ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ
ΣΧΟΛΗ ΗΛΕΚΤΡΟΛΟΓΩΝ ΜΗΧΑΝΙΚΩΝ ΚΑΙ ΜΗΧΑΝΙΚΩΝ ΥΠΟΛΟΓΙΣΤΩΝ

Ρομποτική ΙΙ: Ευφυή Ρομποτικά Συστήματα

Εξαμηνιαία Εργασία 2:

Mobile Robots: Wall Following

Αναφορά

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Ομάδα 50

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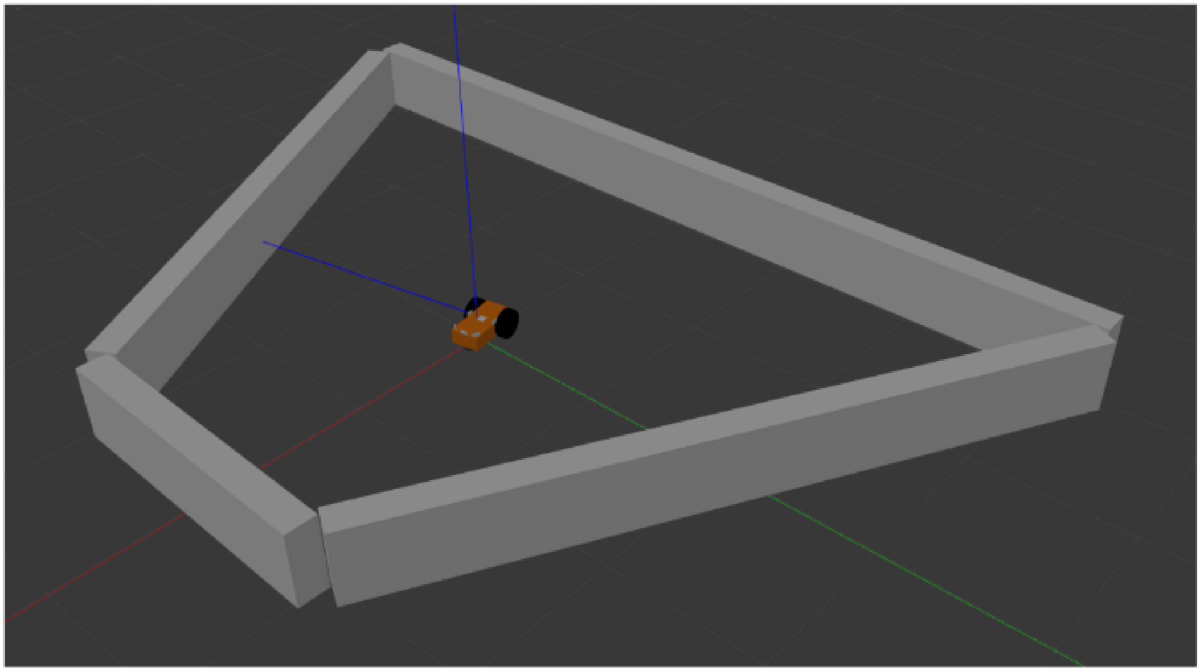
THEORETICAL ANALYSIS

INTRODUCTION

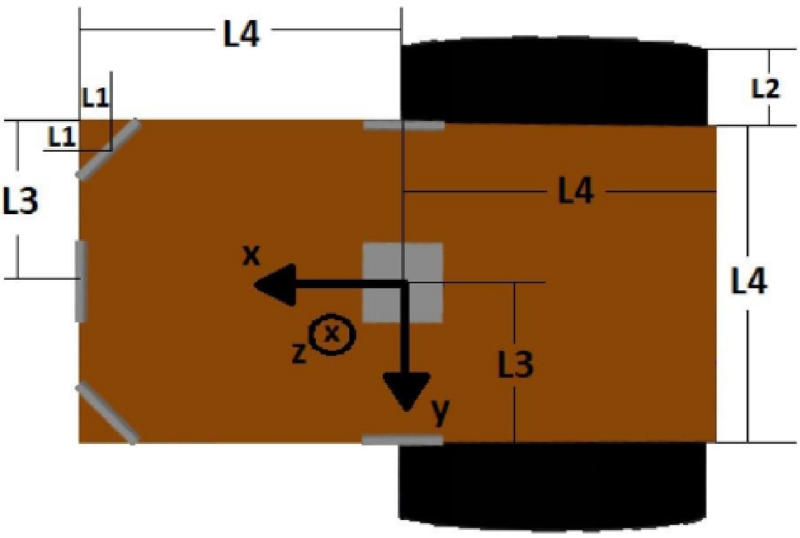
In this task, we implement a wall-following methodology for a mobile robot. More precisely, we focus on keeping a stable distance between the robot and the obstacles, while doing a full circumference parallel to the obstacles. The obstacle plane is the following:



Εικόνα 3 - The robot surrounded by obstacles (in Gazebo)

DESCRIPTION OF THE ROBOT

We use a differential-drive robot with 2 20 cm - diameter wheels. The robot is equipped with 5 ultrasonic distance sensors and a 9-axis IMU(Inertial Measurement Unit).



,where:

$L1 = 0.018\ m$

$L2 = 0.05\ m$

$L3 = 0.1\ m$

$L4 = 0.2\ m$

Εικόνα 2 - Scheme Design

Our number is X = X1 + X2 = 7

So, angle = mod(7,π) = 0.717

and X is odd so we have counter-clockwise motion.

