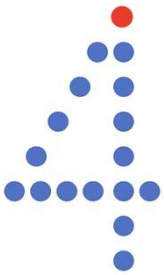
SEMTRON

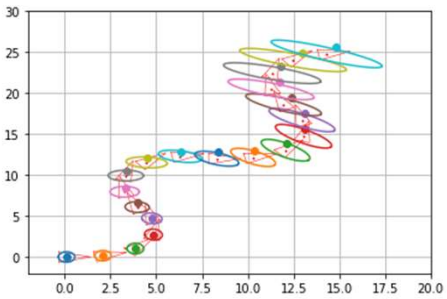
FOUR

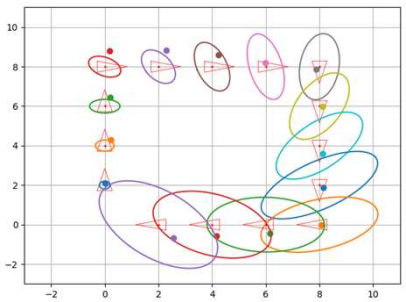
Robot Motion Models



SEMTRON

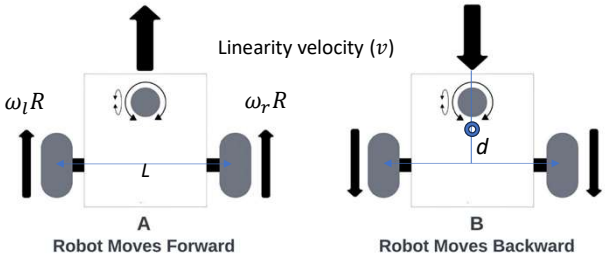
Velocity Models





$$v = \frac{v_l + v_r}{2}$$

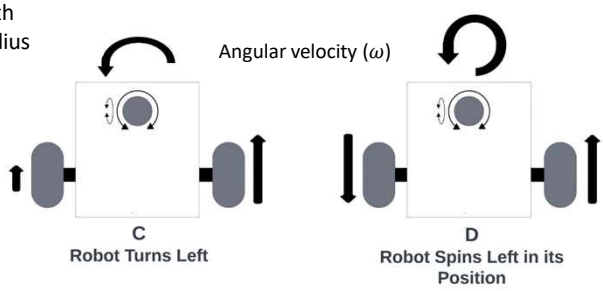
$$\omega = \frac{v_r - v_l}{L}$$



L, robot's track width
R, robot wheel's radius

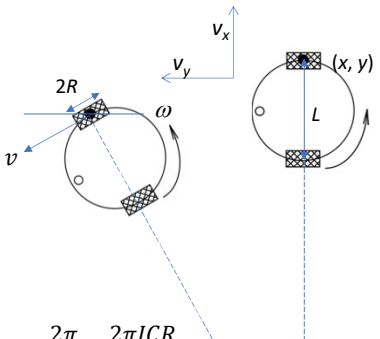
$$v_{max} = \frac{R\omega_{r,l}^{max}}{2}$$

$$\omega_{max} = \frac{R\omega_{r,l}^{max}}{L}$$



Differential drive robot

3



$$\frac{2\pi}{\omega} = \frac{2\pi ICR}{v}$$

$$\omega = \frac{v}{ICR}$$

zero motion line

γ

Instantaneous center of rotation

$$\begin{bmatrix} v \\ \omega \end{bmatrix} = \begin{bmatrix} R/2 & R/2 \\ R/L & -R/L \end{bmatrix} \begin{bmatrix} \omega_r \\ \omega_l \end{bmatrix}$$

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\gamma} \end{bmatrix} = \begin{bmatrix} \cos\gamma & 0 \\ \sin\gamma & 0 \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} v \\ \omega \end{bmatrix}$$

