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LATERAL COLLISION DETECTION FOR MOBILE ROBOTS

HP INC

Lateral collision detection for mobile robots

Abstract

A system for accurately detecting lateral collisions with an obstacle is introduced. When a mobile robot rotates, it might collide with a wall or pillar it had not seen before. With this system, the collision can be detected, and a recovery manoeuvre performed, minimizing physical damage to the robot and downtime, without user intervention. Otherwise, the robot would get stuck trying to move to the next target, requiring manual intervention. Finally, when a collision is detected, the obstacle position and orientation can be estimated, and this information can be saved for future use (such as mapping).

Disclosure

This disclosure relates to the field of mobile robotics, specifically differential wheeled robots that operate in an environment with obstacles.

A system for detecting lateral collisions with unknown physical obstacles is disclosed. This system involves processing the orientation measurements from an Inertial Measurement Unit (IMU), or a similar sensor.

For mobile robots, it is usually not feasible to include safety sensors that point to its left and right sides. Due to cost and complexity reasons, unmanned vehicles that move on a flat surface usually have one sensor in its front side, or an additional one on its back. However, this means that, when the robot rotates, it might collide with an obstacle that it hadn't been able to detect before.

Even if the robot has prior knowledge of the position of obstacles (such as pillar and walls), this knowledge could be incomplete or wrong. In such case, if the robot is positioned along an obstacle (Fig. 1), it might not be detected by the front/back sensors, thus the robot would crash with the wall while rotating. If the robot is not able to arrive to its target orientation, it might get stuck and halt. It is therefore needed to implement a system to detect such collisions and act accordingly.

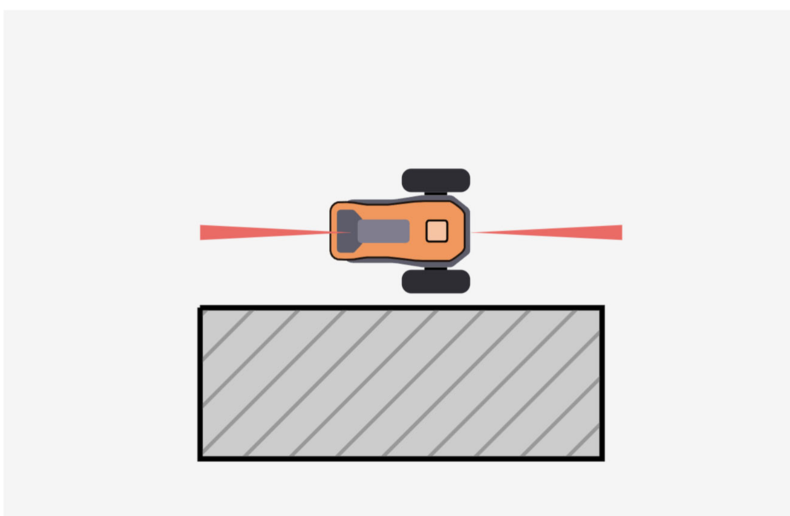

Figure 1. Robot positioned in parallel to a wall that is not being detected by its safety sensors.

Prior solutions exist that minimize the probability of collision. The most complex one involves accounting for obstacles when rotating even if no sensor is detecting the obstacle, if it's thought to be there from previous mapping, the robot could rotate and move away from it. However, this requires previous knowledge of obstacle position, and would not prevent collision with unexpected obstacles.

In general, a system that prevents all collisions with obstacles is unfeasible. Instead, the following idea focuses on collision detection and recovery maneuver. It requires the use of an Inertial Measurement Unit (IMU) able to output timestamped angular velocity data (ω). The angular velocity around the Z axis (perpendicular to the ground and positive up) is then introduced in a filtered derivative module [1], that computes an angular acceleration (a) and can work with noisy sensor measurements. Then, the absolute value of the angular acceleration is compared with a predefined threshold; if it is larger than the threshold, then a potential collision has been detected. To discard false positives, two additional checks are performed: first, the absolute value of the angular velocity must be above another predefined threshold (meaning the robot is rotating and not stopped); second, the angular acceleration and the angular velocity must have different signs (the rotation was decelerated). If both checks pass, then a collision event is sent. The complete system is represented in Fig. 2.

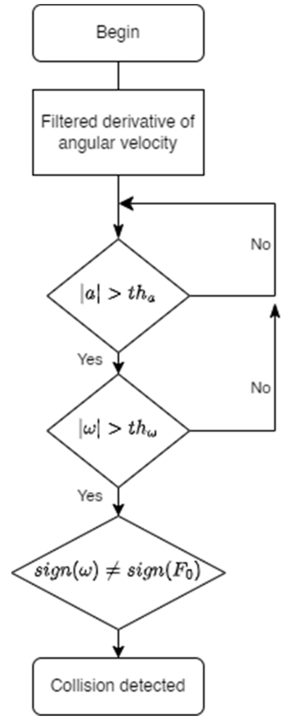

Figure 2. Flow chart of the collision detection system.

The second part of the proposed idea is the recovery maneuver. If the angular acceleration is positive, a left collision has occurred; otherwise, it is a right collision. First, the robot is rotated 135° counterclockwise if there was a left collision, or clockwise if it was a right-side collision. This angle is selected so that the robot will be approximately pointing towards the obstacle. Finally, the robot is told to move backwards a distance that will depend on its physical size. Then the robot is free to rotate and move to its next target. Plus, the obstacle is added to the internal robot map so that it is accounted for in the future and further collisions are avoided. The distance to the obstacle can also be estimated with the angle that the robot had already rotated before the collision happened.

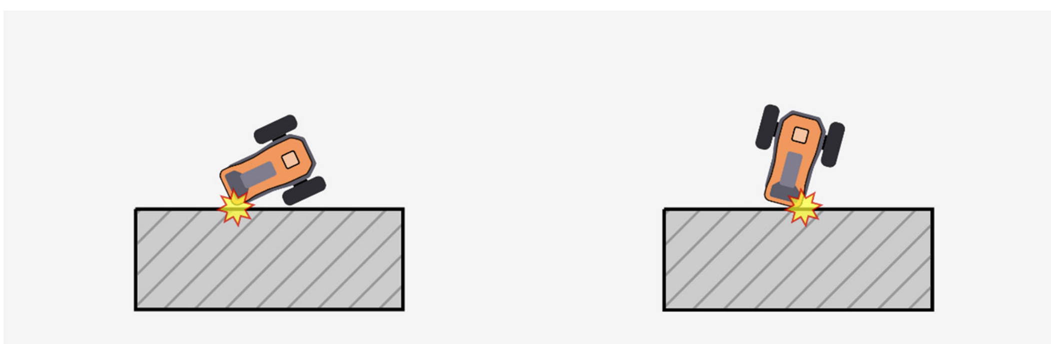

Figure 3. On the left, robot is very close to a wall and collides with it while rotating. On the right, robot is far from the wall and, while rotating, barely touches it. In both cases, it is a right collision.

References

[1] Julius O. Smith. Introduction to Digital Filters with Audio Applications. W3K Publishing, http://www.w3k.org/books/http://www.w3k.org/books/, 2007.

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