Oregon State University

Auction-Based Multi-Robot Task Allocation and Path Planning for Vehicle Routing

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Sequential Decision Making in Robotics, Final Project Presentation

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Motivation



Figure 1: BellaBot Delivery Robots **[1]**



Figure 2: Starship Delivery Robots **[2]**

Related Works

- Markov Decision Processes (MDP) for addressing task allocation and path planning in underwater environments **[3].**
- Advanced SMT Solver (Z3) and CBS for task allocation and path planning for multi-robot pick up and delivery **[4].**
- Behavior Trees with Market-Based Task Allocation in Dynamic Environments **[5].**

Assumptions / Control Variables



Figure 3: Overhead View of the Robotarium **[9]**

- Robots Confined to 2D Plane
- Known Environment
- Static Environment
- Perfect communication
- Homogenous Utilities
- One Robot Per Task
- Tasks Generated in Random Accessible Locations at Random Intervals

Varying / Uncontrolled Variables



Figure 4: Total Annihilation (RTS Video Game - AI) **[11]**

- Task Locations
- Task Completion Rewards
- Robot Starting Locations
- Task Durations
- Auctioning Mode

Path Planners

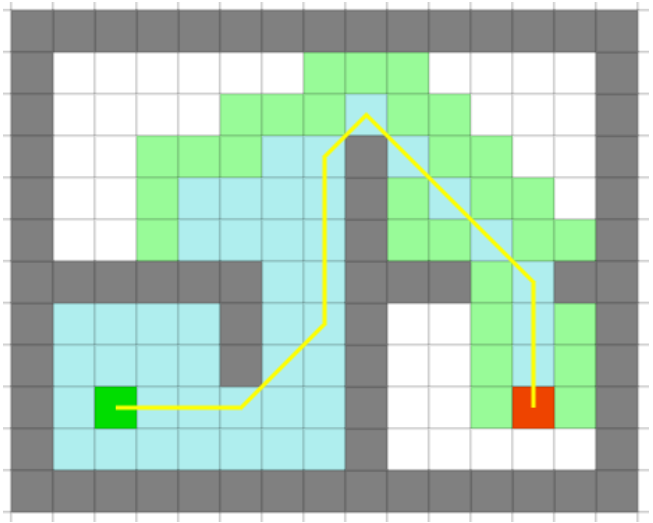


Figure 6: A* Path Planner **[7]**

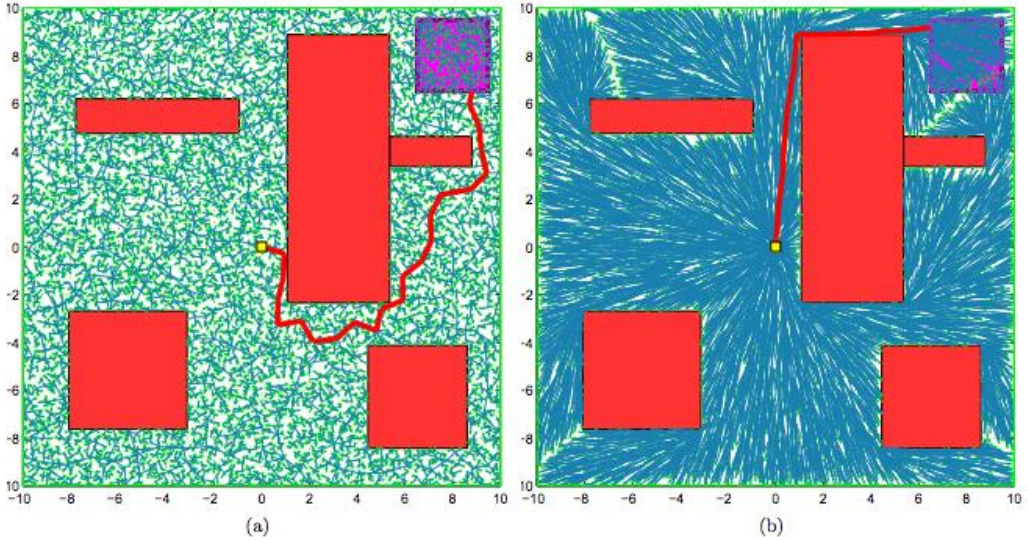


Figure 7: RRT and RRT* Path Planners **[8]**

Auctioning

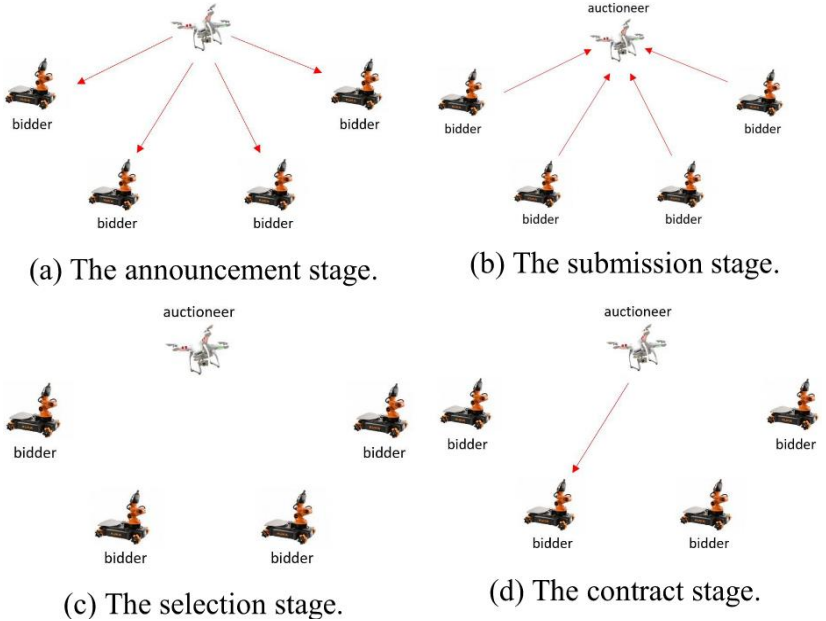


Figure 5: Auctioning **[6]**

4 Auctioning Modes:

- Task Reward Priority
- Oldest Task
- Lowest Cost Task
- Random Order (Baseline)

The Robotarium at Georgia Tech **[10]**



Figure 8: Current Robotarium (Picture by Atharv Marathe)