$$\dot{x} = \frac{R(\omega_r + \omega_l)}{2}\cos\gamma$$

$$\dot{y} = \frac{R(\omega_r + \omega_l)}{2}\sin\gamma$$

$$\dot{\gamma} = \frac{R(\omega_r - \omega_l)}{L}$$

Differential drive forward kinematic

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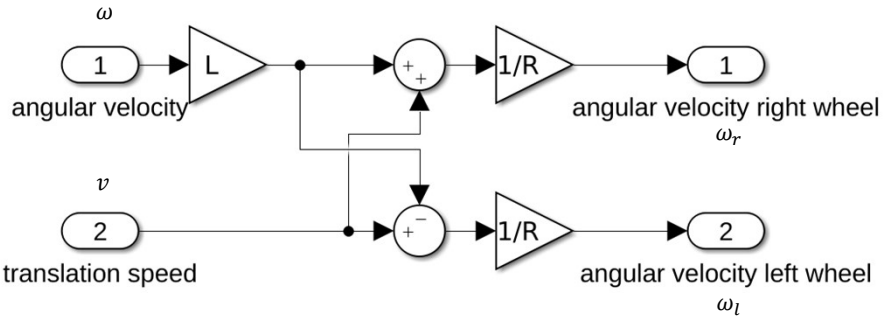
$$\omega_r = \frac{2v + \omega L}{2R} \qquad v_{max} = \frac{0.075 \times 290\pi}{60}$$

$$\omega_l = \frac{2v - \omega L}{2R} \qquad \omega_{max} = \frac{0.075 \times 290\pi \times 2}{0.193 \times 60}$$



Inverse kinematic model of wheel

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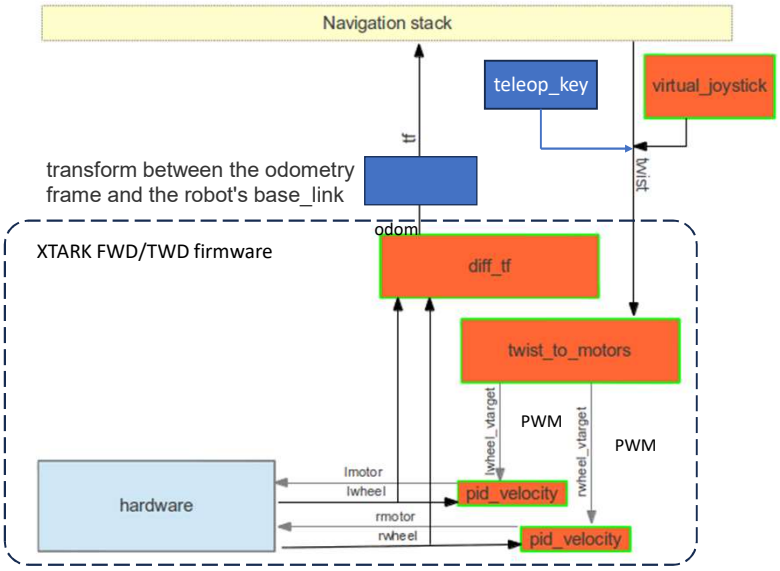
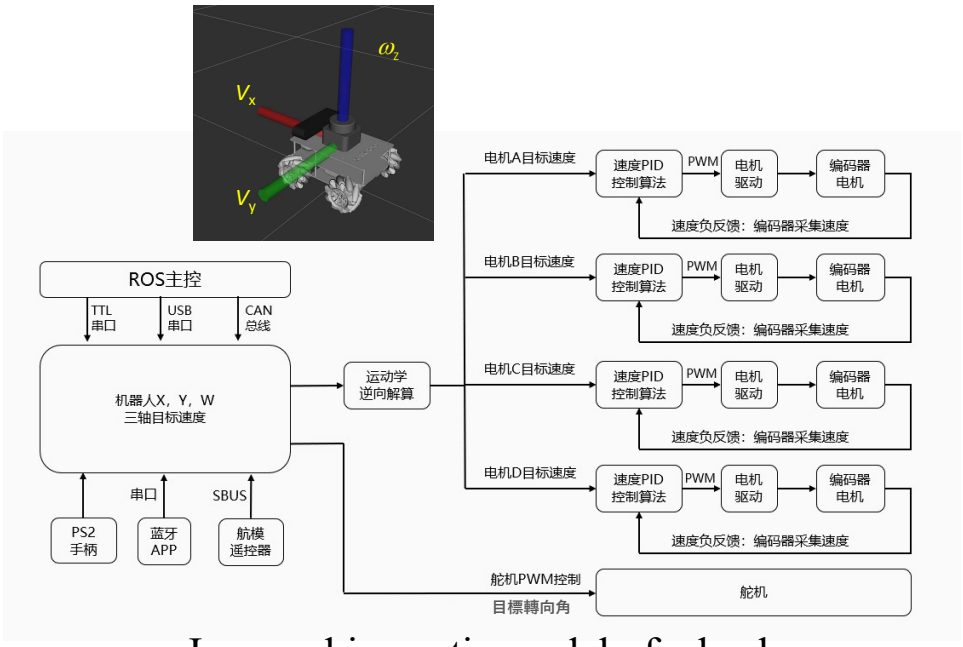
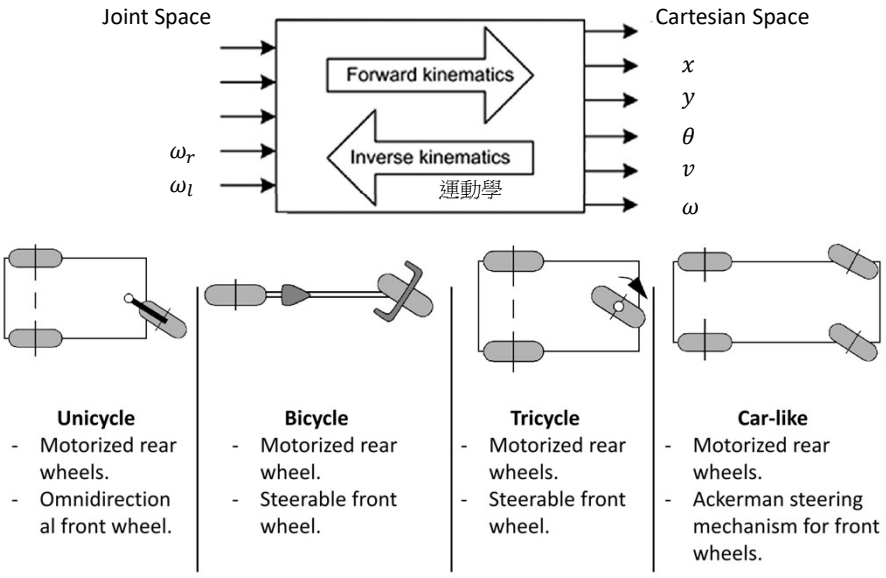


