Multi-Agent Team Access Monitoring

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Introduction

In this research, we generalize an existing robot access monitoring technique to support multiple target areas. We use two approaches: iterating on individual targets and examining collections of targets holistically. Through simulation, we examine the characteristics of scenarios that benefit from a holistic approach versus an individualized approach and vice versa.

Consider the obstacle-filled environment in Figure 1a and Figure 1b. Three non-contiguous target regions are surrounded so that nothing can enter from the edge of the environment and reach them without being detected by a robot.

Figure 1a.

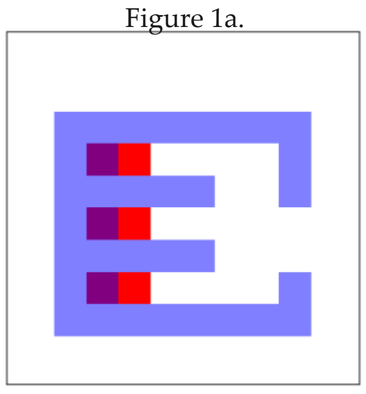


Figure 1b.

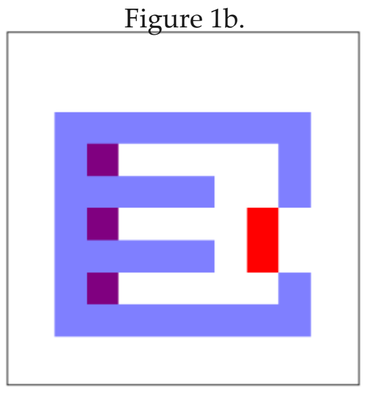
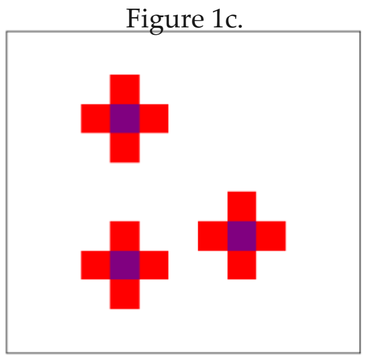


Figure 1c.



Attempting to minimize the amount of robots required to guard each target region individually requires three robots (Figure 1a), one for each target.

Conversely, by treating the target regions holistically, the amount of agents required to survey an area can be reduced to two (Figure 1b), the size of the common opening to the targets.

In some scenarios, the individual and holistic approach result in identical solutions. (Figure 1c).

Algorithm

The individual approach takes Gupta's existing algorithm[0] and applies it to each target region individually. Sink points correspond to target regions. For each target region, a planar graph is created that corresponds to the access-monitoring problem for that single region.

The holistic approach considers all targets simultaneously. A single non-planar graph is created that corresponds to the holistic access-monitoring problem. The graph is non-planar because the non-contiguous target regions are joined together.

Experiment

We compare the results of our holistic and iterative algorithms on simulated environments within a discretized grid. Each square of an environment can be free, a target region, or blocked by an obstacle. Each robot can block a single free square.

Conclusion

Our results revealed that in medium density environments, robots can monitor access to a group of target areas more efficiently than monitoring access to each target area individually. The holistic approach showed fewer improvements in sparse environments and in environments with a high density of obstacles.

References

[0] M. Gupta, M. C. Lin, D. Manocha, H. Xu, and M. Otte, "Monitoring access to user defined areas with multi-agent team in urban environments," in *2019 International Symposium on Multi-Robot and Multi-Agent Systems (MRS)*, (New Brunswick, NJ, USA), pp 56-62, IEEE, Aug 2019

