Towards Autonomous Navigation and Assembly: Environment Modeling
Brandon Martinez, Bryan Rodriguez, Eli Zamora, Saurabh Mishra, Read Sandstrom, Nancy M. Amato

Project Setup
- Robot has a computer mounted on top which is in charge of seeing the markers and sending back their information.
- It is in charge of exploring the environment and ultimately assemble the boxes that form the A&M logo.
- Tested the robot with and without a plow to determine if results were affected.
- Markers have unique numbers and positions on the boxes and environment.
- Used for robot localization and positioning.
- Each contain programmed instructions for robot to follow.

Environment Markers:
- Each has a unique marker ID
- x, y and marker orientation information was inserted into a map for easy retrieval.
- Environment Markers: measured x & y coordinates of each marker from the origin.
- Object Markers: contain commands for object manipulation.

Environment Setup
- A total of 158 markers were placed throughout the environment and boxes.
- Each has a unique marker ID.
- x, y and marker orientation information.
- Plow vs. No Plow Centering Tests

What is Motion Planning?
- Motion Planning is the problem of finding a collision-free path from a start to goal configuration.
- Generates random samples to form a roadmap, then extracts the best valid path.

The Goal of the Project
- Use visual aid to localize the robot and boxes.
- Plan a path for the robot to take.
- Use robot to manipulate the environment.
- Recharge autonomously.

Method
- Able to successfully acquire data from the markers e.g., position of marker, distance and angle to the robot.
- Robot can successfully push a box forward a given distance with a margin of error under 5%.
- Robot can accurately compute the distance between two markers and wall.
- Robot uses trigonometric functions to center itself in front of the box, facing towards it.

Results
- Centering: Tested with different tolerances (acceptable range of alignment accuracy).
- Strict: Continuous adjustments reveal hardware issues.
- Relaxed: Software compromises accuracy to save time.
- Optimal: Point where hardware and software issues are least severe.

Moving a Box a Set Distance off Two Walls:
- Plow vs. No Plow
- As second operation, X Error decreased with plow.
- Unexpected inverse relationship between tolerance and error with plow.
- %Error & Time were reduced with plow.

Centering Tests
- Centering tested with different tolerances.
- Found that the optimal tolerance value is .25 because it balances hardware and software error.

Conclusion
We were able to localize, push, and dock with the robot. Performance improved by adding a plow and refining the tolerance value.

Future work includes extending this method to more complex scenarios with multiple objects and robots.

Acknowledgements
This research supported in part by NSF awards CCF-0833199, CCF-0551685, CCF-0830753, CCF-0916053, CCF-0917266, CCF-1016218, CCF-1016673, CCF-1016674, CCF-1016760, CCF-1016771, CCF-1016782, CCF-1217991, CCF-1340263, CCF-1354245, CCF-1423111, CCF-1439145, and by DOE awards DE-AC02-06CH11357, DE-NA0002376, B575363.


This research supported in part by the CRA-W Distributed REU (DREU) project.

Towards Autonomous Navigation and Assembly: Environment Modeling
Brandon Martinez, Bryan Rodriguez, Eli Zamora, Saurabh Mishra, Read Sandstrom, Nancy M. Amato

Project Setup
- Robot has a computer mounted on top which is in charge of seeing the markers and sending back their information.
- It is in charge of exploring the environment and ultimately assemble the boxes that form the A&M logo.
- Tested the robot with and without a plow to determine if results were affected.
- Markers have unique numbers and positions on the boxes and environment.
- Used for robot localization and positioning.
- Each contain programmed instructions for robot to follow.

Environment Markers:
- Each has a unique marker ID
- x, y and marker orientation information was inserted into a map for easy retrieval.
- Environment Markers: measured x & y coordinates of each marker from the origin.
- Object Markers: contain commands for object manipulation.

Environment Setup
- A total of 158 markers were placed throughout the environment and boxes.
- Each has a unique marker ID.
- x, y and marker orientation information.
- Plow vs. No Plow Centering Tests

What is Motion Planning?
- Motion Planning is the problem of finding a collision-free path from a start to goal configuration.
- Generates random samples to form a roadmap, then extracts the best valid path.

The Goal of the Project
- Use visual aid to localize the robot and boxes.
- Plan a path for the robot to take.
- Use robot to manipulate the environment.
- Recharge autonomously.

Method
- Able to successfully acquire data from the markers e.g., position of marker, distance and angle to the robot.
- Robot can successfully push a box forward a given distance with a margin of error under 5%.
- Robot can accurately compute the distance between two markers and wall.
- Robot uses trigonometric functions to center itself in front of the box, facing towards it.

Results
- Centering: Tested with different tolerances (acceptable range of alignment accuracy).
- Strict: Continuous adjustments reveal hardware issues.
- Relaxed: Software compromises accuracy to save time.
- Optimal: Point where hardware and software issues are least severe.

Moving a Box a Set Distance off Two Walls:
- Plow vs. No Plow
- As second operation, X Error decreased with plow.
- Unexpected inverse relationship between tolerance and error with plow.
- %Error & Time were reduced with plow.

Centering Tests
- Centering tested with different tolerances.
- Found that the optimal tolerance value is .25 because it balances hardware and software error.

Conclusion
We were able to localize, push, and dock with the robot. Performance improved by adding a plow and refining the tolerance value.

Future work includes extending this method to more complex scenarios with multiple objects and robots.

Acknowledgements
This research supported in part by NSF awards CCF-0833199, CCF-0551685, CCF-0830753, CCF-0916053, CCF-0917266, CCF-1016218, CCF-1016673, CCF-1016674, CCF-1016760, CCF-1016771, CCF-1016782, CCF-1217991, CCF-1340263, CCF-1354245, CCF-1423111, CCF-1439145, and by DOE awards DE-AC02-06CH11357, DE-NA0002376, B575363.


This research supported in part by the CRA-W Distributed REU (DREU) project.