Research on the Perception and Decision of Legged Robot

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Introduction

By the development of new technologies such as computer technology and microelectromechanical system technology, the research on legged robot has been gradually processed aiming at utilizing robots to replace humans in hazardous operations, logistics and other tasks. Legged robots have more advantages than wheeled and crawler robots, such as having more degrees of freedom, more flexibility and greater adaptability. The research field on the legged robot should not be limited to the research on legged dynamics, but also should include the study of perception and decision abilities. The ability of percepting the surrounding environment, which can be achieved by computer vision algorithms and sensor fusion technology, has played an important role in realistic missions based on legged robots. This is the perception and decision research part of the whole legged robotics project. Our goal is tracking the interested moving target.

Functional Modules

We design four modules to deal the perception and decision task. They support mutually and work together named as target tracking module, global localization module, region detection module and path planning module. The illustrations are as follows:

1) Target tracking module:

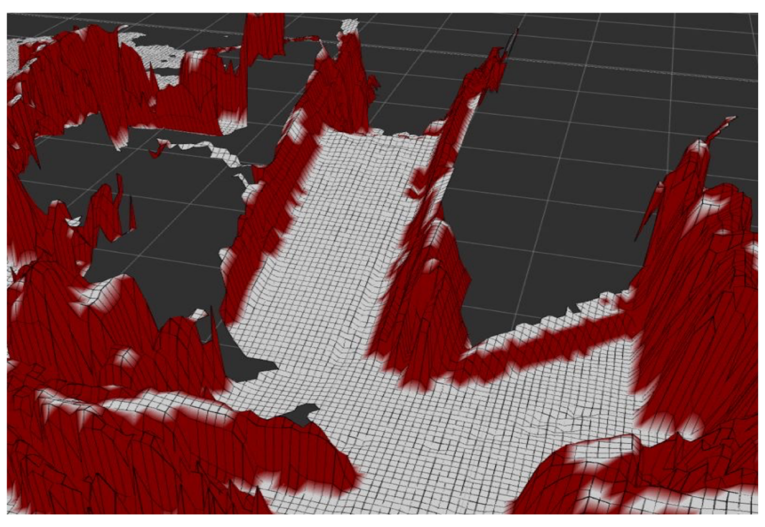
This module is the most basic part of the whole research. A robust target tracking algorithm can achieve the continuous interested target tracking. At present, we adopt a 3D tracking strategy based on LiDAR point cloud data to realize a stable tracking performance under highly dynamic scenarios.

2) Global localization module:

This module plays an important role in the entire target tracking and path planning mission. We use LiDAR as the point cloud acquisition sensor, and rebuild a high-precision point cloud map by matching point cloud features. Based on this prior map, we design an algorithm to realize the robust global location of the legged robot utilizing the LiDAR and IMU.

3) Region Detection module:

Based on the stable global location information, We can rebuild the robot-centric local terrain using a realsense D435 camera, which can generate the 3D point cloud by matching the features of stereo images. The elevation of surroundings and other information are used to display the 2.5D gridmap[1]. After obtaining the elevation distribution information of the terrain, according to the elevation distribution of various regions, the walkable area and the spatial position of the obstacles are divided, which can be used in the later path planning module. **Note we have not jointed this module with the path planning module as it is still under research.** A piece of rebuilt terrain is demonstrated as in the figure below:



where the walkable area is in white and obstacles are coloured in red.

4) Path Planning module:

This module includes global and local path planning. We search the map for a shortest path from the starting point to the target location in global planning. For the local planning, we further consider dynamic obstacles in the environment, establishing a robot-centered costmap and planning an optimal collision-free dynamic trajectory in real time.

References

[1] Fankhauser, Péter and Bloesch, Michael and Hutter, Marco, "Probabilistic Terrain Mapping for Mobile Robots with Uncertain Localization," *IEEE Robotics and Automation Letters (RA-L)*, vol.3, no.4, pp.3019––3026, 2018.