Inverse kinematic model of wheel

6

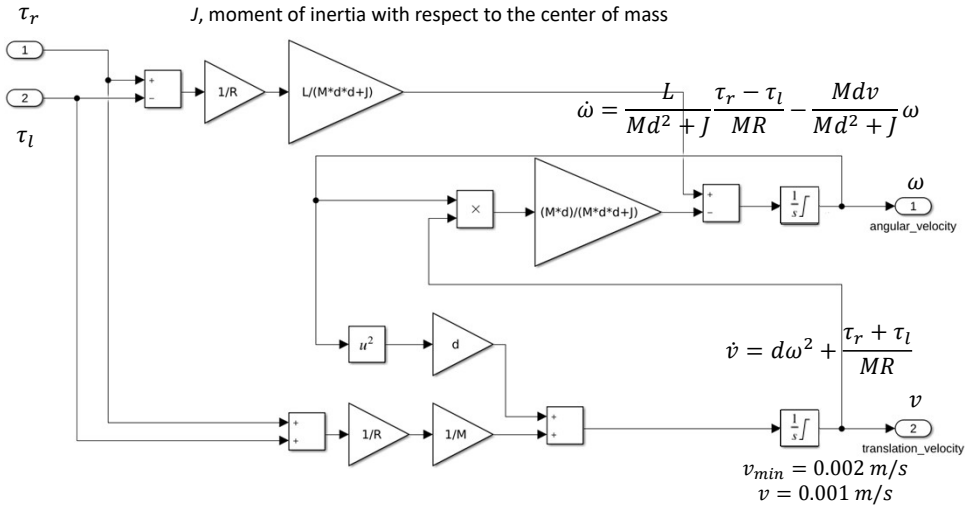


Inverse kinematic model of wheel



Systems of non-holonomic kinematic constraints

d, distance from center of mass of the robot to the axis of the wheel
M, total mass of the robot
J, moment of inertia with respect to the center of mass