SUBTASK ANALYSIS

Initial Wall approach

Initially, the robot has to approach the wall. This is done with a constant linear velocity. (0.5 m/s) and an angular velocity of -0.6 rad/s (it helps a bit because the initial angle of the robot is not perpendicular to the wall).

Alignment to wall

When a distance threshold is reached (0.3 m from the front sensor), the robot starts to align with the wall. So, when the front sensor surpasses that threshold, linear velocity becomes 0.1 m/s (slows down for the turn, not to collide with the wall) and angular velocity becomes:

$$\omega_Z(t) = [\mathrm{K1} * \omega_Z(t-1) - 2\pi]/2$$

we have '-' because we have CCW motion and we use $\mathrm{K1} * \omega_Z(t-1)$ so that there are no sudden changes to angular velocity as it depends on the previous angular velocity (K1 = 0.1).

This turn only stops when the robot is aligned to the wall, or more specifically when $F\_distance$ > $R\_distance$ + 0.2 and $F\_distance$ >$FR\_distance$ + 0.2, where * _distance are distances measured from the sensors(F: front etc), and 0.2m is a safe distance factor.

Wall Following

For the wall following subtask, we will use a PD controller to keep the linear velocity at 0.5 m/s and keep the wall to the following levels (by adjusting the angular velocity):

R_desired_distance = 0.3

FR_desired_distance = (0.3 + L1)*sqrt(2) = 0.45

So the controller is described by the following equations:

$$\omega_Z(t) = -\{ Kp * [(R\_desired\_distance - R\_distance) + (FR\_desired\_distance - FR\_distance)]$$

$$+ Kd * [((R\_desired\_distance - R\_distance) - (R\_desired\_distance - R\_distance)_{prev})/dt$$

$$+ ((FR\_desired\_distance - FR\_distance) - (FR\_desired\_distance - FR\_distance)_{prev})/dt]$$

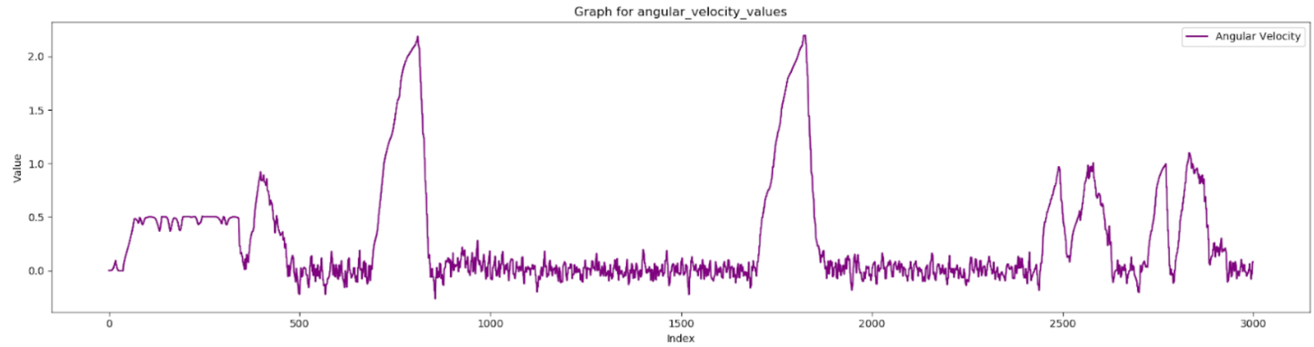
$$+ K1 * \omega_Z(t-1)\}/2$$

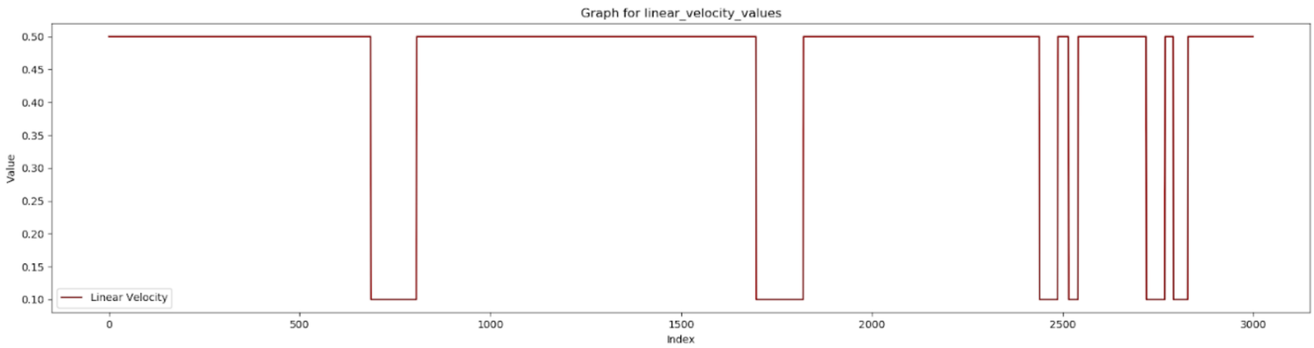
where $\omega_Z(t-1) = -(Kp * Perror + Kd * Derror)$