Project Equipment

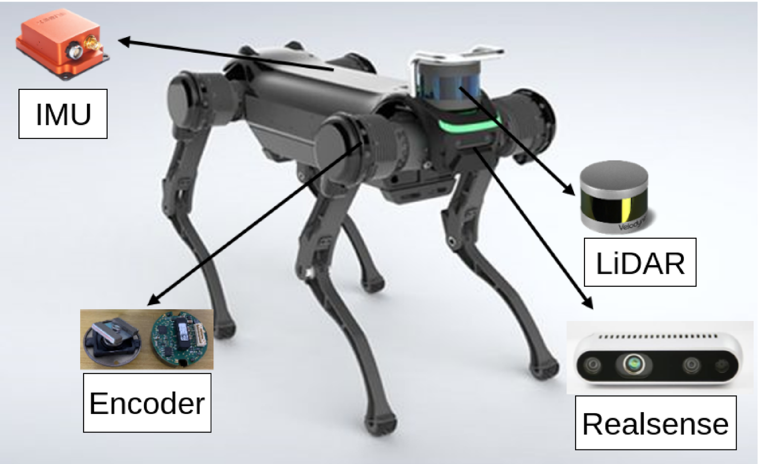
To the right we show the main equipment involved in our project, which allows us to process our research on. Facilities in the figure:

Upper-left: IMU. To measure rotation rate and accelerated velocity, making the global localization module and tracking module more robust.

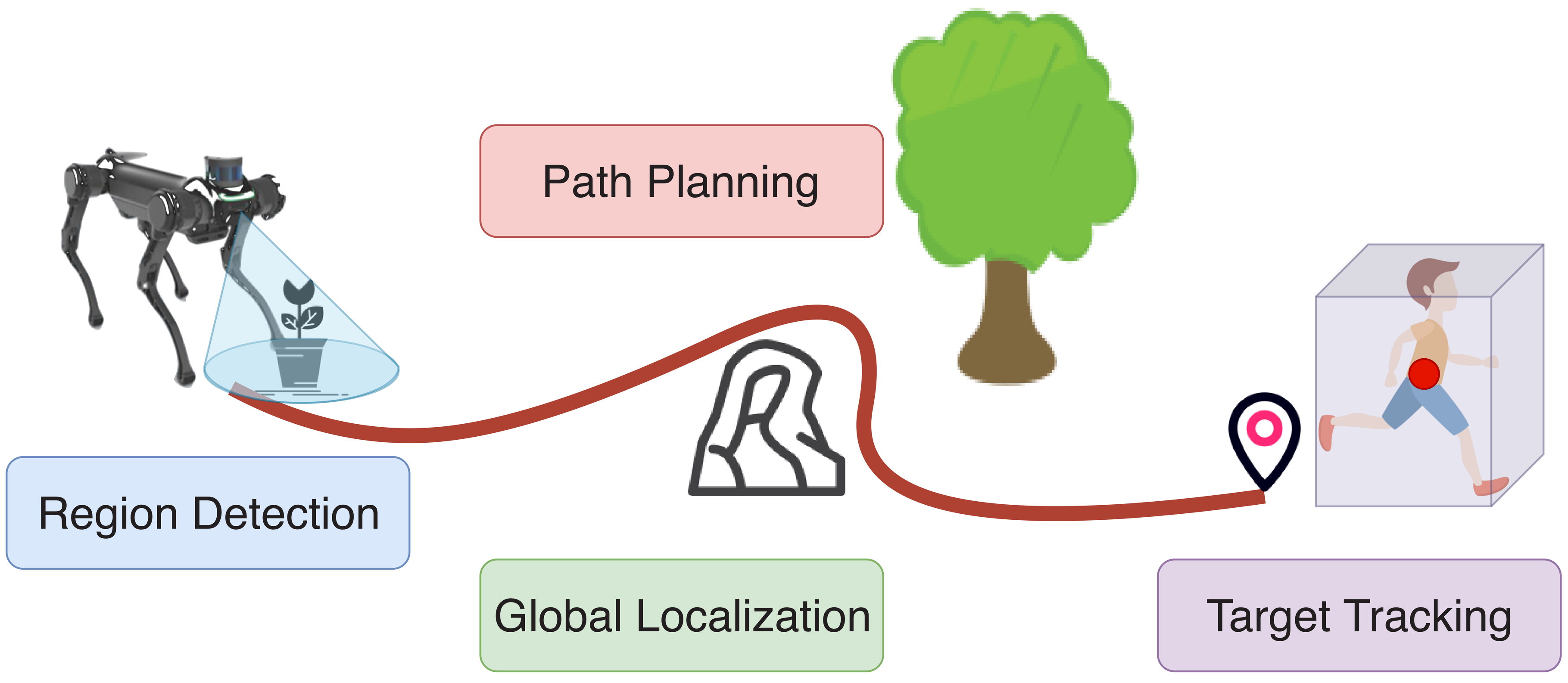
Upper-right: LiDAR. To percept surroundings by generating point clouds, using in the global localization module, tracking module and path planning module.

