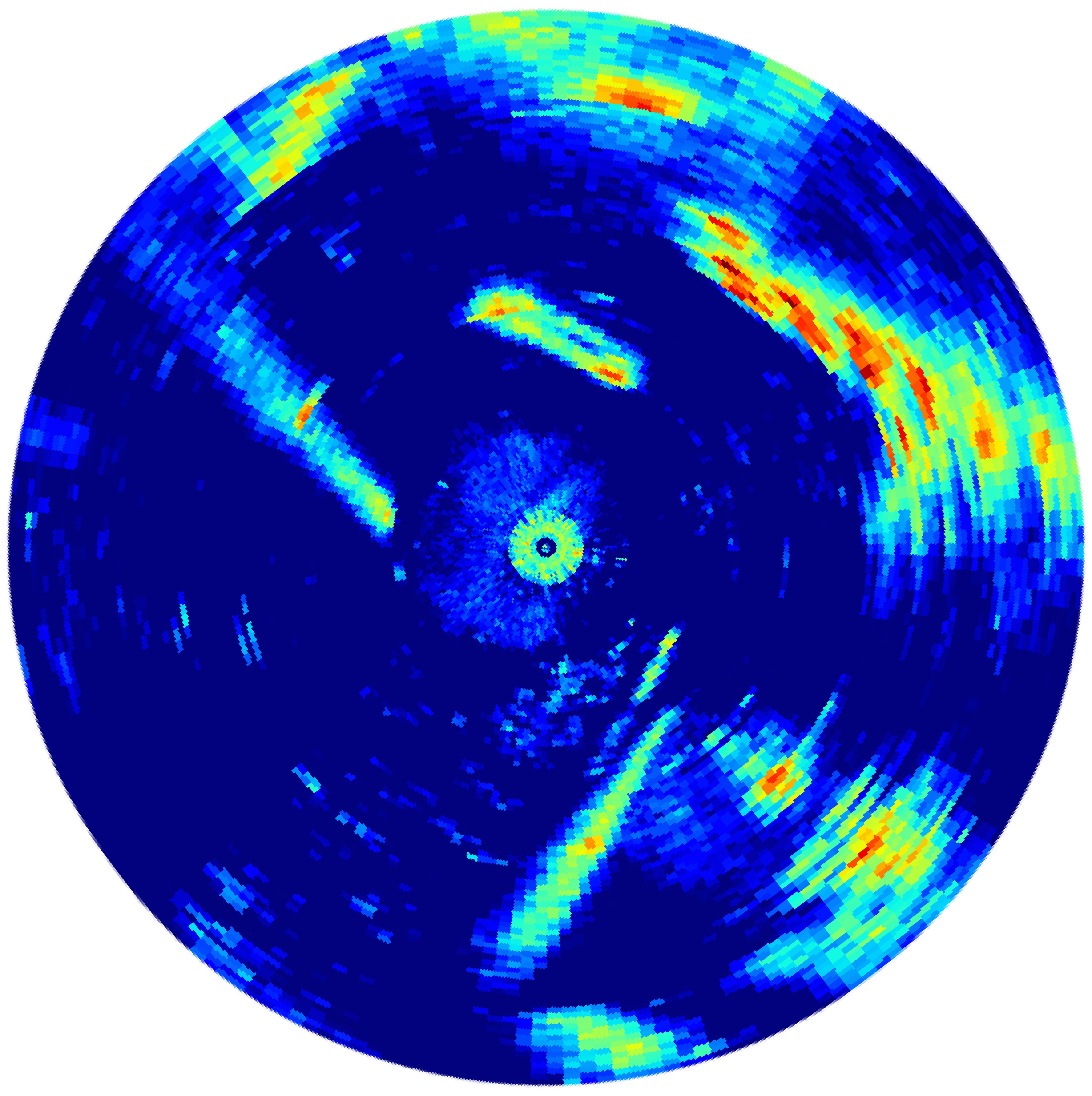


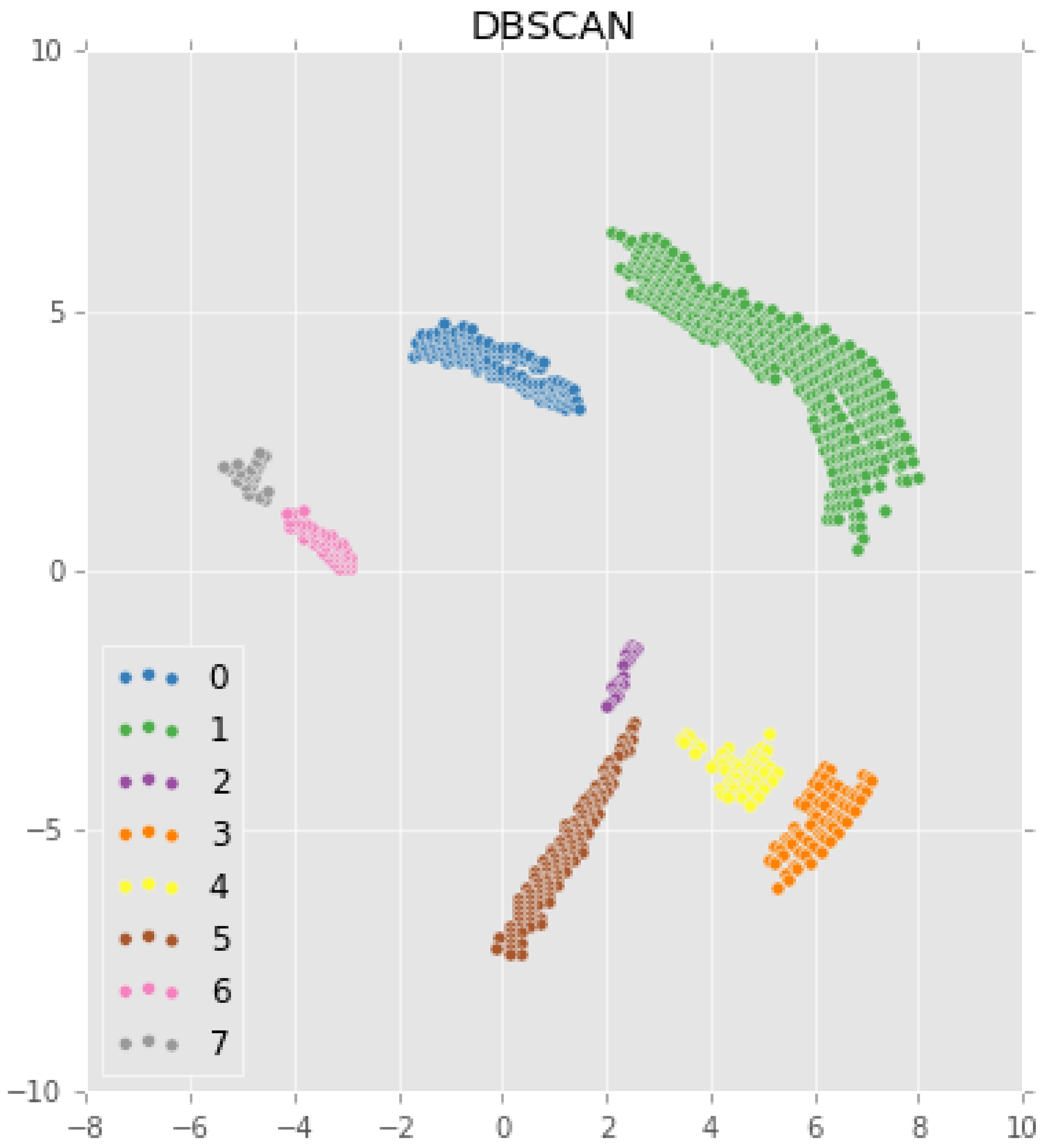
Proposed Solution: Adapt Gaussian process occupancy mapping for real-time use in three dimensions over sparse and noisy data, so that it may provide a basis for making predictive exploration decisions. With this process in place, the operator can focus on mission-level decision-making and the contents of the robot's imagery.

