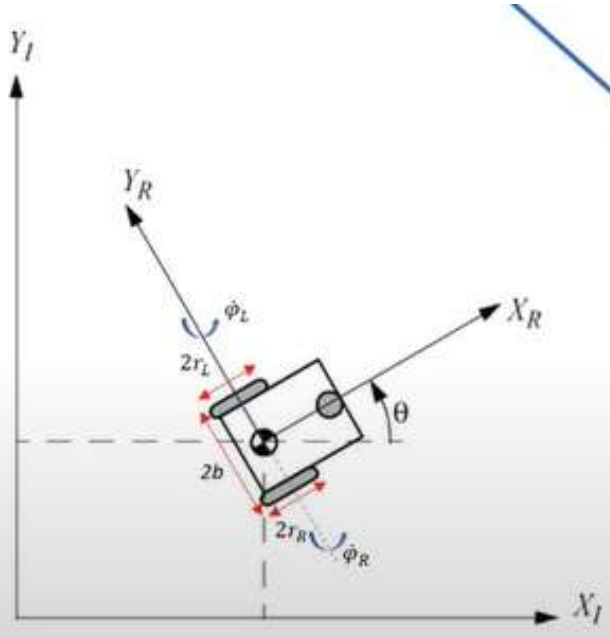

$$\begin{bmatrix}\dot{x}\\ \dot{y}\\ \dot{\theta}\end{bmatrix} = R_z(\theta)\begin{bmatrix}V\\ 0\\ \omega\end{bmatrix} = \begin{bmatrix}\cos(\theta) & -\sin(\theta) & 0\\ \sin(\theta) & \cos(\theta) & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}V\\ 0\\ \omega\end{bmatrix} \quad (1)$$

$$\begin{bmatrix}V\\ \omega\end{bmatrix} = \begin{bmatrix}\frac{r_R}{2} & \frac{r_L}{2}\\ \frac{r_R}{2b} & -\frac{r_L}{2b}\end{bmatrix}\begin{bmatrix}\dot{\varphi}_R\\ \dot{\varphi}_L\end{bmatrix} \quad (2)$$

$$(1)\&\ (2) \Rightarrow \begin{bmatrix}\dot{x}\\ \dot{y}\\ \dot{\theta}\end{bmatrix} = \begin{bmatrix}\frac{r_R}{2}\cos(\theta) & \frac{r_L}{2}\cos(\theta)\\ \frac{r_R}{2}\sin(\theta) & \frac{r_L}{2}\sin(\theta)\\ \frac{r_R}{2b} & -\frac{r_L}{2b}\end{bmatrix}\begin{bmatrix}\dot{\varphi}_R\\ \dot{\varphi}_L\end{bmatrix} \quad (3)$$

Odometry: Process of estimating the robot pose from the wheel motions.

$$\begin{bmatrix}\dot{x}\\ \dot{y}\\ \dot{\theta}\end{bmatrix} = \begin{bmatrix}\frac{r_R}{2}\cos(\theta) & \frac{r_L}{2}\cos(\theta)\\ \frac{r_R}{2}\sin(\theta) & \frac{r_L}{2}\sin(\theta)\\ \frac{r_R}{2b} & -\frac{r_L}{2b}\end{bmatrix}\begin{bmatrix}\dot{\varphi}_R\\ \dot{\varphi}_L\end{bmatrix} \Rightarrow \begin{bmatrix}x(t)\\ y(t)\\ \theta(t)\end{bmatrix} = \begin{bmatrix}x(t-\Delta t)\\ y(t-\Delta t)\\ \theta(t-\Delta t)\end{bmatrix} + \Delta t\begin{bmatrix}\frac{r_R}{2}\cos(\theta(t-\Delta t)) & \frac{r_L}{2}\cos(\theta(t-\Delta t))\\ \frac{r_R}{2}\sin(\theta(t-\Delta t)) & \frac{r_L}{2}\sin(\theta(t-\Delta t))\\ \frac{r_R}{2b} & -\frac{r_L}{2b}\end{bmatrix}\begin{bmatrix}\dot{\varphi}_R(t-\Delta t)\\ \dot{\varphi}_L(t-\Delta t)\end{bmatrix}$$

If the angular velocity is not given as feedback by encoder.

$$x(t+dt) = x(t) + R\frac{\Delta\varphi_R + \Delta\varphi_L}{2}\cos\theta(t)$$

$$y(t+dt) = y(t) + R\frac{\Delta\varphi_R + \Delta\varphi_L}{2}\sin\theta(t)$$

$$\theta = R\frac{\varphi_R - \varphi_L}{2b}$$

Drift Problem

- **Tyre Slipping**
- **Process Time**