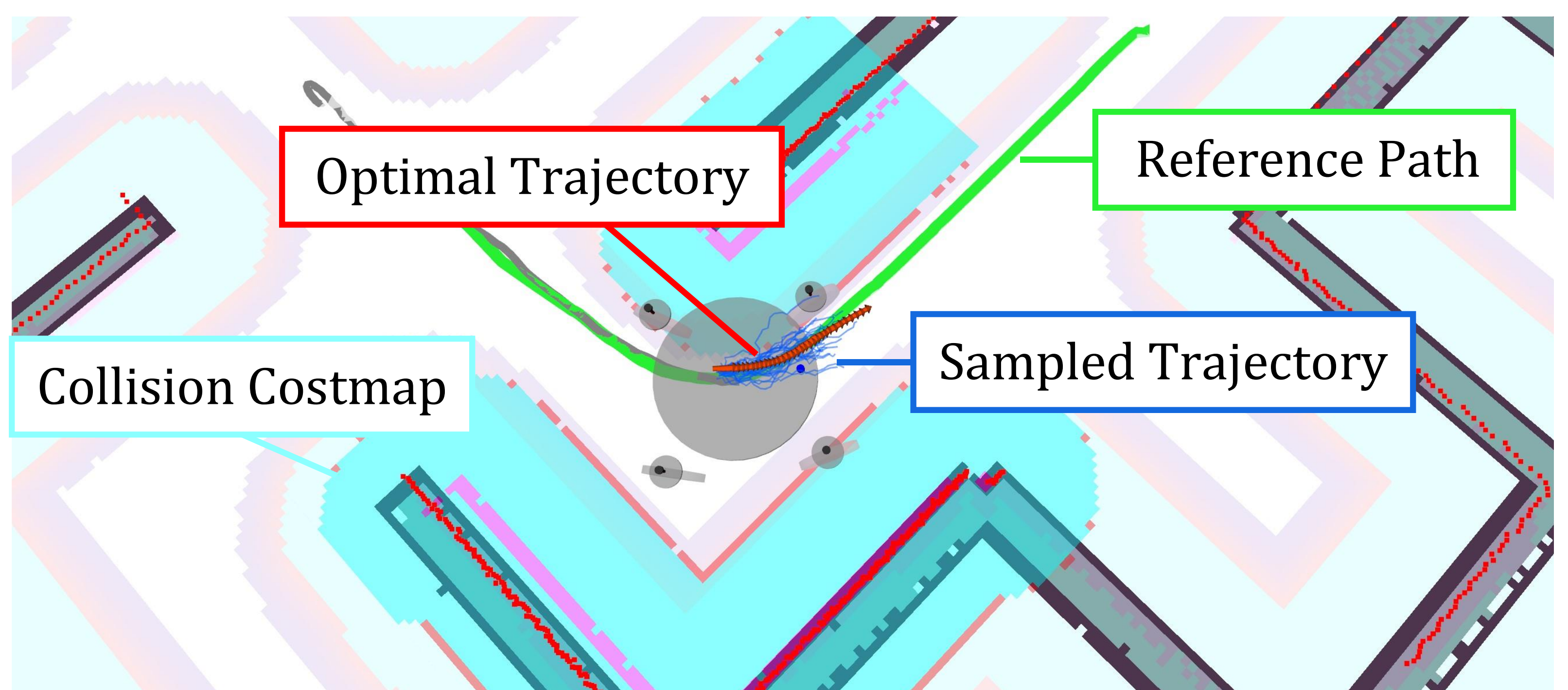


Switching Sampling Space of Model Predictive Path-Integral Controller to Balance Efficiency and Safety in 4WIDS Vehicle Navigation

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Take Home Messages

- Selection of sampling space for MPPI has a significant impact on its optimality.
- Switching sampling space depending on the real-time situation improves performance.



1 Issue

4WIDS vehicle has 8 Degrees of Freedom.

Steering angles: $\delta_{fL}, \delta_{fR}, \delta_{rL}, \delta_{rR}$
 Wheel velocities: $V_{fL}, V_{fR}, V_{rL}, V_{rR}$

To explore high-dimensional optimal input with MPPI, selecting proper sampling space is essential to ensure solution quality.

2 Approach

Among several sampling spaces tested, the two best options are selected.

3D space and 4D space

Let's find which strategy works best.

- [MPPI-3D] Always use 3D space
- [MPPI-4D] Always use 4D space
- [MPPI-H] Hybrid use of 3D space and 4D space

3 Result

Switching sampling space in real-time (MPPI-H) result in better driving behavior.

	Quickness	Safety
MPPI-3D	😊	😞
MPPI-4D	😞	😊
MPPI-H	😊	😊

What is MPPI ?

Model Predictive Path-Integral Control (MPPI) is a sampling-based optimal control algorithm.

Randomly sampling control input sequence of the near future, and compute the cost value to be minimized for each sample.

The better (i.e. less costly) samples are assigned larger weights, and obtain the optimal solution as weighted sum of the samples.

Wide range of applicability by gradient-free algorithm. (PROS)

Bad selection of sampling space leads to poor solution quality. (CONS) (i.e. proposal distribution)

Architecture of Switching Sampling Space

3D space ... Minimum dimensional space to express vehicle motion without tire slip

4D space ... Redundant dimensional space to express vehicle motion without tire slip

Switching according to real-time conditions

Vehicle Command

Converting sampled state to vehicle command

Trajectory Comparison

Example Scenario

Initial Pose, Goal Pose

MPPI-3D: Large Turning Radius, Close to Collision

MPPI-4D: Turn in Place

MPPI-H: MPPI-3D is Active, MPPI-4D is Active, Turn in Place

MPPI-H can safely turn the vehicle (strength of MPPI-4D), achieving quick driving in open areas (strength of MPPI-3D).