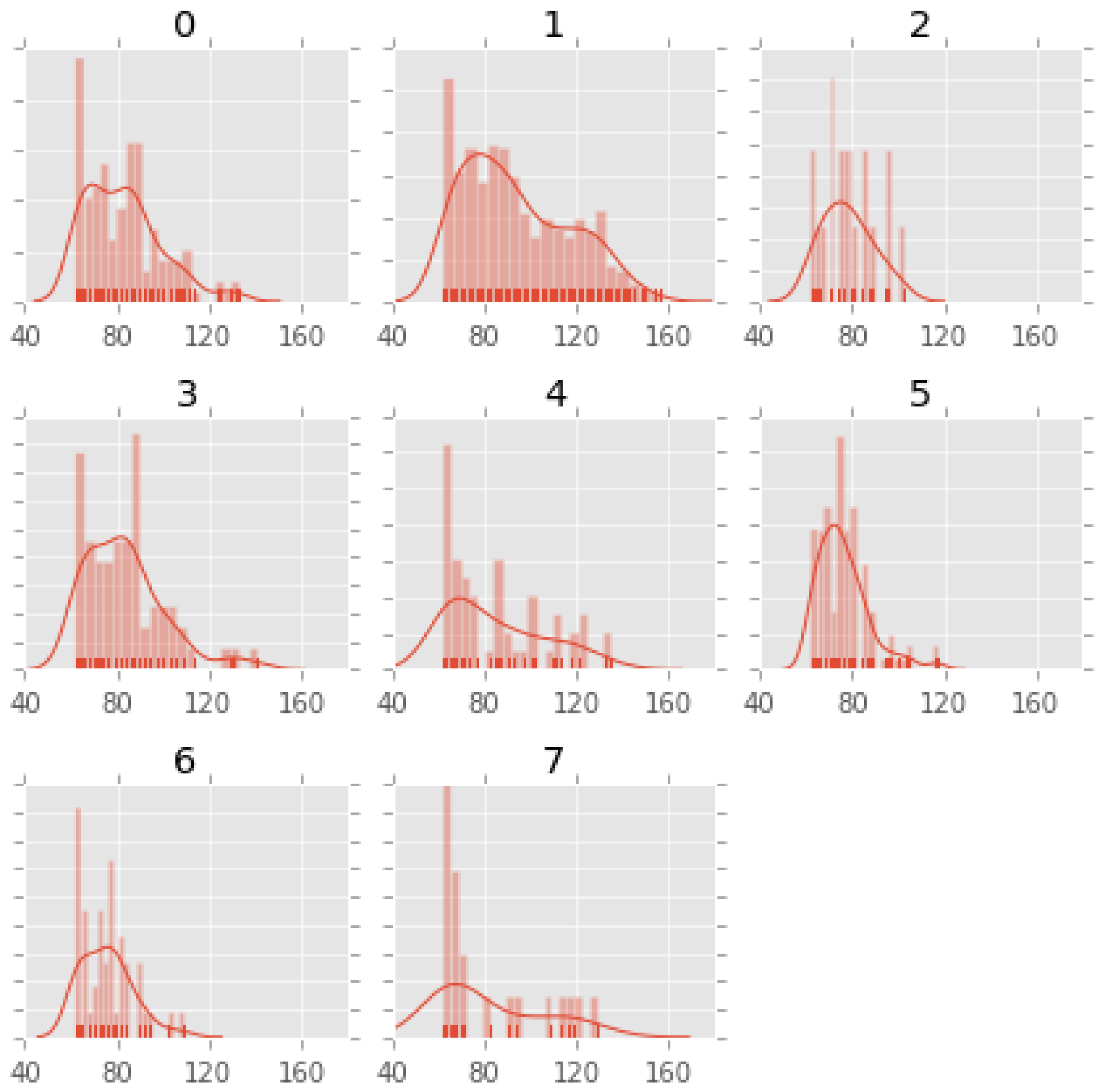
At left: Stevens Institute of Technology's VideoRay Pro4 remotely operated vehicle (ROV), our Hudson River pier where the vehicle is operated, and representative imagery from our Micron DST scanning sonar during an inspection of the pier. **Above:** Illustrative example of Gaussian process occupancy mapping using a representative laser rangefinder scan.