Lower-left: Encoder. To acquire the movement information of joints on robot legs, may using in the future modules.

Lower-right: Realsense D435. A module integrating a infrared equipment, a pair of stereo single channel cameras and a RGB camera, using in the region detection module to percept obstacles on the ground.



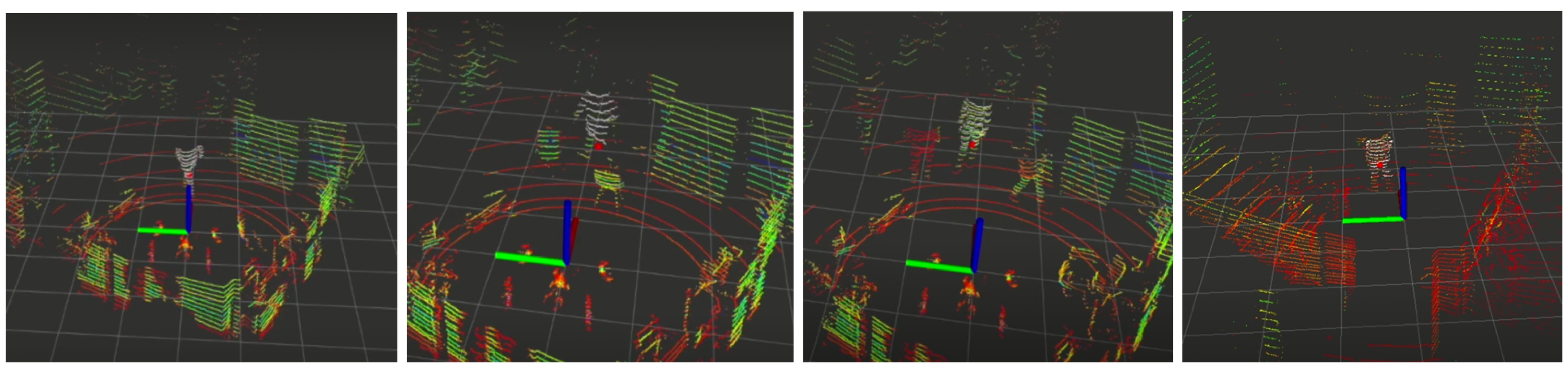
Present Results



The figure above shows our pipeline. Our present performance of each module is demostrated as follows:

1) Target tracking module:

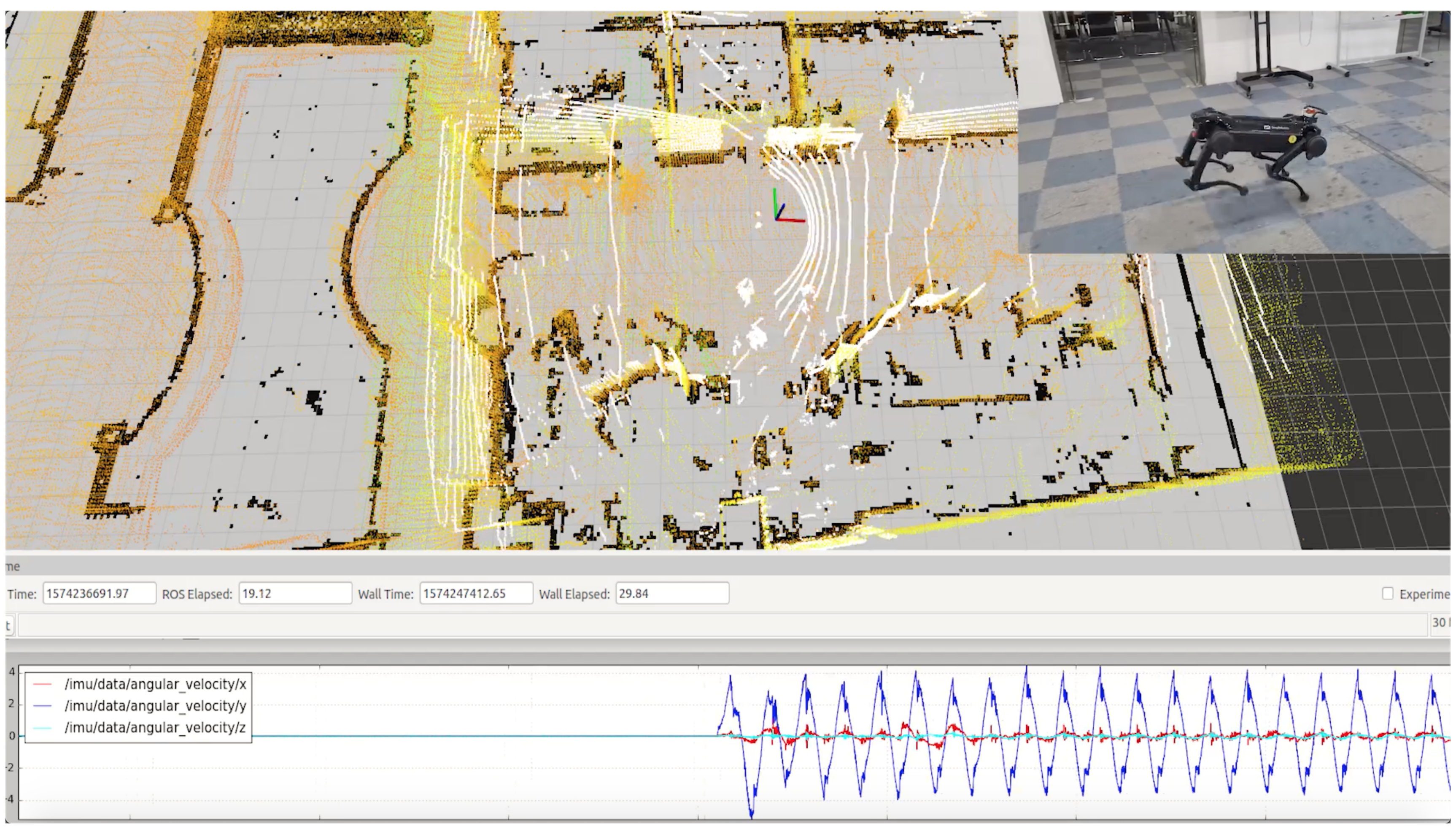
We show the present perfomance of tracking module under various circumstances including four parts.



First: An example of scenes full of obstacles.
Second: An illustration of scenes existing many active people.
Third: An instance that the robot keeps station.
Last: An exemplification for both robot and target staying dynamic state.

2) Global localization module:

We test the performance of localization module in a prior builded point cloud map when the quadruped robot is in the galloping mode.



Note that the pitch angular velocity rate is up to 4 rad/s, which is coloured in blue.

3) Path Planning module:

For present, we search the planning path based on the costmap and detect obstacles utilizing the old version of region detection module judging a object, which is higher than a certain height on z-axis, as an obstacle. We test the quadruped robot in the trot mode.