- Scalable
- Accessible
- Safety Guarantees
  - Barrier certificates

Results

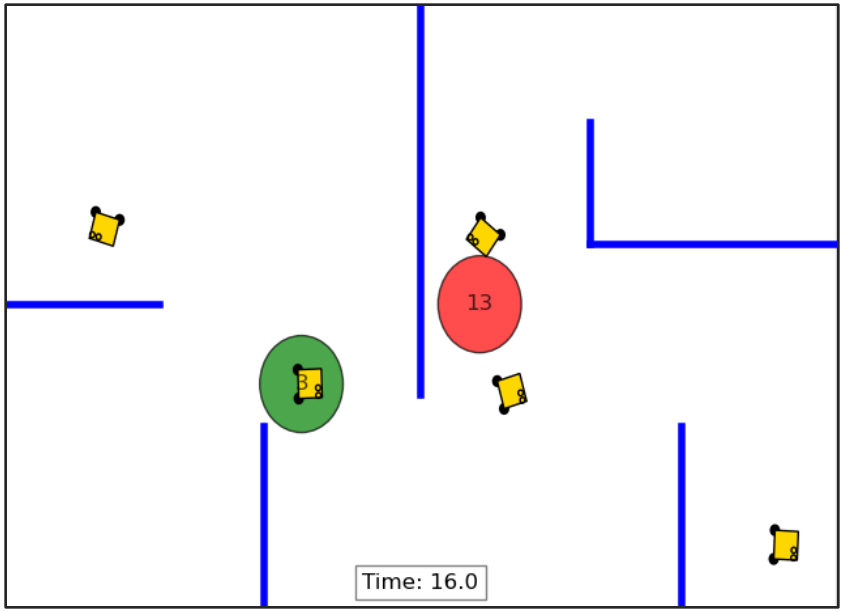


Figure 9: Virtual Simulation

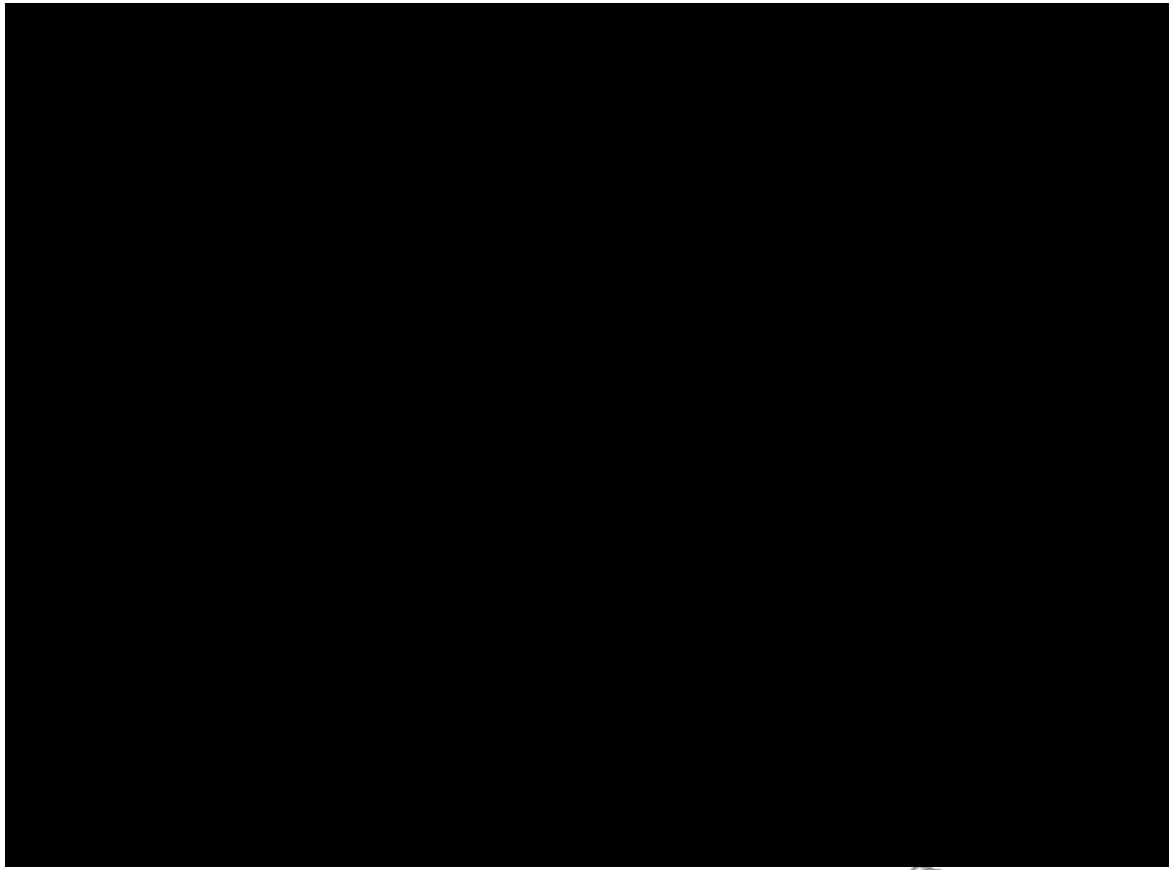
- Time taken with 5 robot(s) using RRT planner: 49.46 seconds
- Completed 9 tasks with total cost: 35.11
- Time taken with 5 robot(s) using RRT* planner: 50.52 seconds
- Completed 9 tasks with total cost: 27.49

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Conclusion

- Currently Analyzing and Tabulating Results of Additional Trials
- Running experiments with A* + PRM is in the pipeline
- RRT and RRT* Can Lead to Unexpected Behaviors
- Tradeoff Between Auctioning Modes Minor for Small Data Sets (Preliminary)

Questions?



References

1. Pudu Robotics. (n.d.). *BellaBot: Smart Delivery Robot*. Retrieved March 9, 2025, from https://www.pudurobotics.com/product/detail/bellabot
2. Starship Technologies. (n.d.). *Starship: Autonomous Delivery Robots*. Retrieved March 9, 2025, from https://www.starship.xyz/
3. F. Nawaz and M. Ornik, "Multiagent, multitarget path planning in markov decision processes," IEEE Transactions on Automatic Control, vol. 68, no. 12, pp. 7560–7574, Dec. 2023.
4. A. Aryan, M. Modi, I. Saha, R. Majumdar, and S. Mohalik, "Optimal integrated task and path planning and its application to multi-robot pickup and delivery," arXiv preprint arXiv:2403.01277, 2024.