Dynamic model of differential-drive robot

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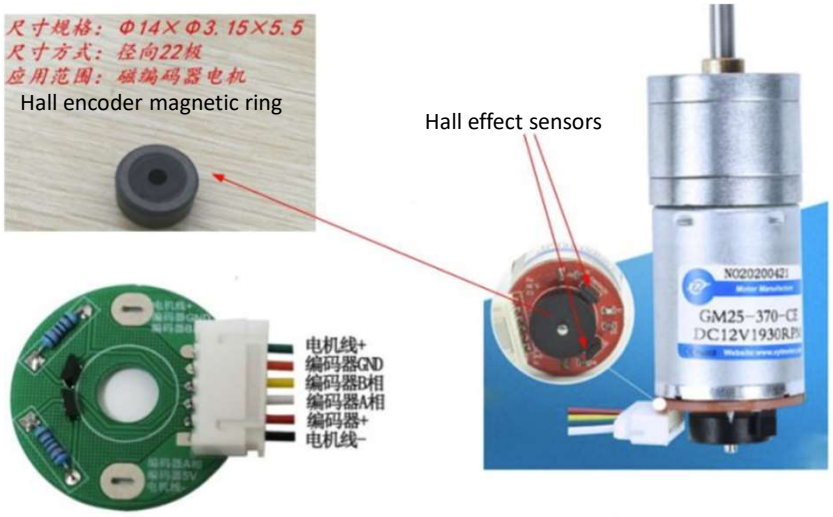

Dynamic model of differential-drive robot

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	TWD	FWD
电机型号	MC520P30_12V	MC520P60_12V
减速比	1:30	1:60
额定电流	0.3A	0.3A
堵转电流	3.2A	3.2A
空载转速	360±20rpm	190±10rpm
额定转速	290±20rpm	150±10rpm
额定扭矩	1.5kg·cm	2.6kg·cm
堵转扭矩	4.5kg·cm	9.2kg·cm
额定功率	4.32W	4.32W
重量	~150g	~150g
Wheel	75 mm Rubber	100 mm Rubber
Track Width	193 mm	
Speed	1.4 m/s	0.8 m/s
v_{max}, ω_{max}	1.14 m/s, 11.8 rad/s	

Dynamic model of differential-drive robot

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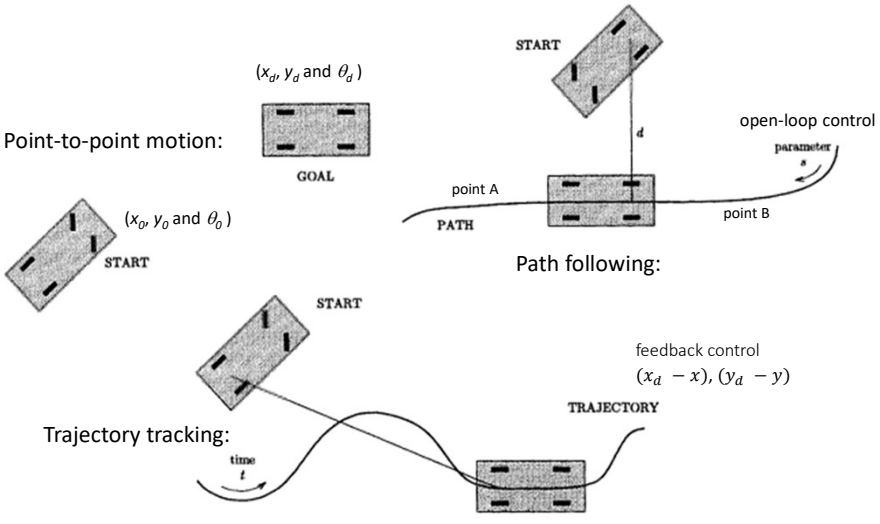

