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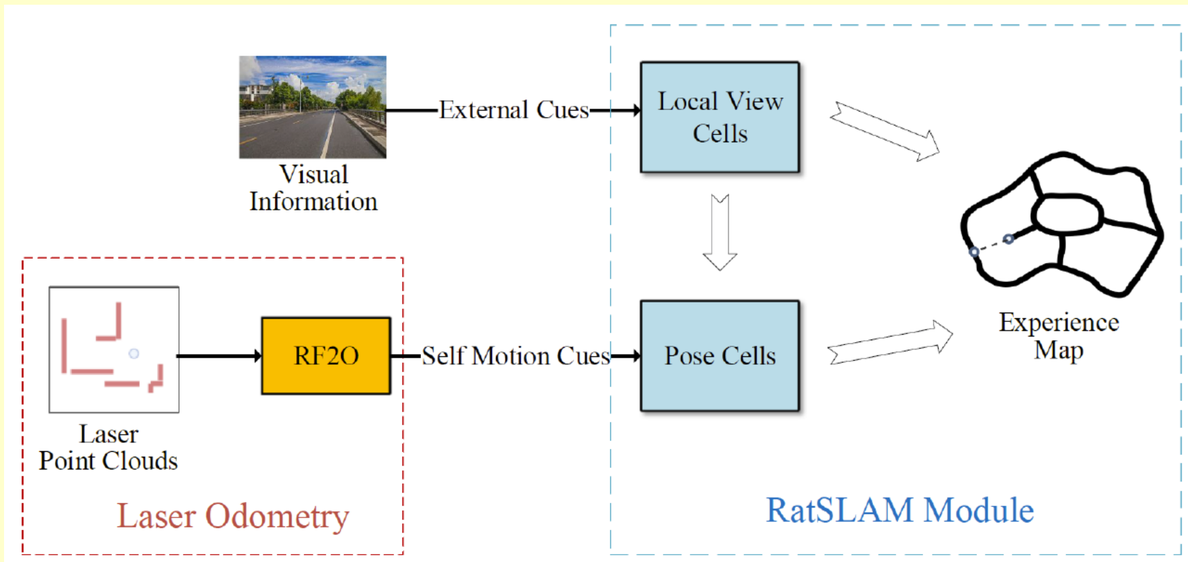
A Bio-inspired SLAM System for a Legged Robot

Jiazhe Guo, Maotong Cheng, Jiayi Ren, Qinyuan Ren
College of Control Science and Engineering
Zhejiang University

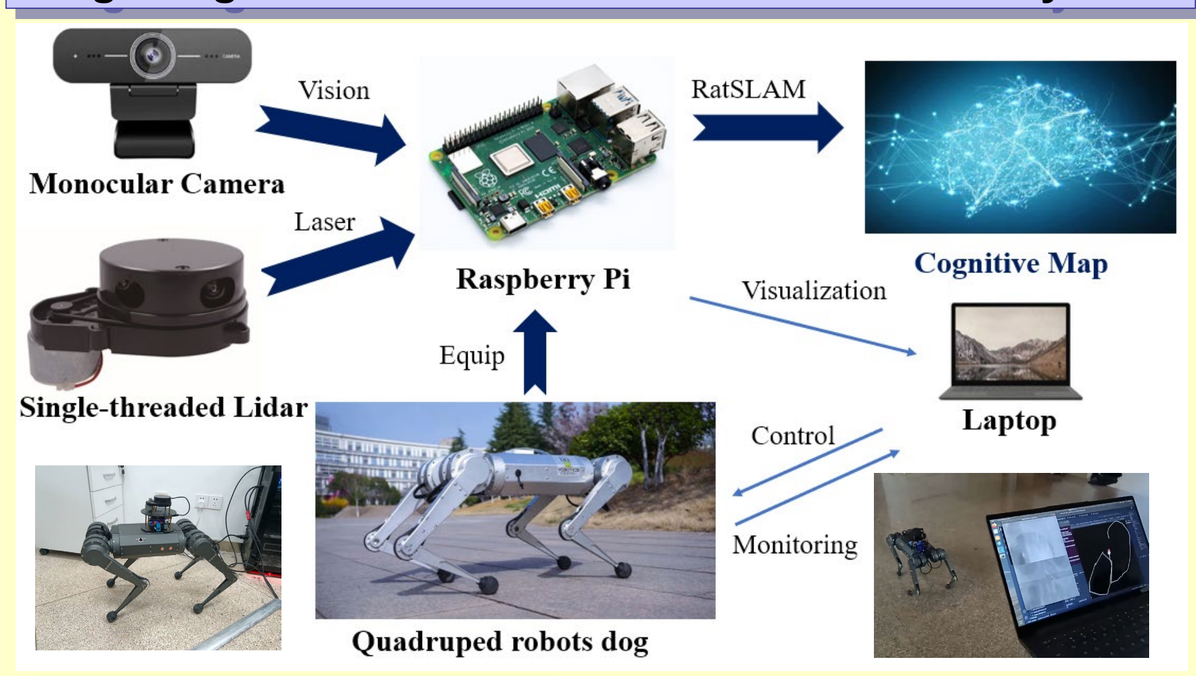
Backgrounds

1.Legged robots have strong adaptability
2.Animals do not need to rely on high-precision sensors
3.Visual only RatSLAM has bad performance on legged robots

