Motion Primitives Design

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First, we define 3 angular velocities to apply: HL(Hard Left), SL(Soft Left) and HR(Hard Right), SR(Soft Right) and N(No turn). Second, we define 3 velocities to apply: A(acceleration), H(hold current speed), D(deceleration). Therefore, we have totally 15 motion primitives for each state. However, depending on the current state and the actual motor of the robot, some of the motion primitives may not be feasible. In Figure 1, we list the parameters we used in the experiment.

Here, we give a demonstration of how to get the control parameters ω and v. Let's say the robot is currently in a state with the linear velocity v_c and angular velocity ω_c, and we want to get the two parameters of the motion primitive that consist of linear velocity A along with angular velocity SL. To get the velocity v, we need one additional parameters v_{max} (which is the maximum velocity of the robot, for pioneer, it is $1.2m/s$) . Then we can get v by the following formula.

$$v = \min(v_c + 300 \times \delta t, v_{max})$$

We can get angular velocity by the following formula.

$$\omega = \omega_c + (\pi/8) \times \delta t$$

Analogously, we then can get the control parameters of all other motion primitives.

With the ω and v on hand, we now can simulate the position of the robot in next state by applying the following formula. Figure 2 gives a example of the simulated states(red dots) along with its motion primitives(black curve).

$$\begin{aligned}\dot{x} &= v\cos\Phi \\ \dot{y} &= v\sin\Phi \\ \dot{\Phi} &= \omega\end{aligned}$$

As the project going, we may extend our motion primitive based on the planner's capability and the physical limitation of Pioneer robot. We find the rotation speed of Pioneer is $300^\circ/s$; this will be the limit of the hard turns. We may also extend linear velocity to fast and slow. Then, because of the safety reason, we may forbid the motion primitive with both hard turn and fast speed.

SL	$\pi/8$	rad/s^2
SR	$-\pi/8$	rad/s^2
HL	$\pi/4$	rad/s^2
HR	$-\pi/4$	rad/s^2
N	0	rad/s^2
A	300	mm/s^2
H	0	mm/s^2
D	-300	mm/s^2
δt	250	millisecond

Figure 1: Motion primitives' parameter.

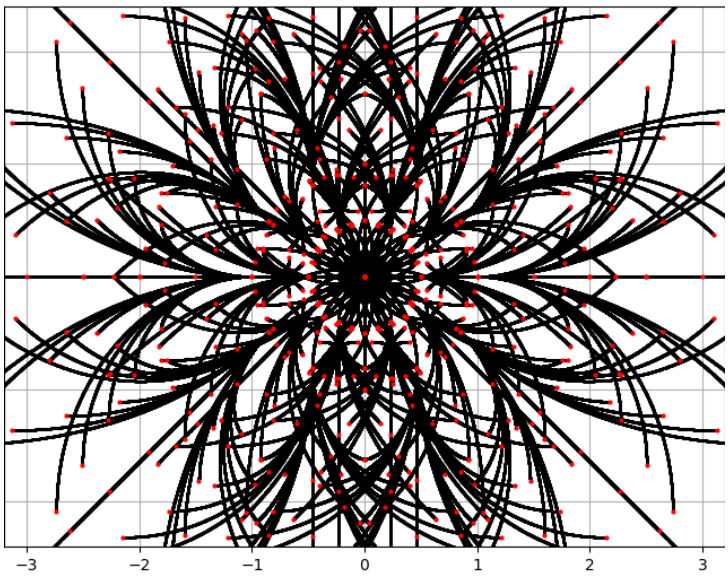

Figure 2: The example of the motion primitives. The red dots are the states, the black lines/curves are trajectories between states.