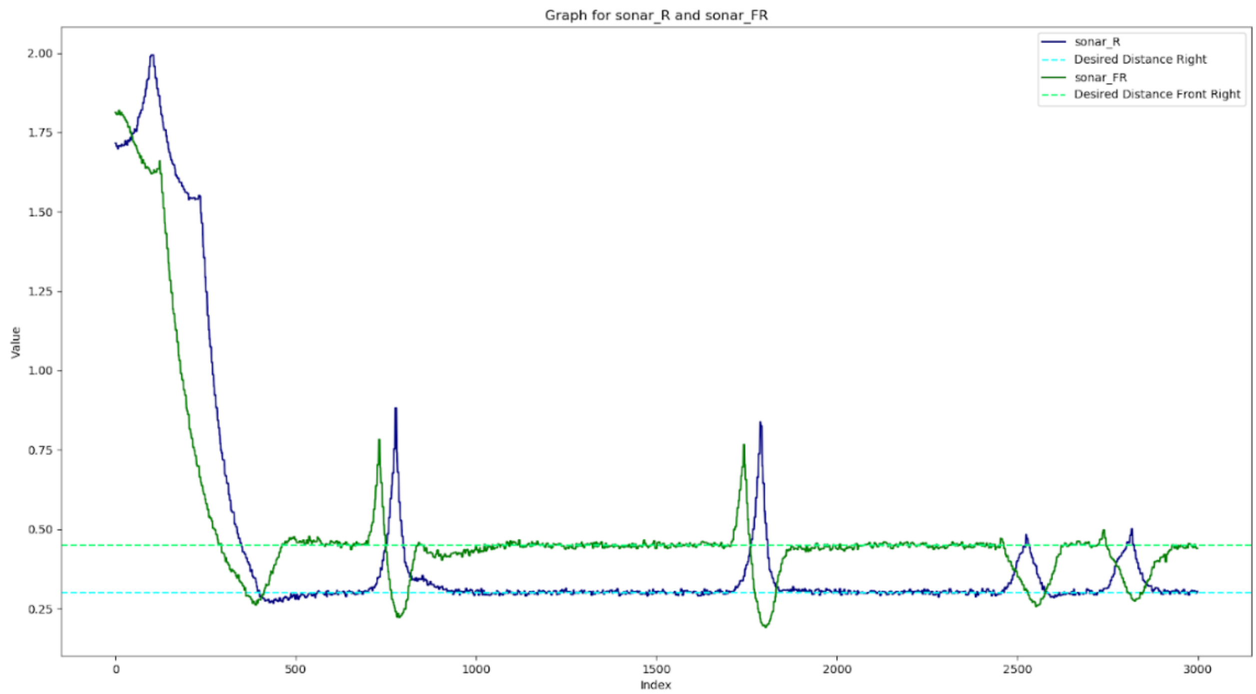
#we use P, D error as abbreviations

We find the best Kp,Kd parameter combination value by testing:

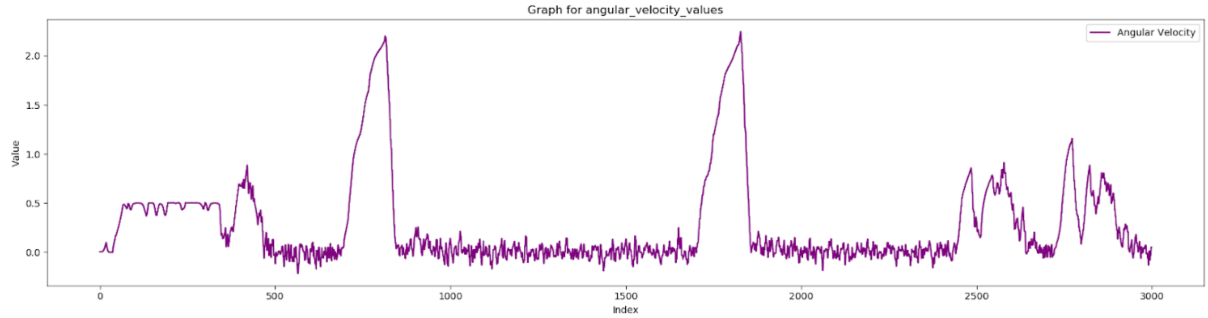
for Kp = 30, Kd = 10:

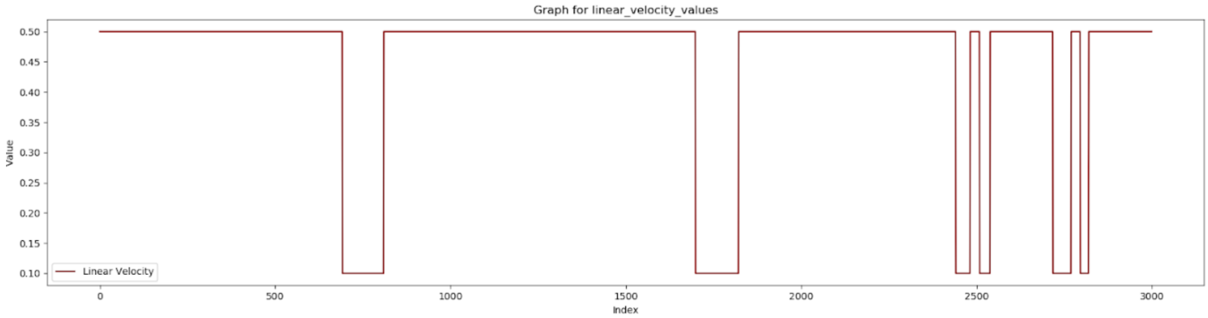


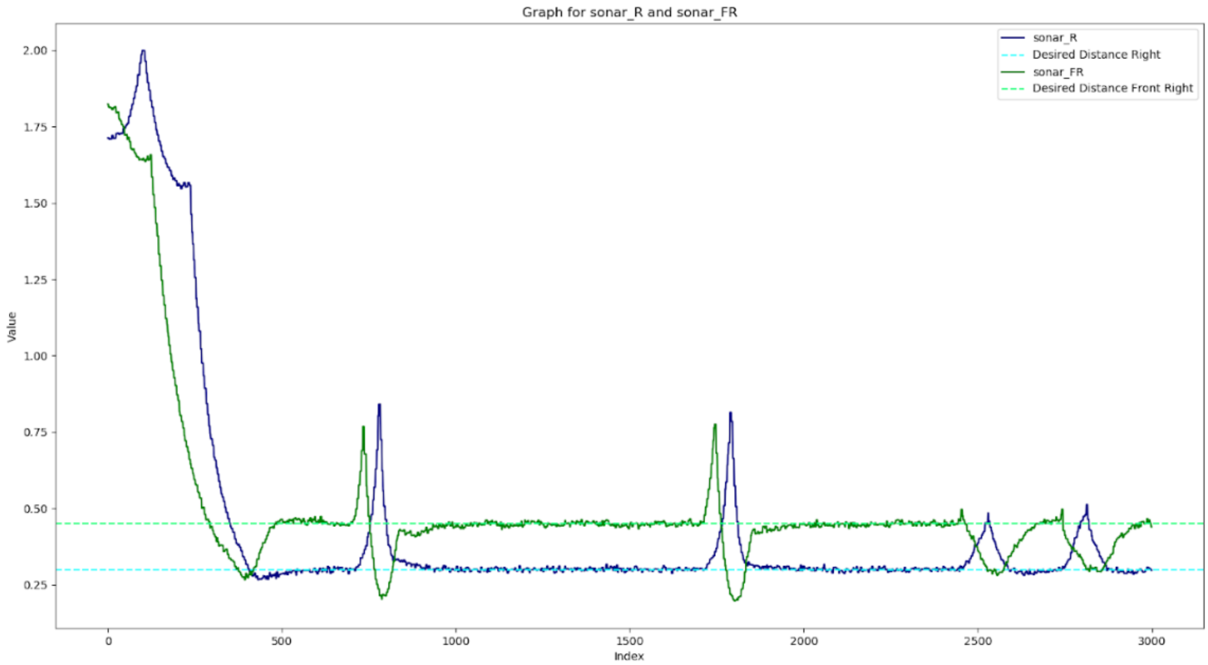




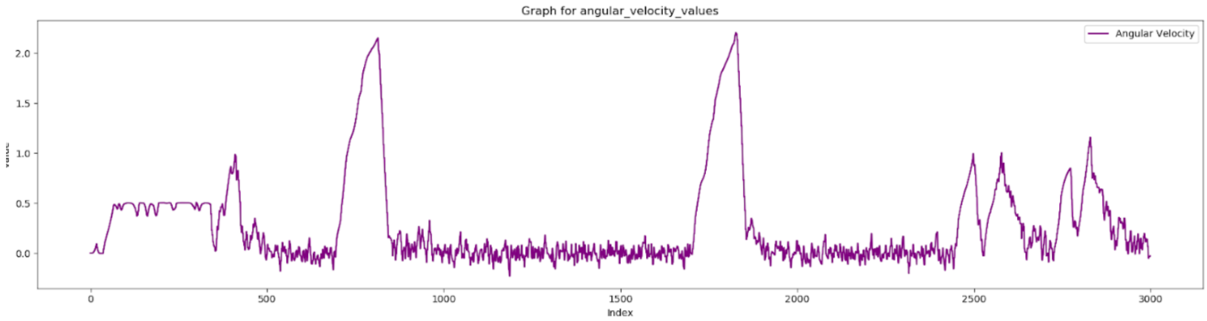
for Kp = 20, Kd = 10:

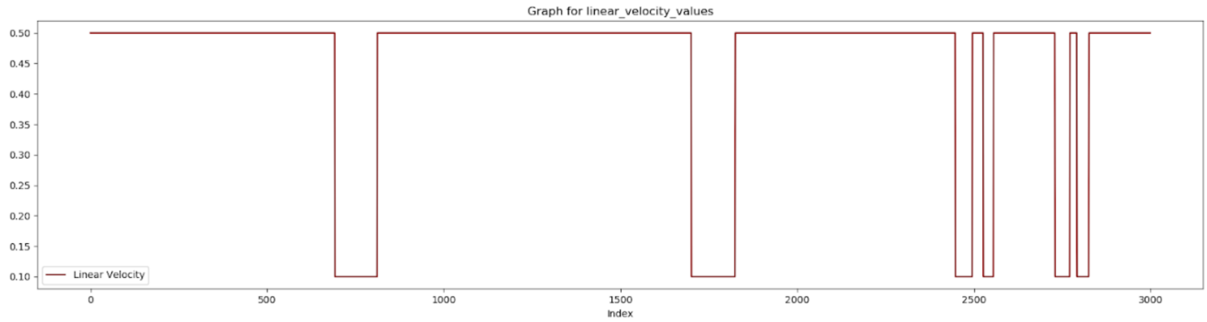


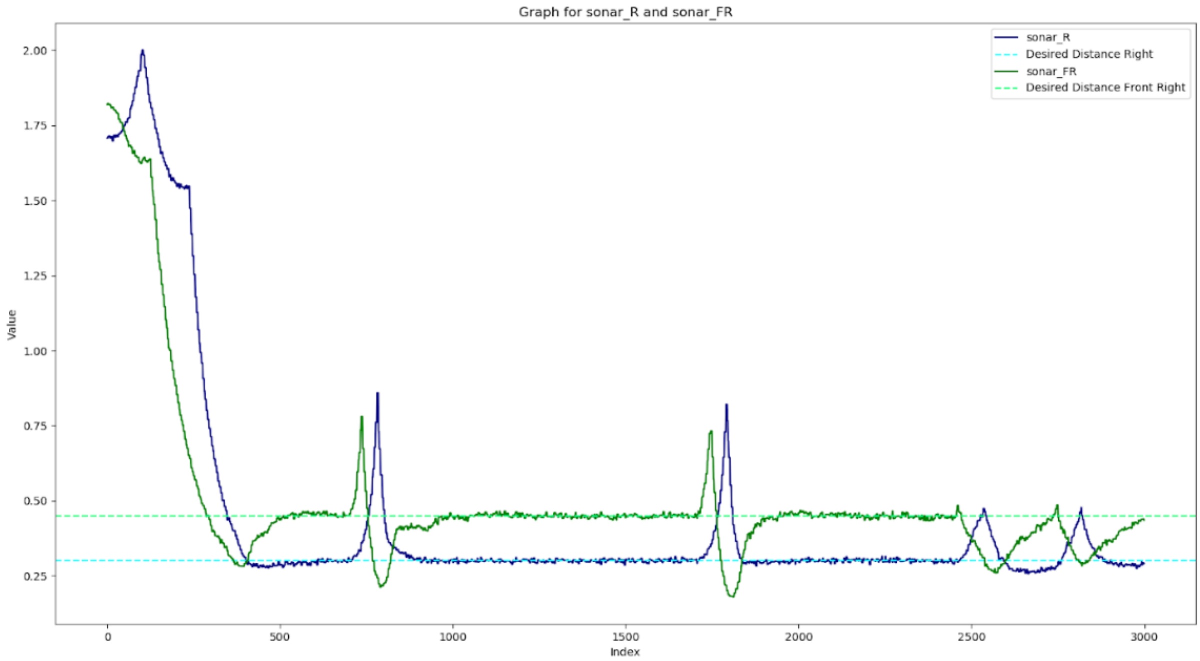




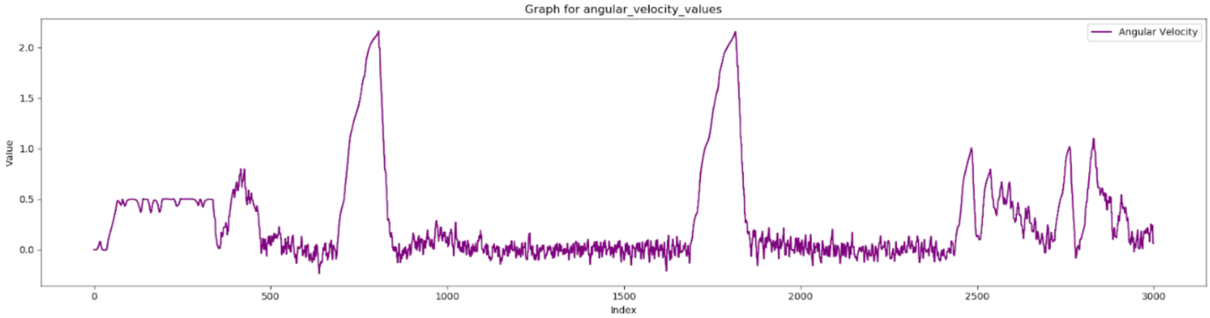
for Kp = 20, Kd = 20:

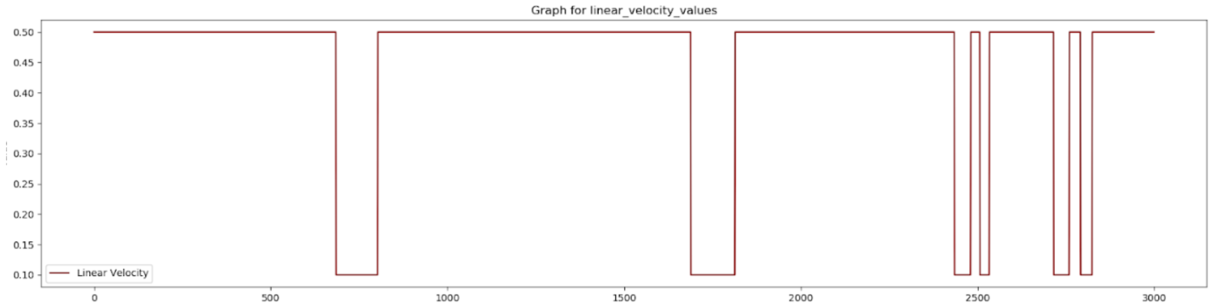


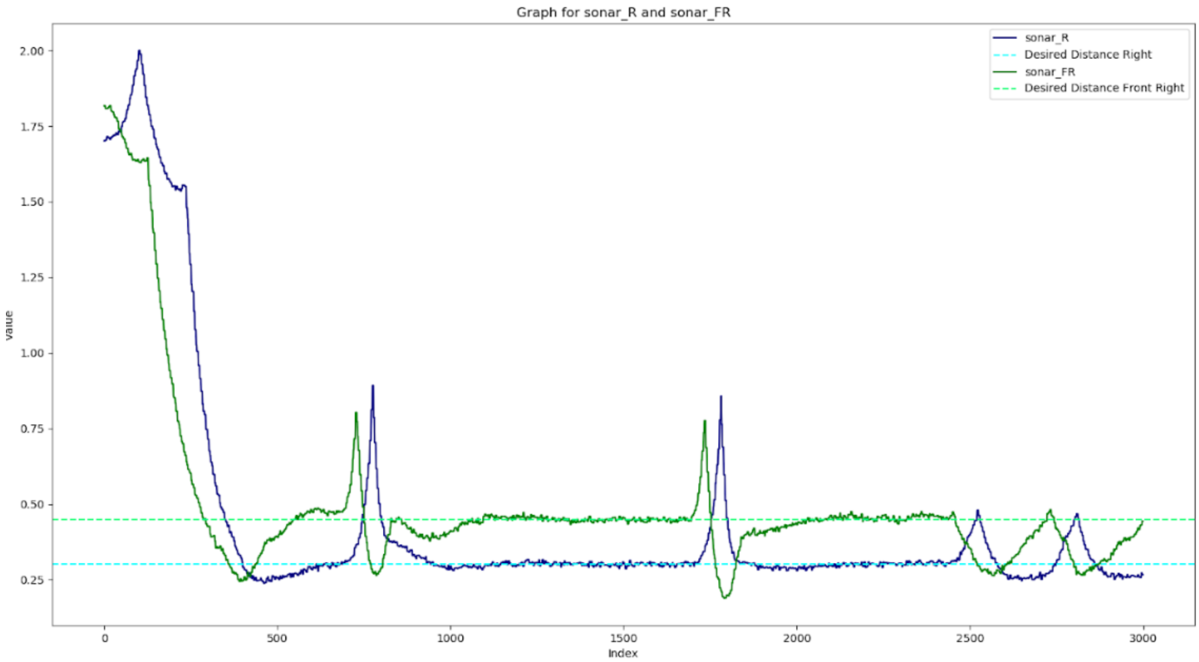




for Kp = 10, Kd = 10:

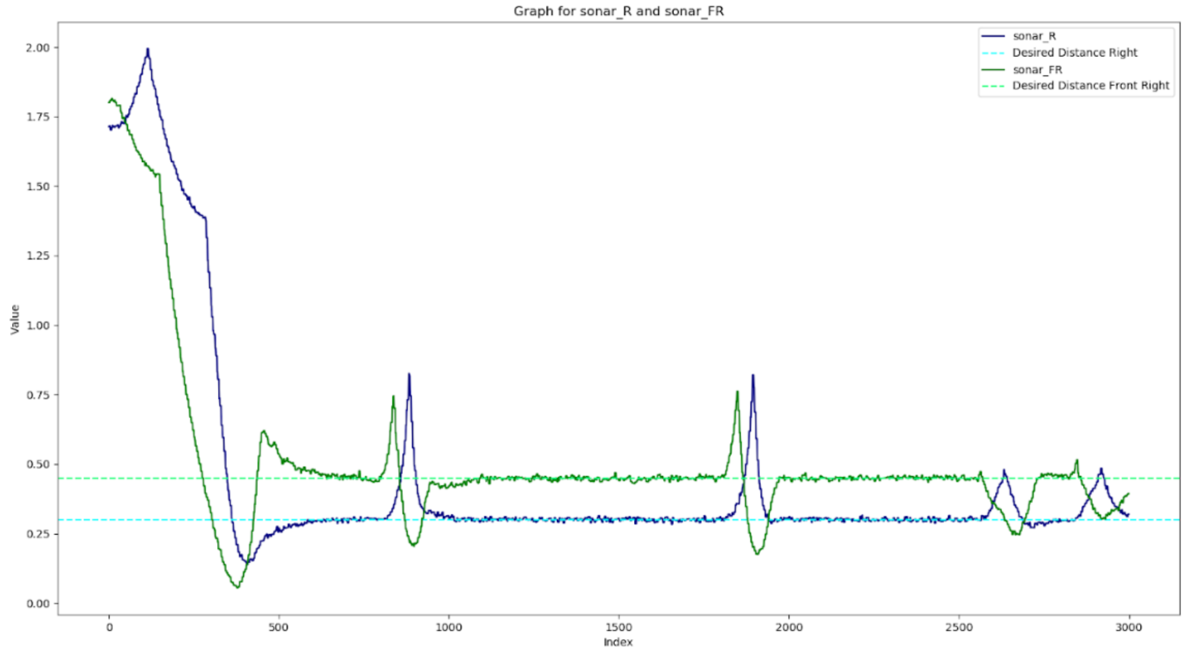






We observe that the best combination is <u>Kp = 20, Kd = 10</u> and next is Kp = 20, Kd = 20. Our selection criterions were least error and movement smoothness, mainly in the sensor distance diagrams. The selected combination has less overestimates in the turn.