Results

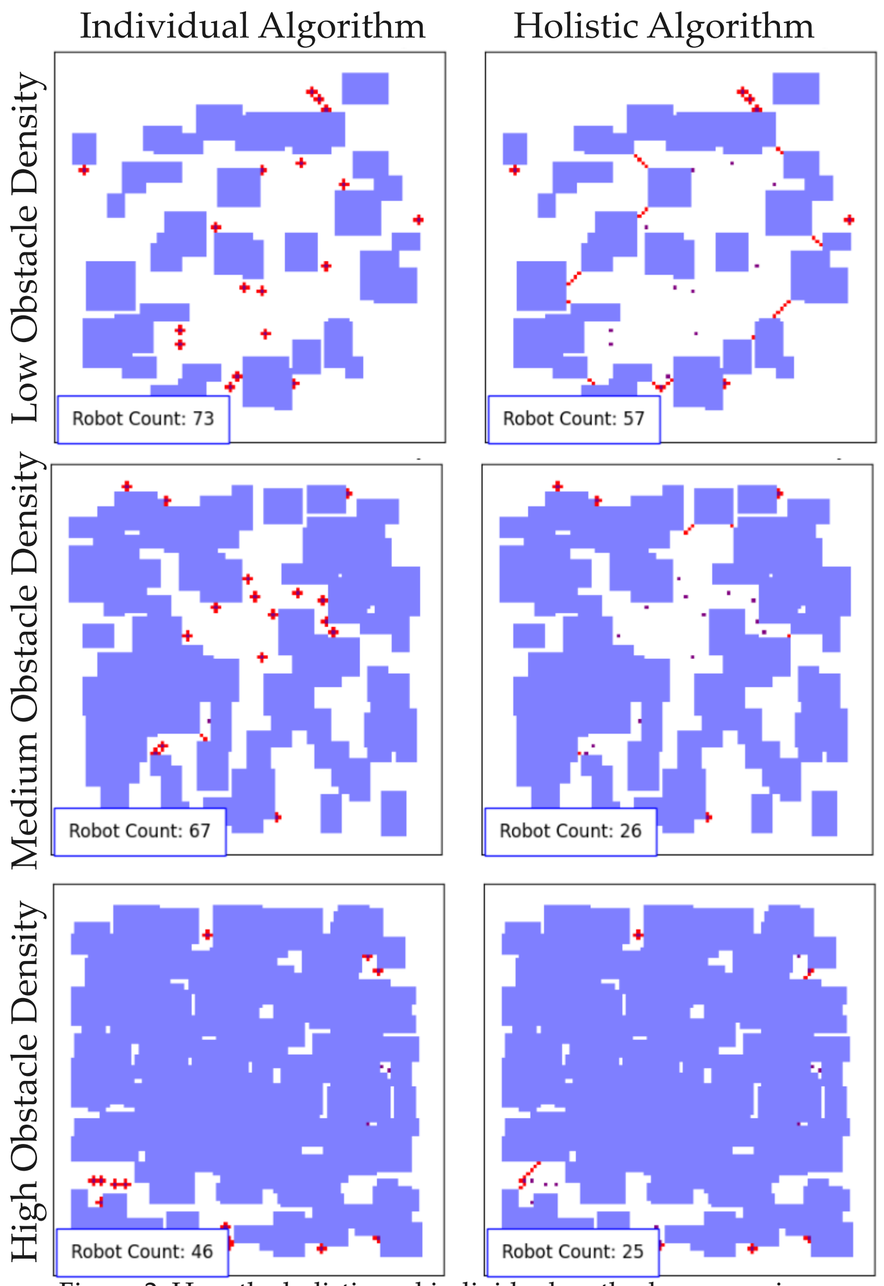


Figure 2. How the holistic and individual method compare in open environments.

