Home Work 1

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Section : 1

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Ans to the QNO-1 (i)

(a) Unicycle Model:

State Space Equation (Differential equation):

$$\dot{x} = v \cos\theta$$
$$\dot{y} = v \sin\theta$$
$$\dot{\theta} = \omega$$

State variables:

(i) x and y: Position coordinates of the robot in a 2D plane.

(ii) θ: Orientation angle of the robot with respect to a reference axis.

Control variables:

(i) v: Linear velocity of the robot.

(ii) ω: Angular velocity of the robot.

(b) Differential drive robot:

State Space Equation (Differential equation):

$$\dot{x} = \frac{V_l + V_r}{2} \cdot \cos\theta$$
$$\dot{y} = \frac{V_l + V_r}{2} \sin\theta$$
$$\dot{\theta} = \frac{V_r - V_l}{L}$$; where L is the distance between the two wheels.

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State variables:

(i) x and y: Position coordinates of the robot in a 2D plane.

(ii) θ: Orientation angle of the robot with respect to a reference axis.

Control variables:

(i) V_l: Linear velocity of the left wheel.

(ii) V_r: Linear velocity of the right wheel.

(c) Simplified Car Model:

State Space Equation (Differential equation):

$$\dot{x} = v\cos\theta$$
$$\dot{y} = v\sin\theta$$
$$\dot{\theta} = \frac{v\tan\phi}{L}$$, where L is the distance between front and rear axles

$$\dot{v} = a$$, where a is the acceleration.

State variables:

(i) x and y: Position coordinates of the car in a 2D plane.

(ii) θ: Orientation angle of the car with respect to a reference axis.

(iii) v: Linear velocity of the car.

Control variables:

ϕ: Steering angle of the front wheels.

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Ans to the QNO-1(ii)

State variables representation:

State variables represent the current state of the system, such as position, orientation and velocity.

Control variables representation:

Control variables represent the inputs or actions applied to the system to influence its state evolution, such as velocities, accelerations or steering angles.

Ans to the QNO-1 (iii)

Unicycle Model	Differential Drive Robot	Simplified Car Model
(1) State variables: x (position), y (position), θ (orientation angle)	(1) State variables: x (position), y (position), θ (orientation angle)	(1) State variables: x (position), y (position), θ (orientation angle), v (linear velocity).
(2) Control variables: v (linear velocity), ω (angular velocity).	(2) Control variables: V_L (left-wheel velocity), V_R (right wheel velocity)	(2) Control variables: v (linear velocity), ϕ (steering angle)

(3) Suitable for robots with independent control over linear and angular velocities. Provides simple motion control but lacks precise positioning.	(3) Suitable for robots with independently controlled wheels. Allows for precise motion control including turning in place and following curved paths.	(3) Suitable for car-like robots with steering capabilities. Allows for precise trajectory following and dynamic speed adjustment.
(4) wheeled robots, drones etc are applications.	(4) Mobile robots, robotic vehicles, rovers etc are applications	(4) Autonomous cars, car-like robots etc are applications.