Quadrupedal Robot Implementation in Collaborative Planning for Package Transportation

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Robots serve as a crucial tool for distribution centers where they are used to automate tasks traditionally done by humans. Uncertainties in robot coordination, sensor noise and limitations of traditional wheeled transport robots are some of the core challenges in a multi robot transport system. Our work entails implementing a quadrupedal robot with the aim to develop robust strategies to resolve uncertainties in both navigation and integration between robots. Specifically, this work concentrates on quadrupedal pathfinding, coordination between a manipulator and quadrupedal robot when distributing complex and diverse packages; and pathfinding under an unstable load. We are currently focusing on localizing and pathfinding within the developed pipeline.

Background

Traditional wheeled robots unable to respond to unstructured environments.

- Stairs
- Ledges
- Sharp Corners
- Low Friction Environments

[1] Fig. 1. Kiva Mobile Robot

Unitree's Go1 provides dynamic pathfinding capabilities due to locomotion algorithms and onboard sensors.

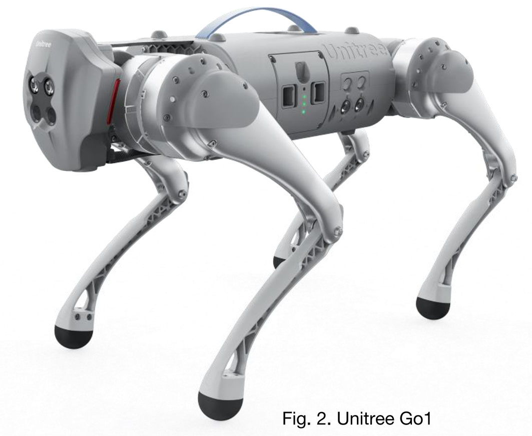


Fig. 2. Unitree Go1

Scheme of Operations

Three Stages

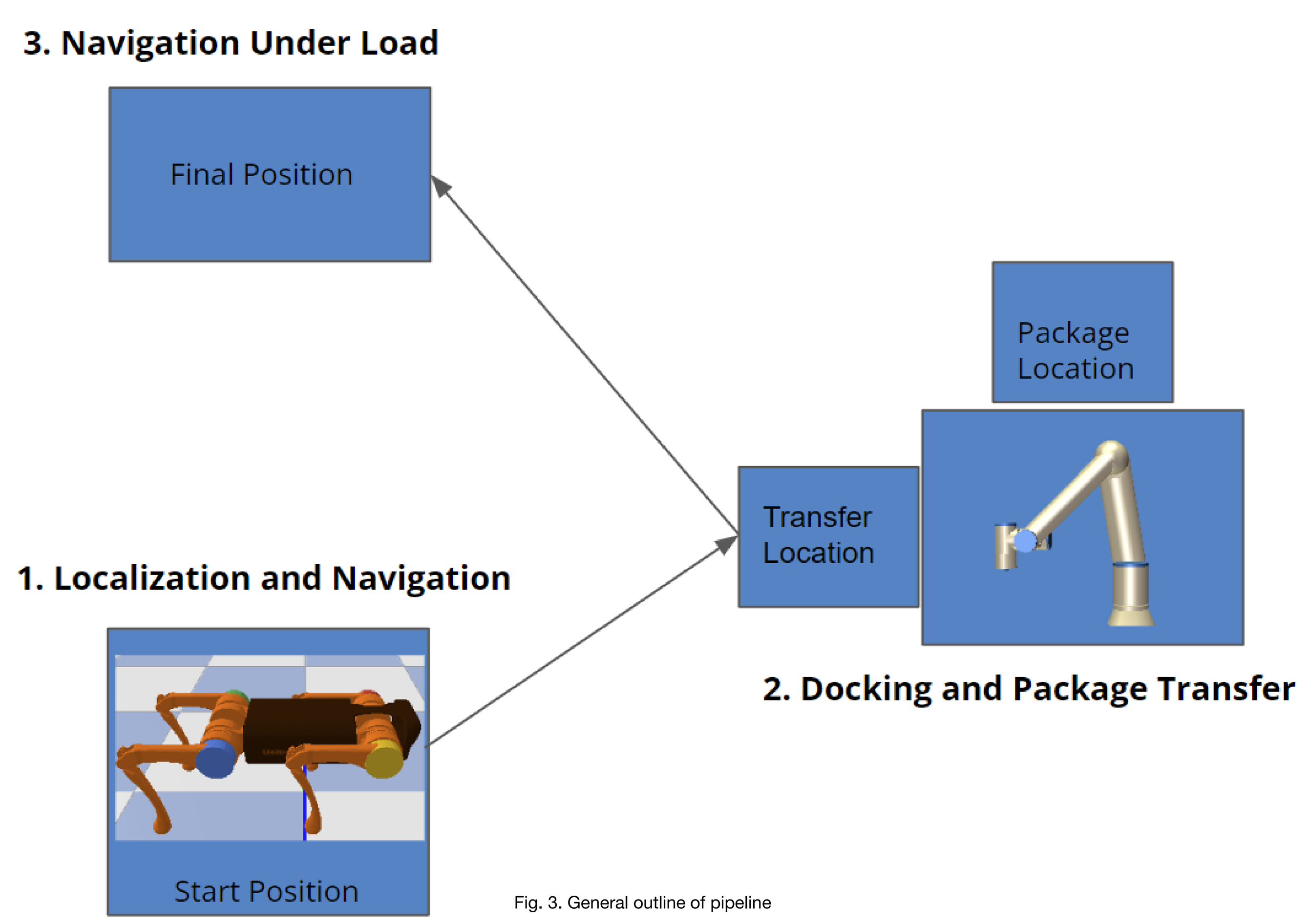


Fig. 3. General outline of pipeline

Methods: Localization and Navigation

1. Develop robust navigation algorithm within simulation:
   - Pybullet based simulation

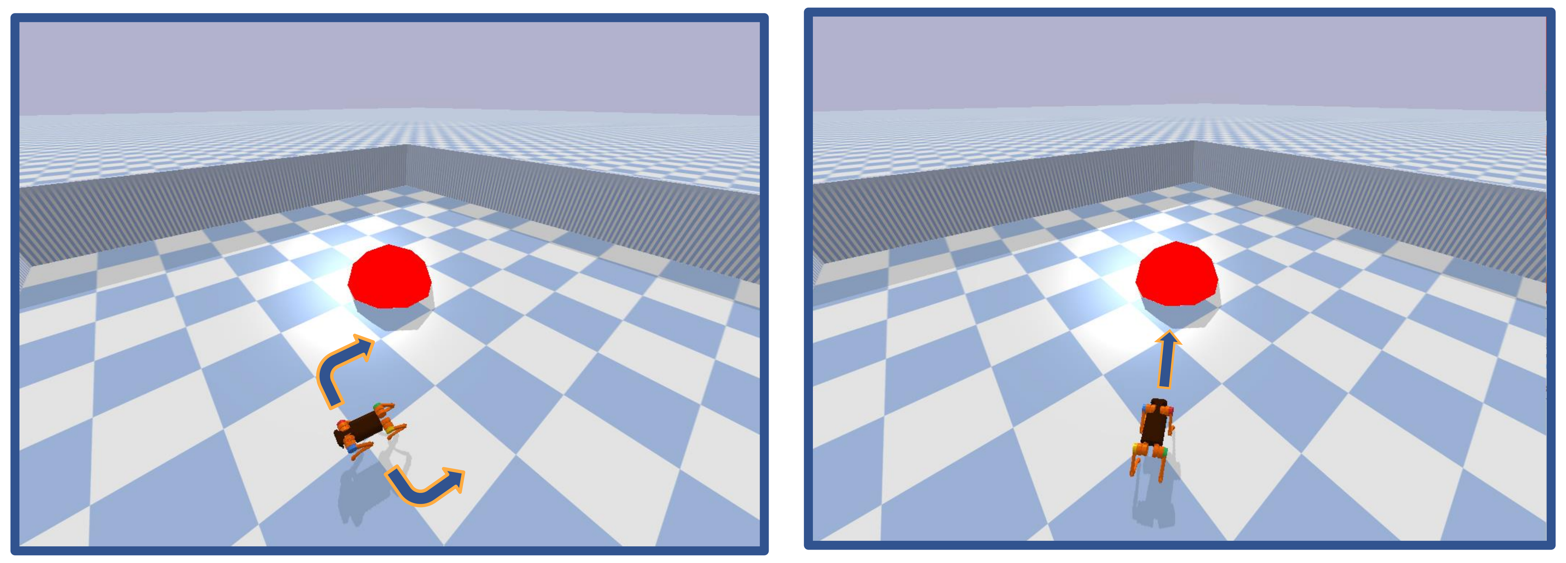


Fig. 4. PyBullet Simulation

2. Calibrate onboard front camera using checkerboard:
   - OpenCV Libraries
   - Unwrap image from sensor
   - Undistort image from sensor

