Real-time Nonlinear Predictive Control for Human-Quadrupedal Shared Environments

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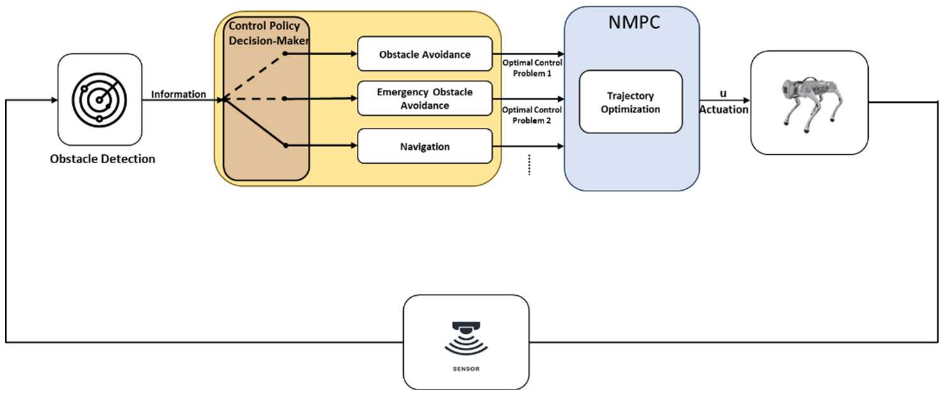
Introduction: Navigation and obstacle avoidance are two important maneuvers for autonomous robots, especially in robot-human shared environments. Effective obstacle detection and avoidance algorithms can enhance the capabilities of mobile robots in real-time obstacle avoidance in dynamic environments, reducing the risk of collisions. To this end, this article proposes a real-time nonlinear predictive control framework for a quadruped robot model.

Objectives: The objectives of this article is to design effective obstacle detection and avoidance algorithms, and integrate them into an MPC framework, testing and evaluating them through simulations in different scenarios. In the end, the proposed framework will be applied to a real physical quadruped robot.

Methodology: We present a novel dynamic collision prediction method based on *velocity obstacles* (VO), and employ VO to generate a smooth artificial potential field by convolving with a Gaussian filter as the obstacle avoidance constraint, as a comparison, we also tested the traditional position-based potential field method in our experiments. To generate collision-free paths in real-time by solving trajectory optimization problem, we utilize a numerical method, the direct method, to convert high-dimensional optimization problems into low-dimensional nonlinear programming. The overall proposed architecture is illustrated in the following diagram:



Findings: The experimental video clips are accessible at here. The experimental results indicate that in the designed scenarios, the proposed obstacle detection algorithm can effectively detect the interaction states between the robot and obstacles. Generally, the avoidance trajectories generated by this NMPC framework with the velocity-based obstacle potential field constraint are smoother than those with the traditional artificial potential field constraint (due to the predictive nature of obstacle velocity). The average NMPC computation time is 9.9 ms, which meets the requirements of real-time systems.