Robot motion tasks

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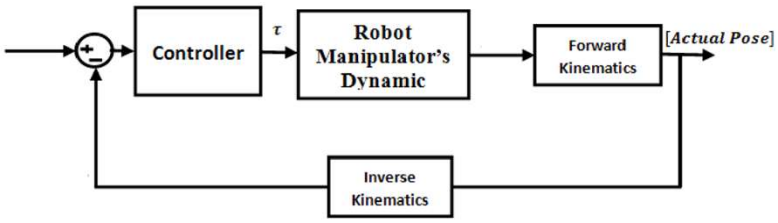
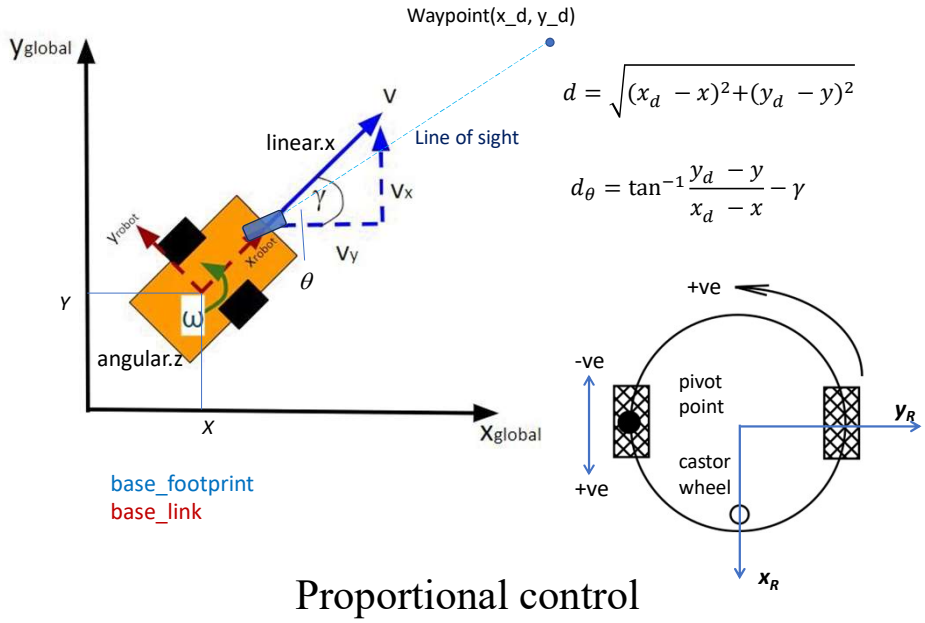
SEMTRON

PID Position Controller



13



Proportional control

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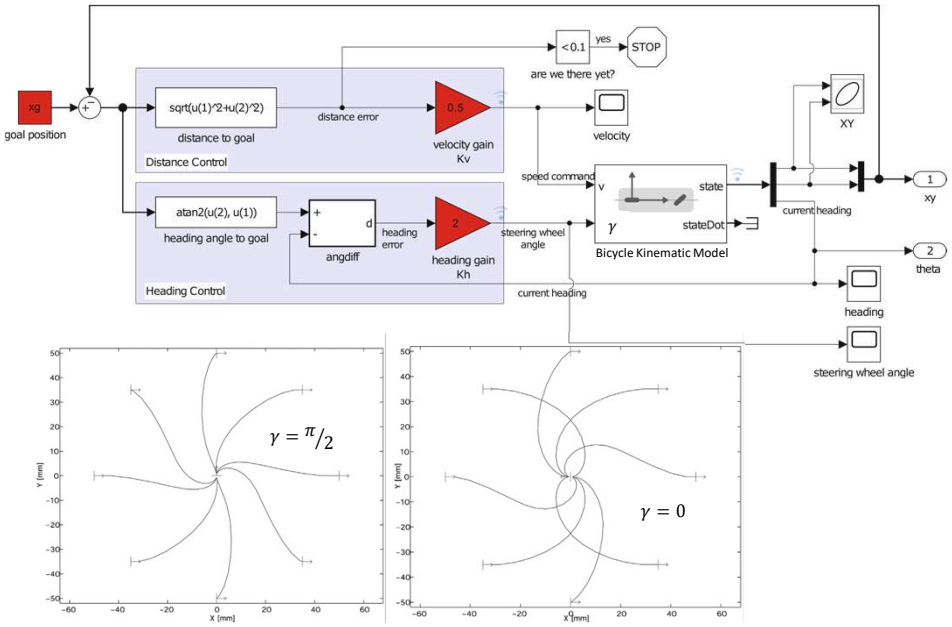