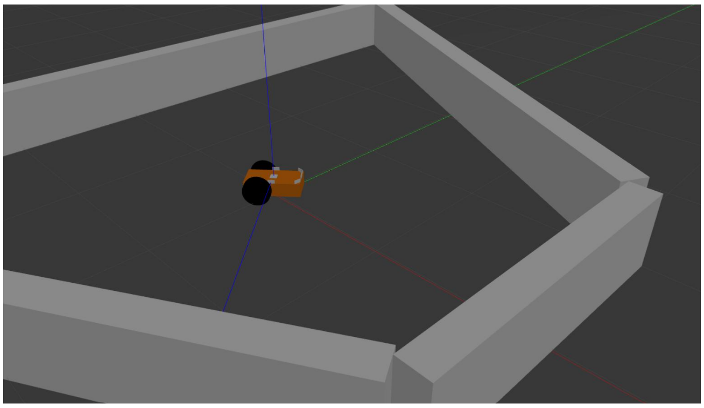
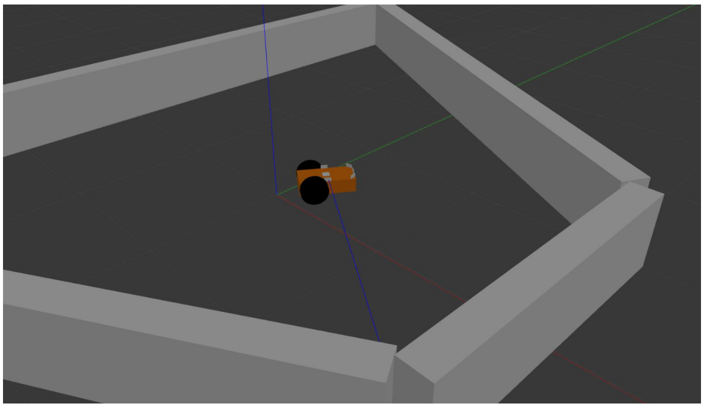
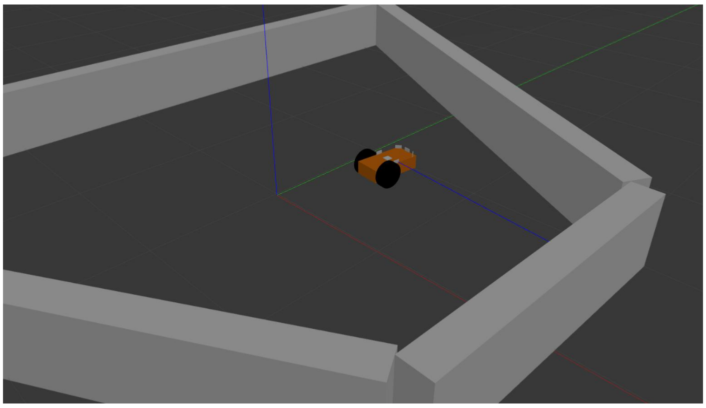
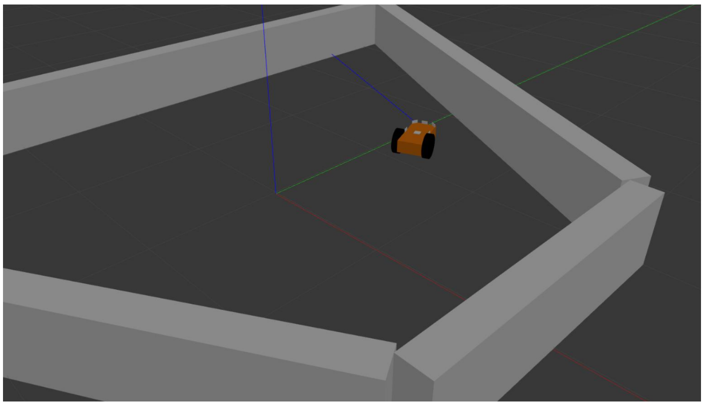
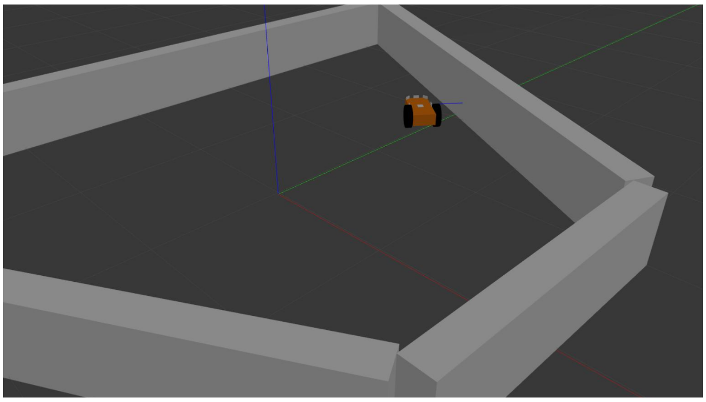
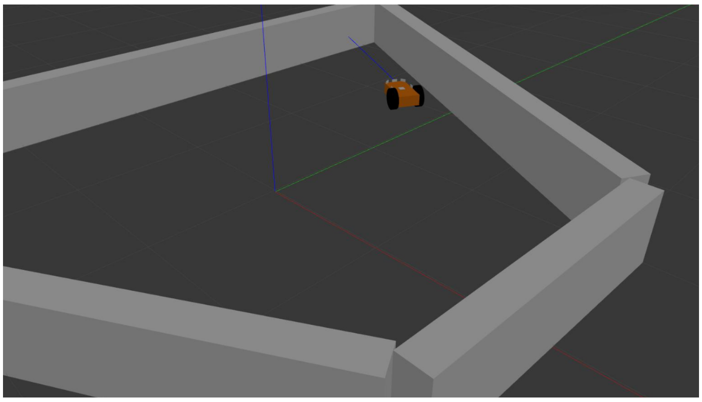
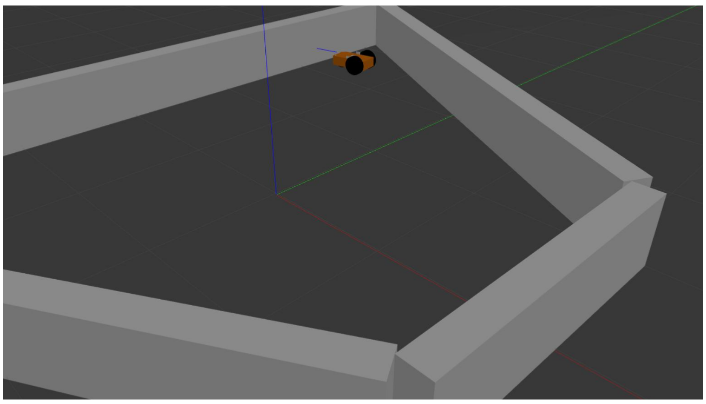
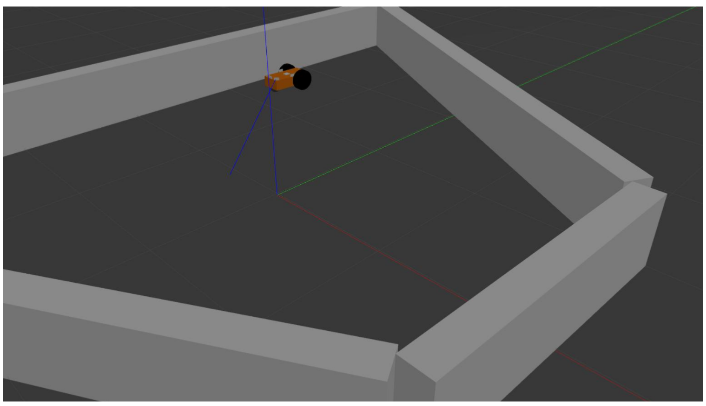
We also have to point out that initially we had chosen angular velocity of - 0.2 rad/s and we had the following diagram:

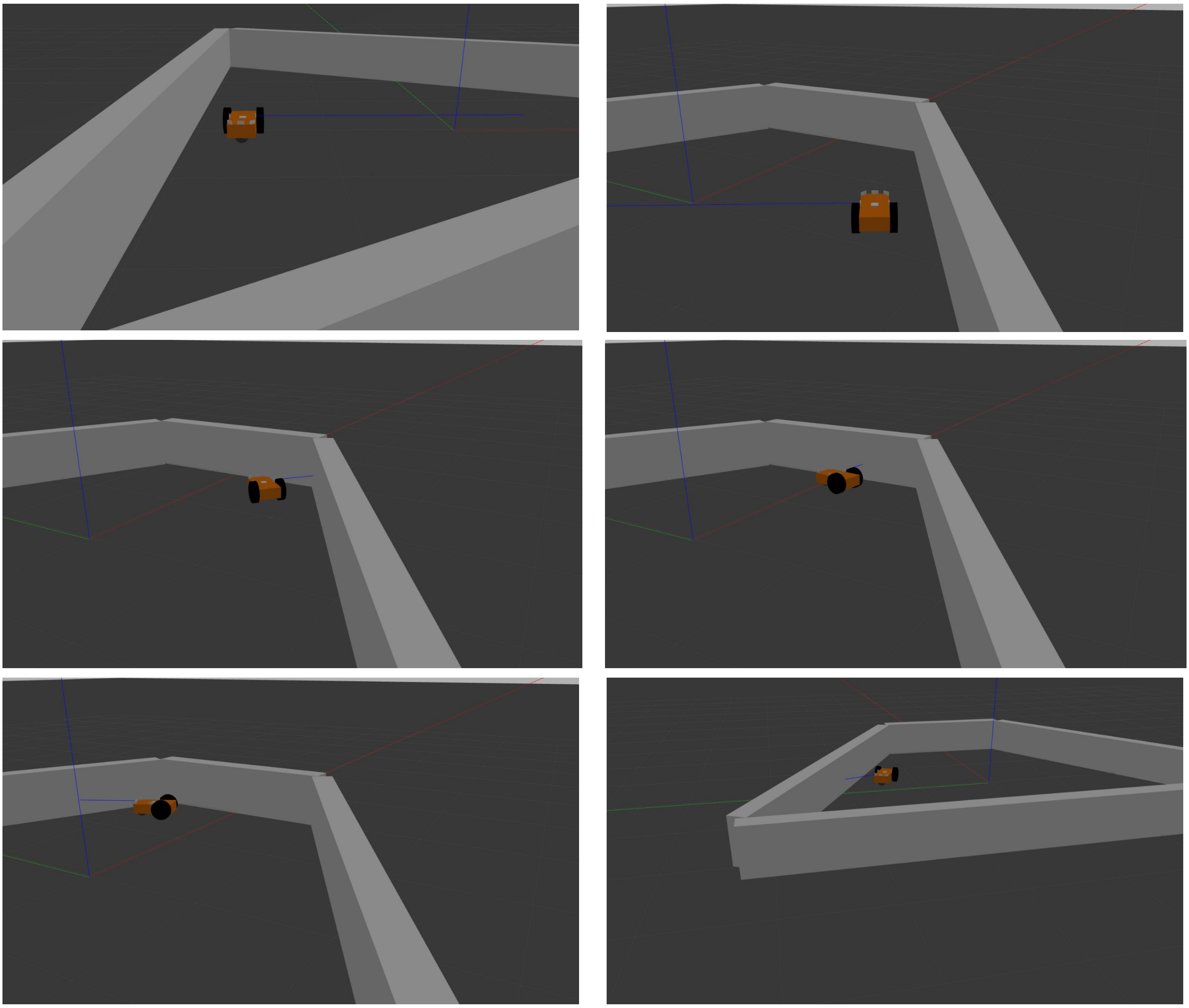


when we switched to angular velocity of - 0.6 rad/s, the movement became smoother as in the previous diagrams.

SIMULATION

Below we can observe some instances of the simulation in the gazebo environment.



We can observe the different stages of the task:

1-3 initial wall approach
4-6 initial alignment
6-∞ wall following