Framework



Integrating Visual Information and Laser Odometry

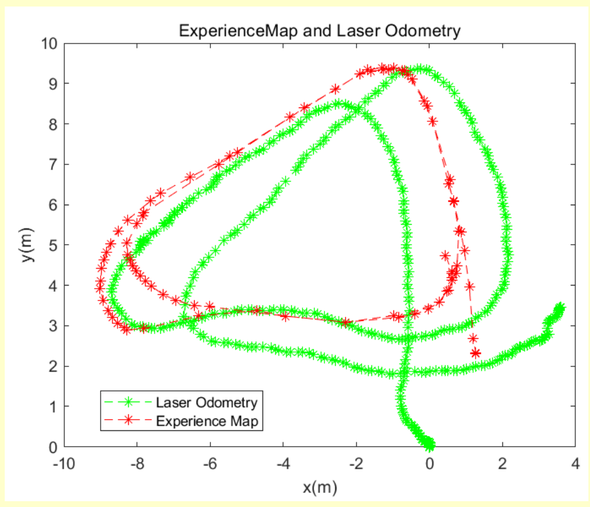


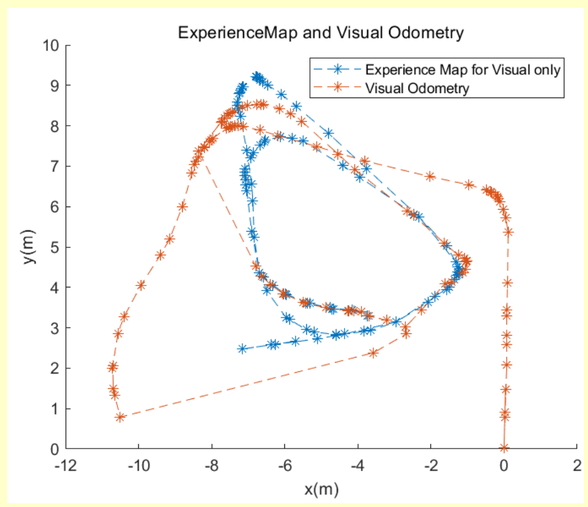
Platform Configuration

This work's idea is to combine bionic robot with bio-inspired SLAM system. This method fuses visual and lidar information, using RF2O as laser odometry. The frequency of lidar data used is 5Hz and this system only utilizes 2 frames of image data per second to minimize computational overhead. This work take advantage of the biological characteristics to provide a low-cost and reliable SLAM system for legged robots.

Pose Cells: use Continuous Attractor Networks (CAN) to encode the pose of a robot (x', y', θ'). It is updated by the self motion cues (laser odometry).
Local View Cells: an expandable array of units, representing external scene V_i. When a robot sees a new sense, a new local view cell is created.
Experience Map: topological map, representing markers
Every experience is described as:$e_i = \{P^i, V^i, \boldsymbol{p}^i\}$
Score for difference between current experience and stored experience is used to detect loop closure.
Range Flow-based 2D Odometry (RF2O): use range flow constraint equation.

Experiment Results





The Experiment Result of Combining Camera and Lidar

The Experiment Result of Pure Visual RatSLAM

The quadruped robotic dog walks along similar but not the same indoor route. In the left figure, laser odometry (green line) shows the drift during the experiment. The red line represents the robot's final localization estimate after vision correction and closed-loop detection. It shows that this bio-inspired SLAM system provides a topologically consistent representation. In the right figure, owing to the vibration of legged robot and low frame rate of the camera, this simple visual odometry drifts severely, leading to the low state estimation accuracy. From another point of view, RatSLAM can obtain a good map representation from drifting odometry through the calibration of local view cells, which reflects the robustness of this bionic system.

Summary

This paper proposes a bio-inspired SLAM system for a legged robot, using an industrial monocular camera and a single-threaded lidar instead of expensive sensors. This method fuses information from multiple sensors based on RatSLAM. Experiment platform is based on a quadruped robot dog, This work is also compared with pure visual SLAM and pure laser SLAM algorithms, in order to exhibit the robustness and superiority of the bionic SLAM algorithms for legged robots. This system provides a reference for the use of bionic algorithms on bionic robots.