Proportional control

$ rosmsg show nav_msgs/Odometry

```
std_msgs/Header header
  uint32 seq
  time stamp
  string frame_id
string child_frame_id
geometry_msgs/PoseWithCovariance pose
  geometry_msgs/Pose pose
    geometry_msgs/Point position
      float64 x
      float64 y
      float64 z
    geometry_msgs/Quaternion orientation
      float64 x
      float64 y
      float64 z
      float64 w
  float64[36] covariance
geometry_msgs/TwistWithCovariance twist
  geometry_msgs/Twist twist
    geometry_msgs/Vector3 linear
      float64 x
      float64 y
      float64 z
    geometry_msgs/Vector3 angular
      float64 x
      float64 y
      float64 z
  float64[36] covariance
```

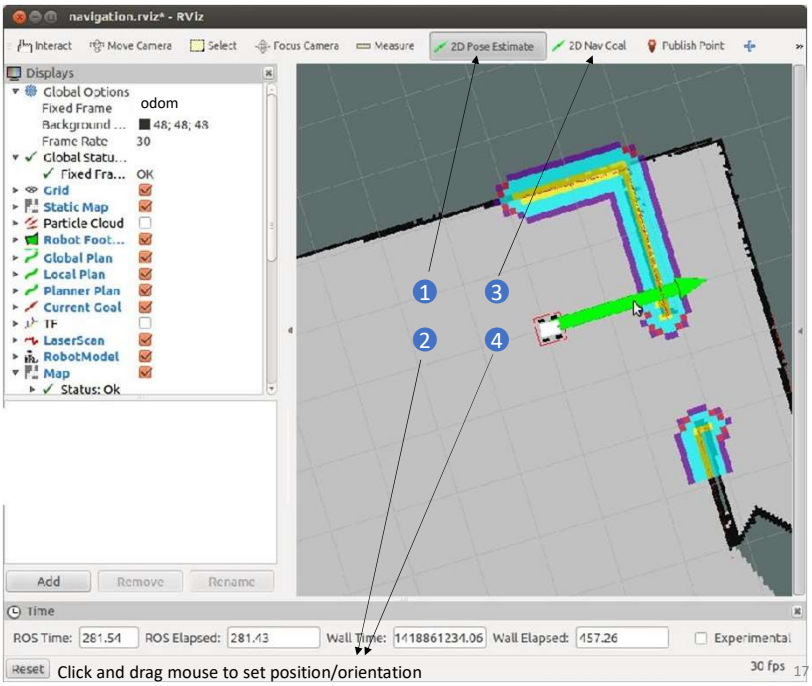
$ rosmsg info geometry_msgs/PoseStamped

geometry_msgs/PoseStamped (2D Nav Goal)

geometry_msgs/PoseWithCovarianceStamped
(2D Pose Estimate)

$ sudo apt install ros-noetic-actionlib-tools
$ roslaunch diff_drive demo_mrobot.launch

