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Teach and Repeat Navigation: A Robust Control Approach

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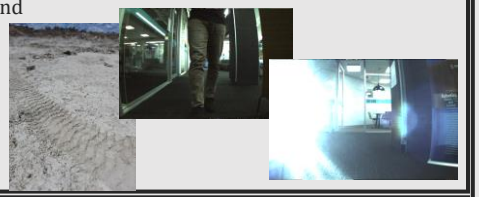
Motivation

Teach and Repeat (T&R): A navigation technique where the localization systems are not available either due to (1) cost/resource limitations or (2) operating environment.


[1] [2]

Motion Control is crucial to ensure a stable and repeatable T&R considering:

- Sensor noises (camera)
- Unmodelled parameters
- Uncertainties and variations in the scene
- Wheel-terrain interaction

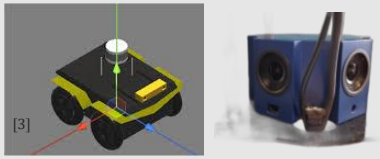


Contribution

We focus on the *motion control* system considering uncertainties in T&R navigation indoors and outdoors.

Sensors: wheel odometry + a low-resolution monocular camera

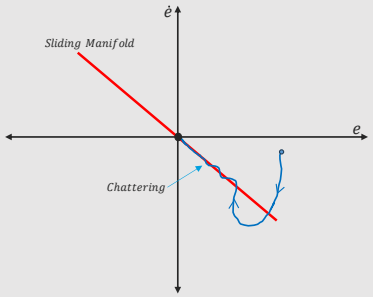
- To deliver reliable and repeatable performance in different conditions
- Evaluate the performance of the proposed framework in indoor and outdoor terrains
- A step towards long-term autonomous T&R navigation


[3]

Goal

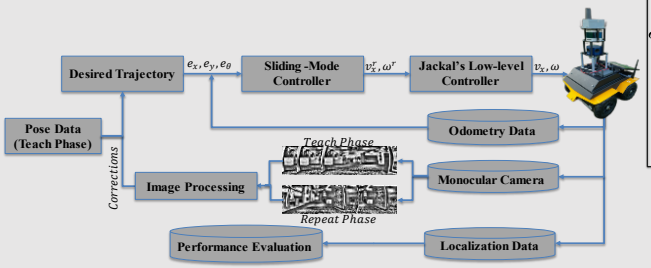
Achieving Robust and Globally Stable T&R

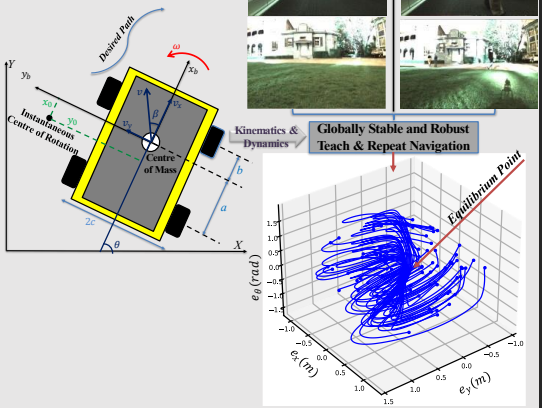
Regulate e_x and e_y and their time derivatives ($\dot{e}_x$, $\dot{e}_y$), ±25% variation in the robot's dynamic + unmodelled uncertainties



Method

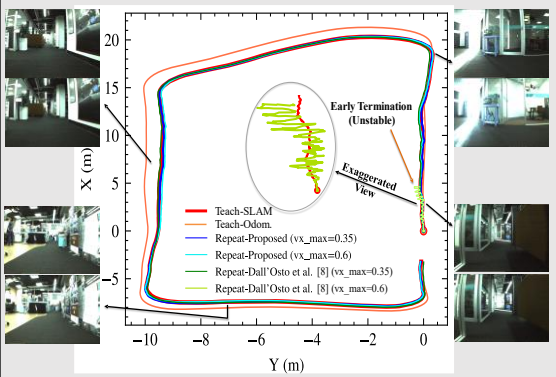
Sliding-Mode Control + Motion Planning using image processing technique to steer the robot in the repeat phase whilst compensating for wheel odometry drifts and errors.



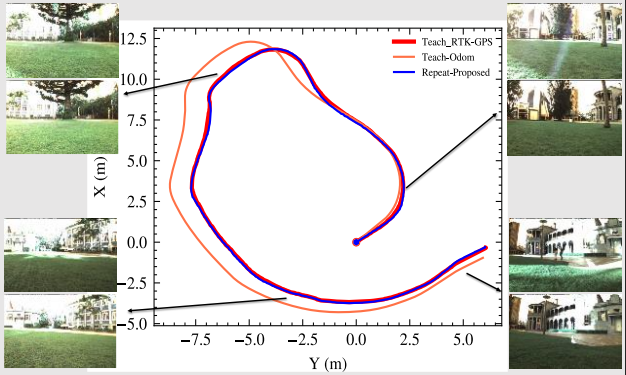


Results

Indoor and outdoor testing on carpeted floor and wet grass.



Method	mae			Mean dist.	Stability
	X	*Y*	*θ*		
Dall'Osto et al. [8]	0.020	0.038	0.70	0.051	Unstable
Proposed	0.015±0.014	0.018±0.016	0.86	0.027	Stable



Method	mae			Mean dist.	Stability
	X	*Y*	*θ*		
Dall'Osto et al. [8]	-	-	-	-	Unstable
Proposed	0.028±0.023	0.032±0.028	0.74	0.046	Stable

References

[1] URL: https://clearpathrobotics.com/blog/2022/01/european-institute-of-technology-improves-mine-safety-with-intelligent-inspection-robot/.
[2] Vasavada AR. Mission Overview and Scientific Contributions from the Mars Science Laboratory Curiosity Rover After Eight Years of Surface Operations. Space Sci Rev. 2022;218(3):14.
[3] Platt, J., Ricks, K. Comparative Analysis of ROS-Unity3D and ROS-Gazebo for Mobile Ground Robot Simulation. J Intell Robot Syst 106, 80 (2022).

Acknowledgments

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