Optimal Online Coverage Pathing with Energy Constraints

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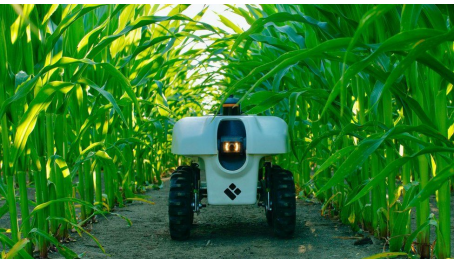

Choose Ohio First

Background and Goal

- Automated Agricultural equipment has become very popular in the last 5 years.
- The robots run on a L x L grid that they are assigned. When they run out of energy they return to charging dock and then continue where they left off.

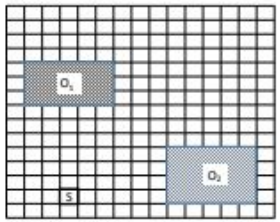

Figure 1: An example environment P with two obstacles O_1 and O_2 and a charging station S inside P. The perimeter of P is considered as a boundary of P. P is shown decomposed as cells of size $L \times L$ same as the size of the robot.

Our goal is to figure out how to account for non-static objects that get moved around the grid.

Importance

- If we are able to develop the equation we could make automated farming more reliable and less required work.
- Could produce crops at a steady pace through the night since it’s all automated.

Challenges

- Getting the robot to detect objects and not rely on that previous positioning when he goes through his pathing again
- Making sure that if an object moves, the robot clears that space since it is available in its grid

Results

- Currently have the proper technology and programming to run a robot through without non-static objects
- The robot knows when to get back to the recharging station and then continues his pathing from where he left off.

Conclusion and Reflections

Still to be determined. The last time I had talked to Dr. Sharma he said that the equation for our problem was still being developed. I really would’ve liked to have worked with Dr. Sharma more to get a better understanding of his work.

References

David L. Applegate, Robert E. Bixby, Vasek Chvatal, and William J. Cook. 2007. The Traveling Salesman Problem: A Computational Study (Princeton Series in Applied Mathematics) .Princeton University Press, Princeton, NJ, USA.

Peter Brass, Andrea Gasparri, Flavio Cabrera-Mora, and Jizhong Xiao. 2009. Multi-robot Tree and Graph Exploration. In ICRA. 495--500.

Young-Ho Choi, Tae-Kyeong Lee, Sanghoon Baek, and Se-Young Oh. 2009. Online complete coverage path planning for mobile robots based on linked spiral paths using constrained inverse distance transform. In IROS. IEEE, 5788--5793.

Howie Choset. 2000. Coverage of Known Spaces: The Boustrophedon Cellular Decomposition. Auton. Robots , Vol. 9, 3 (Dec. 2000), 247--253.

Pierre Fraigniaud, Leszek Gcasieniec, Dariusz R. Kowalski, and Andrzej Pelc. 2006. Collective Tree Exploration. Netw. , Vol. 48, 3 (Oct. 2006), 166--177.

Yoav Gabriely and Elon Rimon. 2001. Spanning-tree Based Coverage of Continuous Areas by a Mobile Robot. Annals of Mathematics and Artificial Intelligence , Vol. 31, 1--4 (May 2001), 77--98.

Enric Galceran and Marc Carreras. 2013. A Survey on Coverage Path Planning for Robotics. Robot. Auton. Syst. , Vol. 61, 12 (Dec. 2013), 1258--1276.

References

Enrique González, Oscar Álvarez, Yul Díaz, Carlos Parra, and César Bustacara. 2005. BSA: A Complete Coverage Algorithm. ICRA (2005), 2040--2044.

Gilbert Laporte. 1992. The Vehicle Routing Problem: An overview of exact and approximate algorithms. European Journal of Operational Research , Vol. 59, 3 (1992), 345--358.

Chung-Lun Li, David Simchi-Levi, and Martin Desrochers. 1992. On the Distance Constrained Vehicle Routing Problem. Oper. Res. , Vol. 40, 4 (Aug. 1992), 790--799.

Raphael Mannadiar and Ioannis M. Rekleitis. 2010. Optimal coverage of a known arbitrary environment. ICRA (2010), 5525--5530.

Saurabh Mishra, Samuel Rodr'i guez, Marco Morales, and Nancy M. Amato. 2016. Battery-constrained coverage. In CASE. IEEE , 695--700.

Viswanath Nagarajan and R. Ravi. 2012. Approximation Algorithms for Distance Constrained Vehicle Routing Problems. Netw. , Vol. 59, 2 (March 2012), 209--214.

Iddo Shnaps and Elon Rimon. 2014. Online Coverage by a Tethered Autonomous Mobile Robot in Planar Unknown Environments. IEEE Trans. Robotics , Vol. 30, 4 (2014), 966--974.

Reference

Iddo Shnaps and Elon Rimon. 2016. Online Coverage of Planar Environments by a Battery Powered Autonomous Mobile Robot. IEEE Trans. Automation Science and Engineering , Vol. 13, 2 (2016), 425--436.

Grant P. Strimel and Manuela M. Veloso. 2014. Coverage planning with finite resources. 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems (2014), 2950--2956.

Minghan Wei and Volkan Isler. 2018a. Coverage Path Planning Under the Energy Constraint. In ICRA. 368--373.

Minghan Wei and Volkan Isler. 2018b. A Log-Approximation for Coverage Path Planning with the Energy Constraint. In ICAPS . 532--539.