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April 09, 2019

April 08 - April 15 Weekly Report

1 Progress

- State Space modelling of the vehicle using Inverse Kinematic Model is attempted. Further analysis can be investigated at Appendix.
- PID parameter optimisation was done. Vehicle can accomplish at least ten full tours. [1]
- Small debug on image processing.
- Ad-hoc network on Raspberry-Pi is created.
- Kalman filter matrices are tried to be tuned. Prediction either followed measurement closely or didn't fit to measurement and added delay.
-

2 Plans

- Further state-space modelling approaches will be investigated.

[1] https://drive.google.com/open?id=1se0yFAcMJst-fzalRnIQb4HR0hAdtwhr

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Appendices

Following speed parameters were used at the modelling, other modelling parameters can be investigated at *Figure 1.*

- v_r is current position linear velocity
- w_r is current angular velocity
- v_R and right wheel linear velocity
- v_L and left wheel linear velocity
- $w_R = \dfrac{v_R}{r}$ and right wheel angular velocity
- $w_L = \dfrac{v_L}{r}$ and left wheel angular velocity

and their relation between linear speed and angular velocity of the vehicle with respect to right and left wheel are as follows [2] [3]

$$v_{vehicle} = \frac{v_R + v_L}{2}$$

$$w_{vehicle} = \frac{v_R - v_L}{r}$$

In our case we could you constant base speed $V = \dfrac{v_R + v_L}{2}$ and $\Delta V = v_R - v_L$. Thus,

$$v_R = V + \Delta V/2$$

$$v_L = V - \Delta V/2$$

$$\dot{q_r} = \begin{bmatrix} \dot{x_r} \\ \dot{y_r} \\ \dot{\theta_r} \end{bmatrix} = \begin{bmatrix} \cos(\theta_r) & 0 \\ \sin(\theta_r) & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v_r \\ w_r \end{bmatrix}$$

$$\dot{q_d} = \begin{bmatrix} \dot{x_d} \\ \dot{y_d} \\ \dot{\theta_d} \end{bmatrix} = \begin{bmatrix} \cos(\theta_d) & 0 \\ \sin(\theta_d) & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v_d \\ w_d \end{bmatrix}$$

$$q = q_r - q_d$$

[2]https://www.researchgate.net/publication/252016633_Trajectory-tracking_and_discrete-time_sliding-mode_control_of_wheeled_mobile_robots
[3]https://www.dis.uniroma1.it/ labrob/pub/papers/Ramsete01.pdf

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where $v = v_r - v_d$ and $w = w_r - w_d$

$$\dot{q} = \begin{bmatrix} \dot{x_r} - \dot{x_d} \\ \dot{y_r} - \dot{y_d} \\ \dot{\theta}_r - \dot{\theta}_d \end{bmatrix} = \begin{bmatrix} 0 & 0 & -v_d \sin(\theta_d) \\ 0 & 0 & +v_d \cos(\theta_d) \\ 0 & 0 & 0 \end{bmatrix} q + \begin{bmatrix} \cos(\theta_d) & 0 \\ \sin(\theta_d) & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ w \end{bmatrix}$$

through a rotation matrix

$$q_R = \begin{bmatrix} \cos(\theta_d) & \sin(\theta_d) & 0 \\ -\sin(\theta_d) & \cos(\theta_d) & 0 \\ 0 & 0 & 1 \end{bmatrix} q$$

$$\dot{q_R} = \begin{bmatrix} 0 & w_d & 0 \\ -w_d & 0 & +v_d \\ 0 & 0 & 0 \end{bmatrix} q_R + \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ w \end{bmatrix}$$

Error for a position

$$\begin{bmatrix} x_e \\ y_e \\ \theta_e \end{bmatrix} = \begin{bmatrix} \cos(\theta_d) & \sin(\theta_d) & 0 \\ -\sin(\theta_d) & \cos(\theta_d) & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} x_d - x_r \\ y_d - y_r \\ \theta_d - \theta_r \end{bmatrix}$$

$$\begin{bmatrix} x_e \\ y_e \\ \theta_e \end{bmatrix} = \begin{bmatrix} y_1 \cos(\beta) \\ y_1 * \sin(\beta) + 50/\cos(\beta) \\ \beta \end{bmatrix}$$

where β and y_1 are measurable quantities

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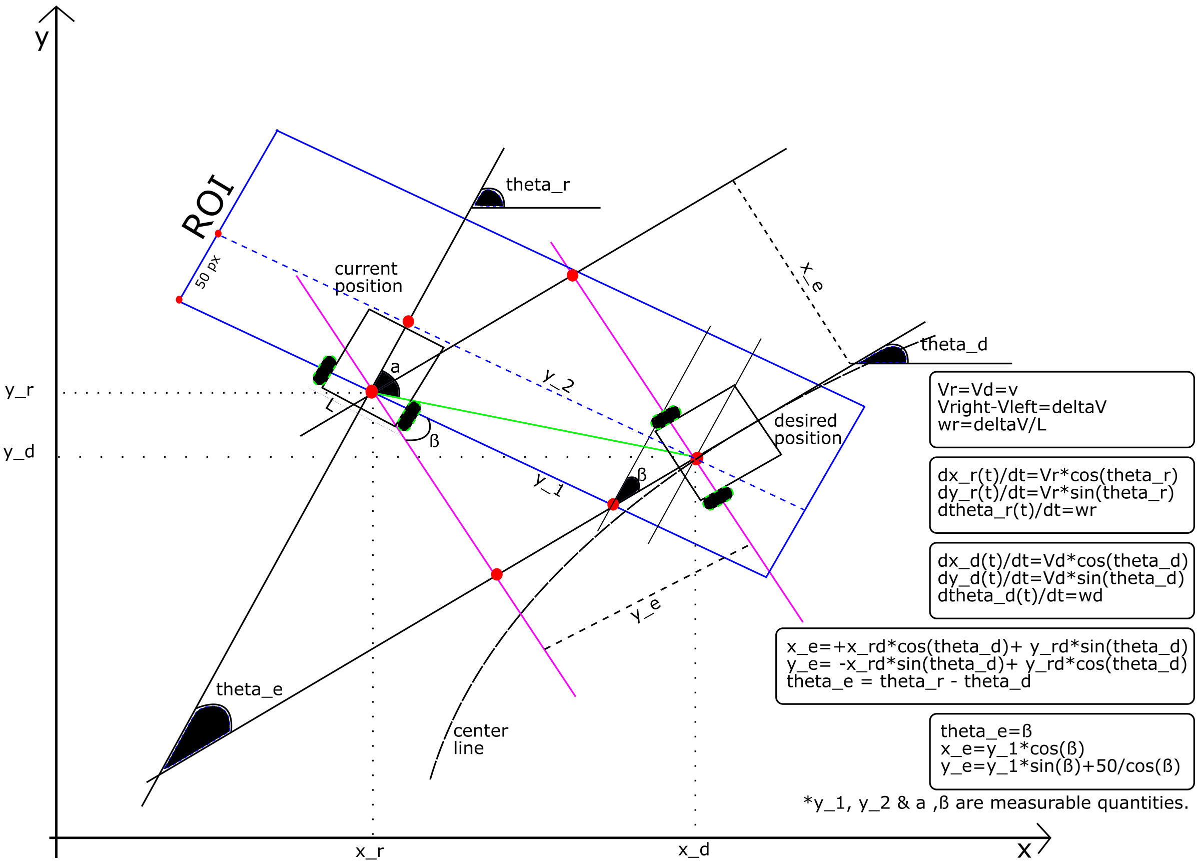

Figure 1: Inverse Kinematic Model for the Differential Drive Motor