Point-to-point motion task



Click and drag mouse to set position/orientation

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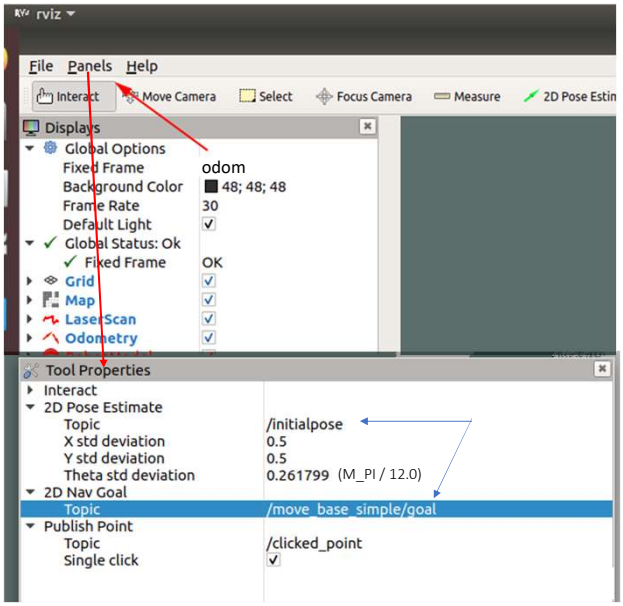
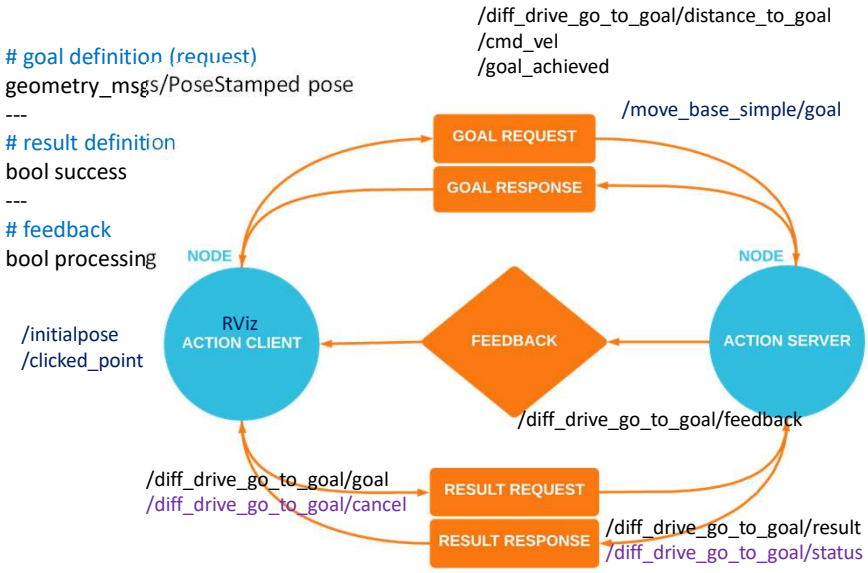


RViz position and orientation publishing

18



Point-to-point go-to-goal

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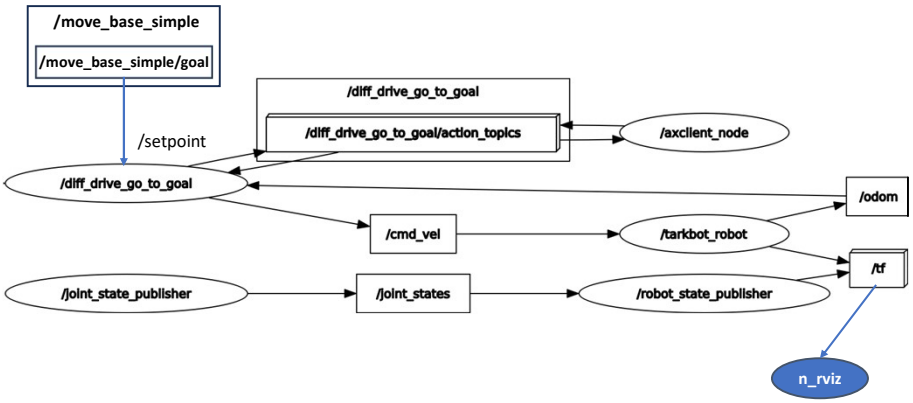
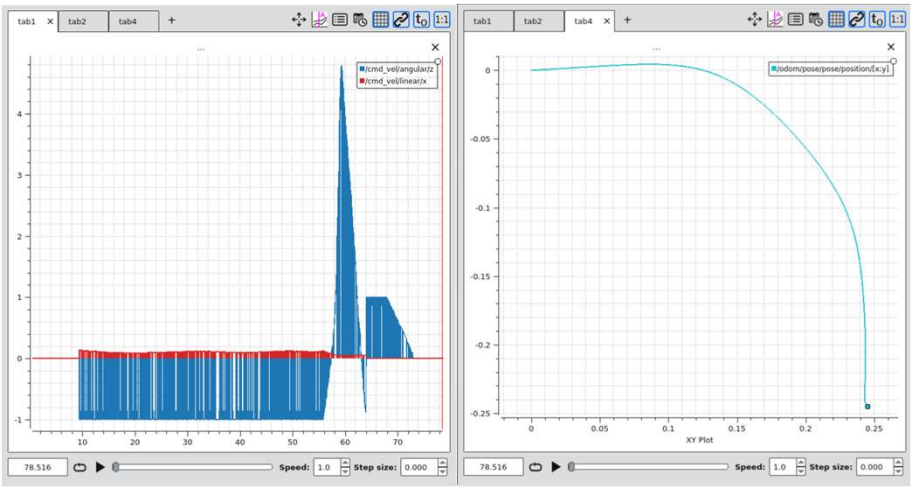