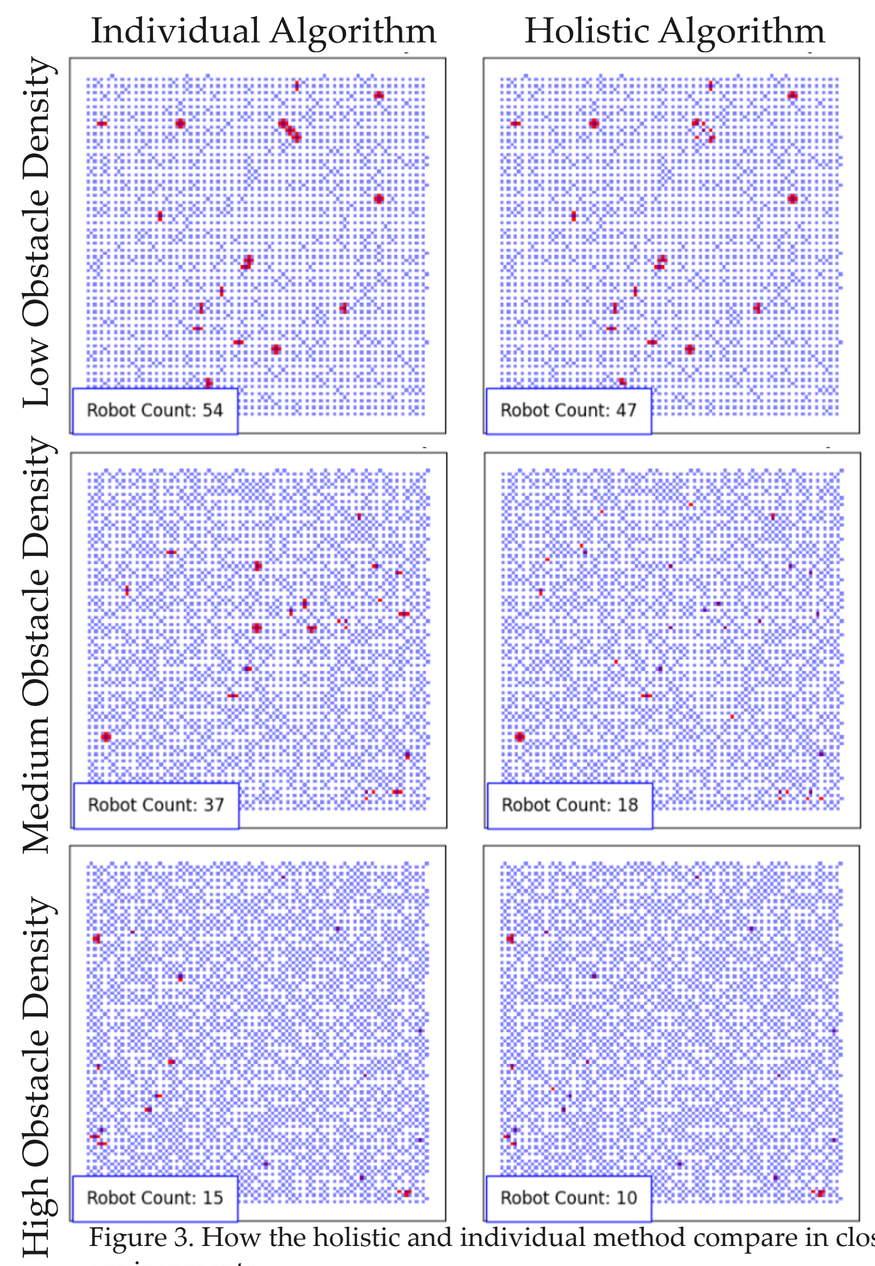


Figure 3. How the holistic and individual method compare in closed environments.

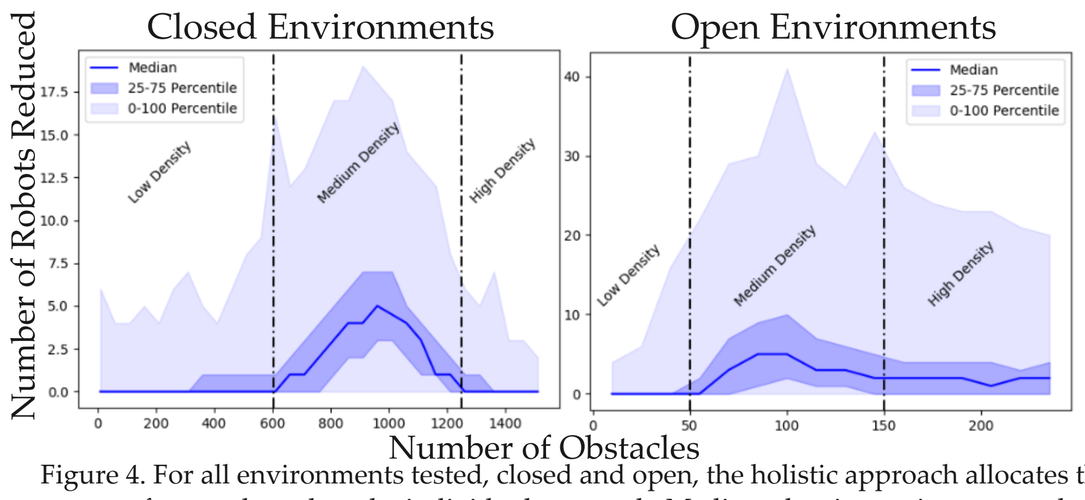


Figure 4. For all environments tested, closed and open, the holistic approach allocates the same or fewer robots than the individual approach. Medium density environments show the greatest improvement.

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