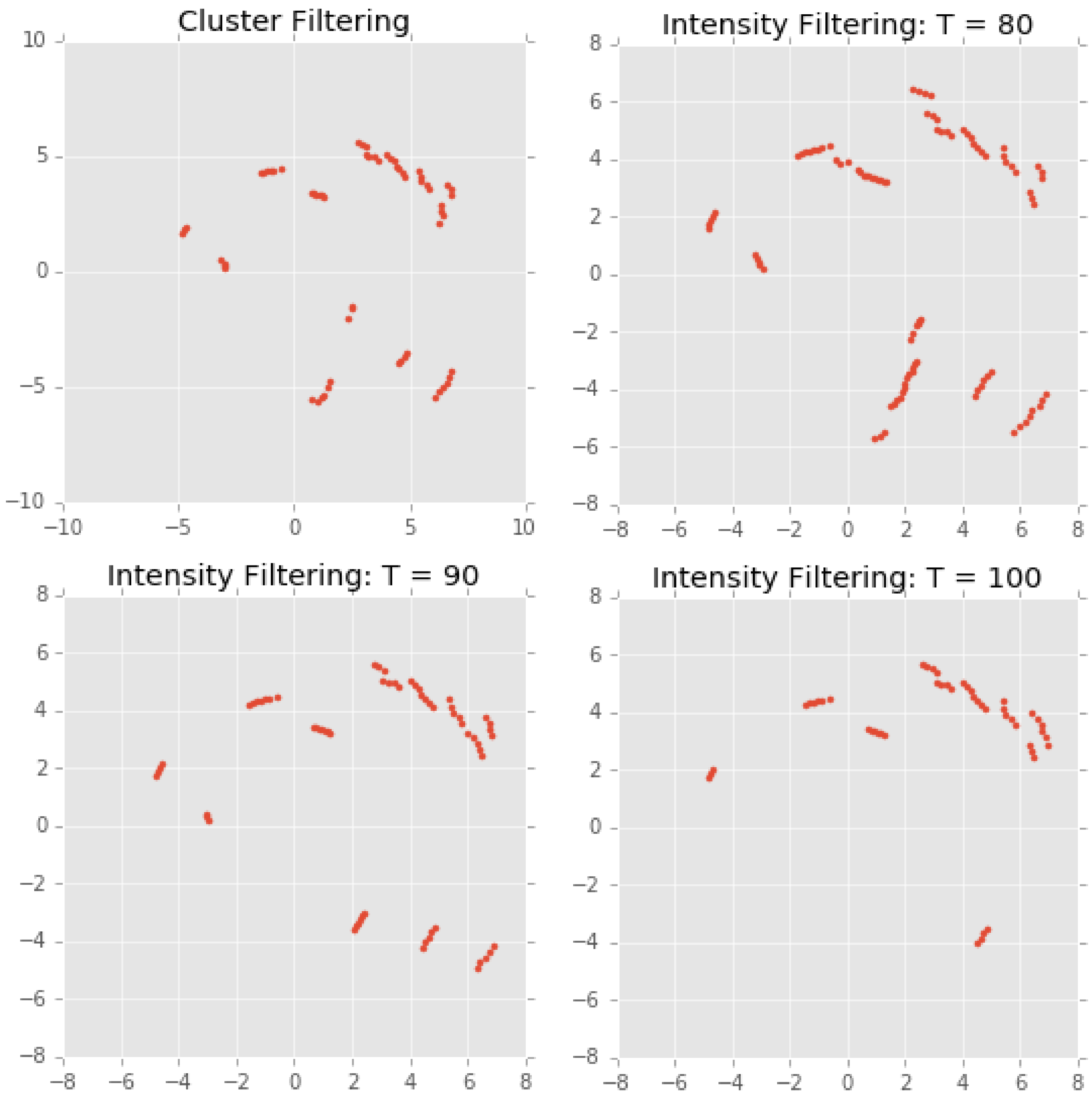
Above: Efficient data structures at the level of both test data and training data allow 3D Gaussian process occupancy mapping in near real-time.