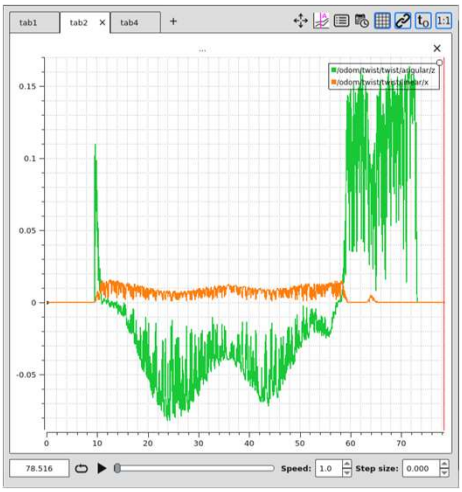
Point-to-point go-to-goal

20



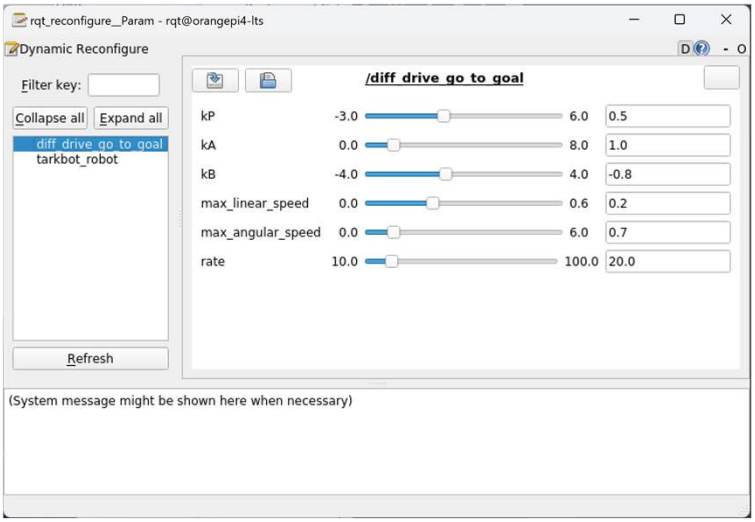
Point-to-point go-to-goal

21



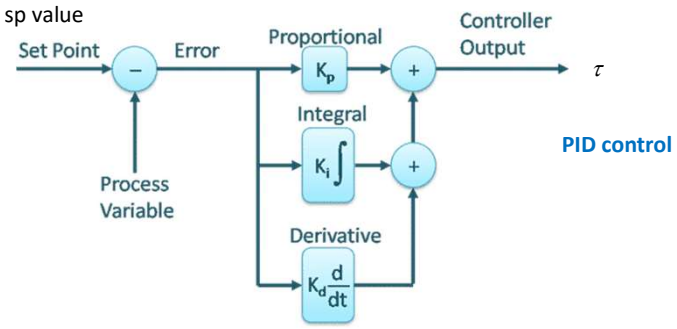
Point-to-point go-to-goal

22



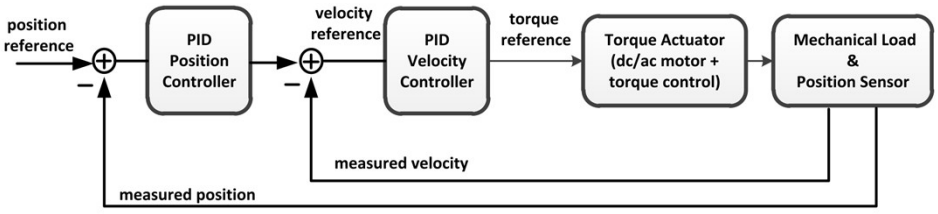
Proportional gain
- linear.velocity x
- steering angle
- orientation angle

Tuning of PID controller



Parameter Increased	Rise Time	Overshoot	Settling Time	Steady-State Error	Stability
K_p	Decrease	Increase	Small Change	Decrease	Degrade
K_i	Decrease	Increase	Increase	Decrease Significantly	Degrade
K_d	Minor Decrease	Minor Decrease	Minor Decrease	No Effect	Improve (for small K_d)

Tuning of PID controller



Tuning of PID controllers