Coursera Capstone
Week 4: Controlling the Robot

# 1 Introduction

For this project you will be implementing a control law to allow the robot to move to a desired location. You will implement and test this in simulation, and later will be moving it to the robot.

# 2 Basic Controller

We are using a simple ground robot with two wheels that it can spin independently, allowing it to achieve any combination of forwards velocity and rotation around its center (including rotating in place). Thus, we can model it with a standard unicycle model:

$$\begin{aligned}\dot{x} =& v\cos(\theta)\\ \dot{y} =& v\sin(\theta)\\ \dot{\theta} =& \omega\end{aligned}$$

The final control equations for this are:

$$\begin{pmatrix} v \\ \omega \end{pmatrix} = \begin{pmatrix} k_\rho & 0 & 0 \\ 0 & k_\alpha & k_\beta \end{pmatrix} \begin{pmatrix} \rho \\ \alpha \\ \beta \end{pmatrix}$$

Where:

$$\begin{aligned}\rho =& \sqrt{\Delta x^2 + \Delta y^2}\\ \alpha =& -\theta + \text{atan2}(\Delta y, \Delta x)\\ \beta =& -\theta - \alpha\end{aligned}$$

With $k_\rho$, $k_\alpha$, $k_\beta$ such that the roots of the following equation are negative:

$$(\lambda + k_\rho)(\lambda^2 + (k_\alpha - k_\rho)\lambda - k_\rho k_\beta) = 0$$

More details are given in the lecture.

# 3 Interface

You will implement the control equations in the `DiffDriveController` class, then test it in simulation before going to the robot. There are two functions given:

1. `__init__`: This is where you intialize all your global parameters, for instance $k_\rho$, and any other constants you need.
2. `compute_vel(state,goal)`: This computes using the control equations above using the `state` argument, given as `(x,y,theta)` in a 3 by 1 numpy array and `goal` given in the same format as state. You will need to convert it into the coordinates specified above and in the lectures with $\rho$, $\alpha$, and $\beta$ to compute the control law.

You may implement any auxillary functions you find useful in the class.

### 3.1 Simulation

Running this in simulation is specified in the document "Using the Simulator". Specifically you will uncomment the relevant lines in the `RobotControl` class and call your implementation in the `process_measurements` function.