Roverside Assistance: Rescuing Rovers on Remote Planets

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**MOTIVATION**
Most autonomous ground vehicle systems that exist today are designed around a single rover. While this is simpler and cheaper to field, solitary robots are limited in the areas they can explore due to the unacceptable risk of a robot getting trapped in a difficult to navigate terrain. Extraterrestrial rovers are also constantly at risk of entrapment for a host of other reasons. A real life example of this is the Mars Spirit rover, which became permanently stuck after driving over a thin crust of normal looking dirt on top of very soft sand.

**RESULTS**

- **Entrapment Detection**
  - Measuring the probability of entrapment by incorporating divergence (between wheel odometry and reference odometry) and rover movement status using Bayesian process.
  - Benefits of using a probabilistic approach:
    - Both status and confidence level become accessible.
    - The detector is then more robust to noise.

- **Docking with Claw Manipulator**
  - Docking requires accurate relative position measurement between the two rovers. This measurement is taken by the HTC Vive Tracker. This provides positional accuracy within 5mm and rotational accuracy within 10°, and a range of 6m, all sufficient for reliable docking.

- **Robot Localization & Navigation**
  - With the claw manipulator always pointing its end effector (the claw) towards the companion rover’s ring, the docking mechanisms of the rescue rover and the entrapped rover shall passively dock, when the rescue rover approaches the entrapped rover.

- **State Machine**
  - The rovers use state machine library SMACH to control the high level actions of the robot. The state machine allows for the disruption or failure of any part of the towing process. The rovers will replan and reattempt the rescue operation until the entrapped rover is freed.

**SYSTEM ARCHITECTURE**

**Dynamic Mapping**
To detect environmental obstacles the rovers build a point cloud of their environments using the Intel Realsense D435 depth camera. From the point cloud surface normals are estimated and used to detect high slope features in the terrain. These features are then labeled as obstacles in the map and avoided by the path planner.

**CONCLUSIONS**
- Simple control strategies free rovers from many orientations in rough terrain.
- Highly robust hardware is required.
- Accurate relative localization is required for docking.
- Coordination between robots is essential - one robot generally cannot generate enough force to free another robot of similar mass.

**PROJECT DESCRIPTION**
This project demonstrates the capability of a two rover system to recover from high centering entrapment events. Because the target systems experience significant time delays that render direct human control infeasible, this system demonstrates autonomous recovery behavior.

**References**