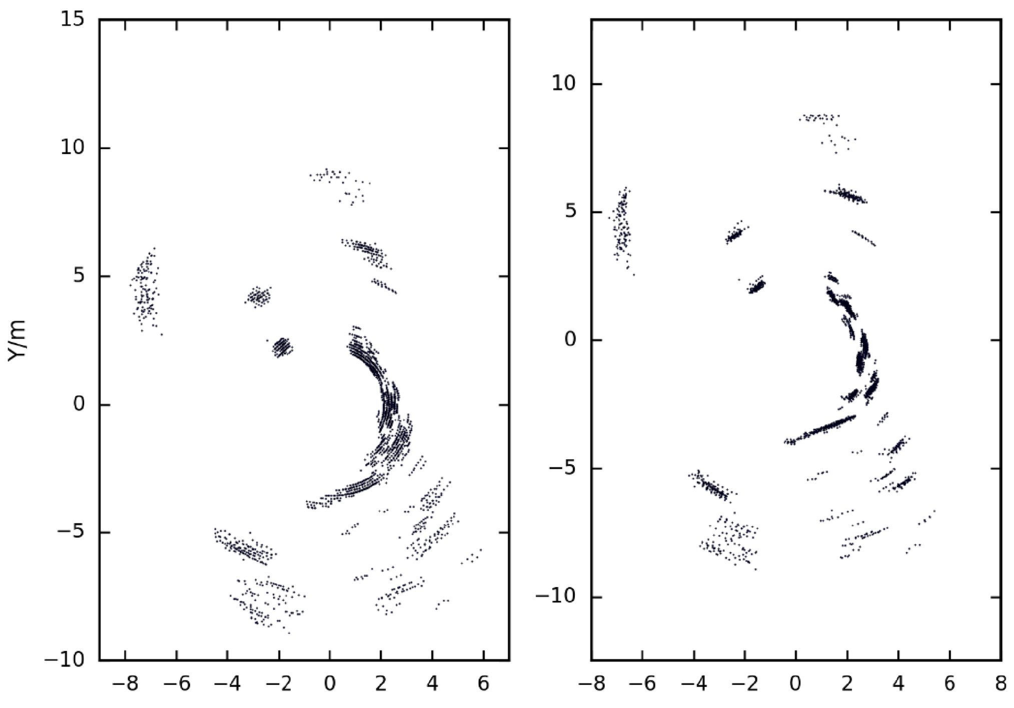


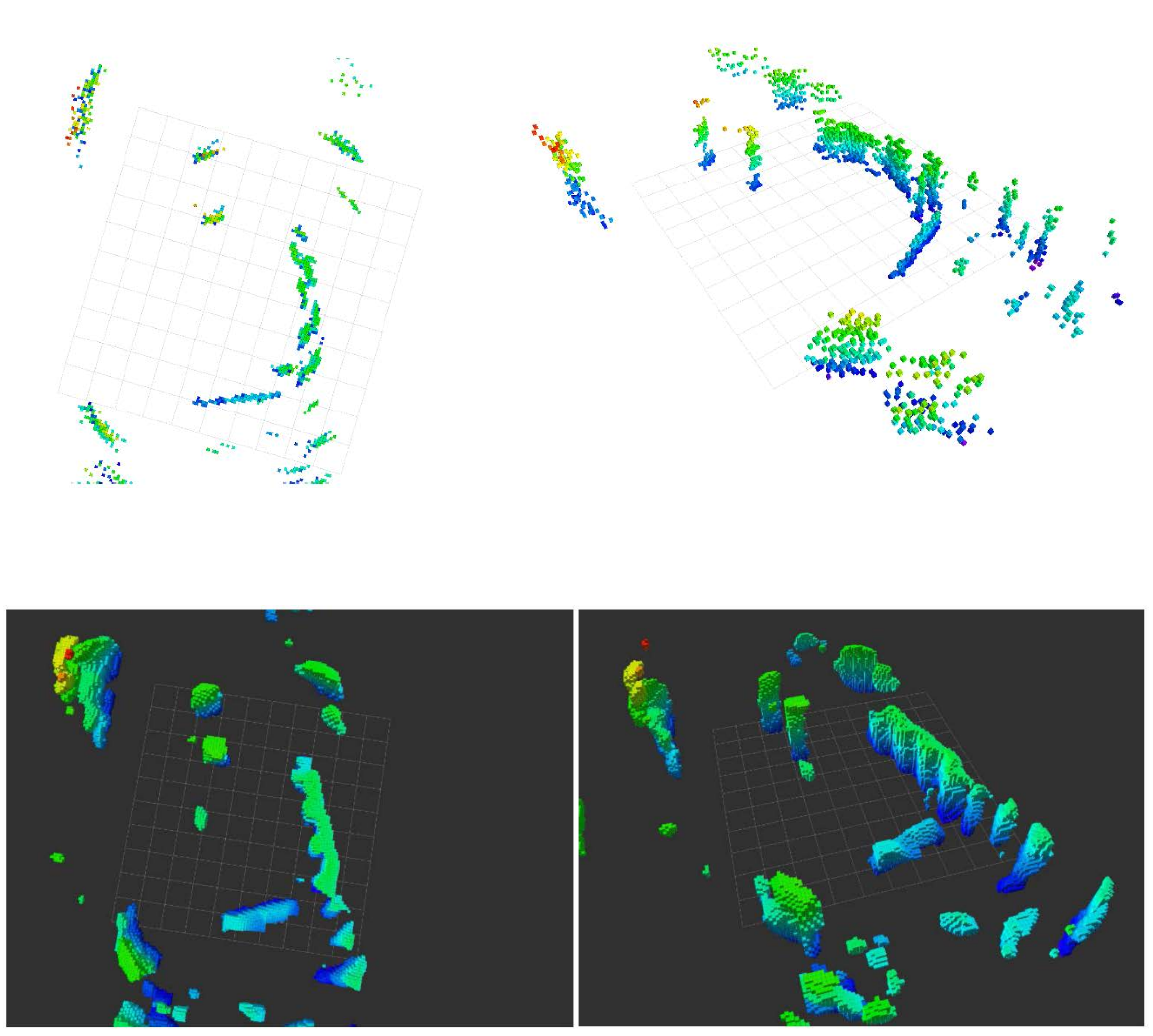




At Left: A representative sonar scan of a cluttered harbor environment, collected at the U.S. Merchant Marine Academy in King's Point, NY. **At Center:** A preliminary filtered point cloud with a conservative amplitude threshold applied to the entire scan, clustered using the DBSCAN algorithm. **At Right:** Histograms demonstrating the amplitude distribution of the points contained in each cluster. A separate amplitude threshold is selected for each cluster, for further filtering, based on its individual distribution of amplitude values.







At Left: Results of filtering a sonar scan using our clustering method vs. applying a single amplitude threshold to the entire scan. **At Center:** A series of filtered scans before and after registration using ICP. **At Right:** The point cloud collected during the robot's execution of a depth-varying transect through this harbor environment is used to populate occupancy maps. A standard OctoMap is shown at top, and the proposed Gaussian process occupancy map is shown at bottom.

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