Fig. 5. Raw checkerboard

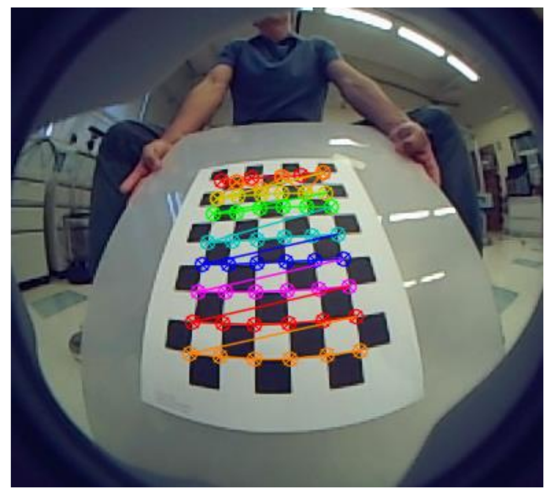
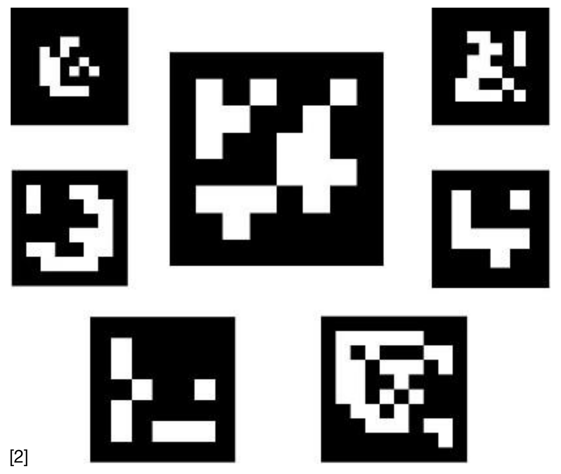
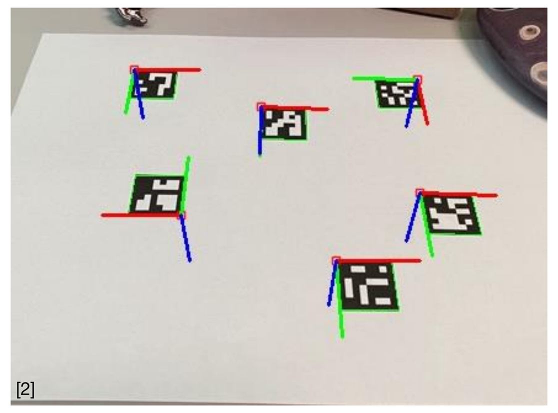


Fig. 6. Detected checkerboard

3. Use ArUco marker localization navigation:
   - Use distortion and calibration matrix for pose estimation



[2] Fig. 7. Raw ArUco Marker



[2] Fig. 8. Detected ArUco Marker

Results

- Navigation algorithm successfully localizes and moves to goal location
- Communication with Go1 camera via Robot Operating System (ROS)
- Calibration script successfully unwraps and undistorts Go1 images

Future Work

- Apply calibration data to pose estimation script
- Utilize pose estimation data for navigation controller
- Successfully localize and navigate robot from an unknown position to a goal location

References

[1] "Amazon Robotics Case Study," *Amazon Web Services, Inc.* https://aws.amazon.com/solutions/case-studies/amazon-robotics-case-study/ (accessed Aug. 05, 2022).

[2] S. Garrido-Jurado, R. Muñoz-Salinas, F. J. Madrid-Cuevas, and M. J. Marín-Jiménez, "Automatic generation and detection of highly reliable fiducial markers under occlusion," *Pattern Recognition*, vol. 47, no. 6, pp. 2280–2292, Jun. 2014, doi: 10.1016/j.patcog.2014.01.005.

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