5. T. Wang, D. Shi, and W. Yi, "Extending behavior trees with market based task allocation in dynamic environments," in Proceedings of the 2020 4th International Symposium on Computer Science and Intelligent Control, 2020, pp. 1–8.
6. Wang, T., Shi, D., & Yi, W. (2020). *Extending Behavior Trees with Market-Based Task Allocation in Dynamic Environments*. Proceedings of the International Conference on Intelligent Systems and Control (ISCSIC), 1-8.
7. Qiao. (n.d.). *PathFinding.js: Visual Demo*. Retrieved March 9, 2025, from https://qiao.github.io/PathFinding.js/visual/
8. Aniti, A. (n.d.). *Revisiting an Old Project: Learning Path Planning with the RRT Algorithm*. Retrieved March 9, 2025, from https://www.linkedin.com/pulse/revisiting-old-project-learning-path-planning-rrt-algorithm-aniti-ascfe
9. Robotarium. (n.d.). *Robotarium: A remotely accessible swarm robotics research platform*. Georgia Institute of Technology. Retrieved from https://www.robotarium.gatech.edu/
10. Sean Wilson, et al., *"The Robotarium: Globally Impactful Opportunities, Challenges, and Lessons Learned in Remote-Access, Distributed Control of Multirobot Systems,"* in IEEE Control Systems Magazine, vol. 40, no. 1, pp. 26-44, Feb. 2020.
11. Einarsson, E. (2018, September 15). *The making of Total Annihilation*. PC Gamer. Retrieved from https://www.pcgamer.com/the-making-of-total-annihilation/