PATH PLANNING AND CONTROL

OVERVIEW

- Path planning and control is basically the unit which actually drives the car
- It takes the map, car position and velocity as input and gives out command signals such as throttle, steering and braking.
- The main aim is to use the data given and devise a path so the car can traverse the track in the fastest time possible and also issue command signals for the same.

THINGS I LEARNT

- Interpolation
- PID controllers - Proportional, Integral, Derivative
- Optimisation

INTERPOLATION

- Given a set of points, interpolation joins all the points by lines (straight or curved).

- There are different kinds of interpolation:
    1. Linear interpolation
    2. Quadratic interpolation
    3. Cubic interpolation
    4. And other higher degrees…

INTERPOLATION

- Linear interpolation uses straight lines (splines) to connect with the points while quadratic interpolation uses quadratic and so on

- In quadratic, the first derivative of spline at either sides of any point is equal; 1st and 2nd for cubic and so on

- We prefer to use cubic spline interpolation so that we can obatain a continuous second derivative which leads to smooth radius of curvature without any sudden changes

INTERPOLATION

- I learnt to develop a code that can perform cubic interpolation for any given set of points
- This can be done by creating a matrix of equations (point putting, slope equalisation, etc.) and performing gauss elimination
- We get the set of splines which can then be plotted using matplotlib

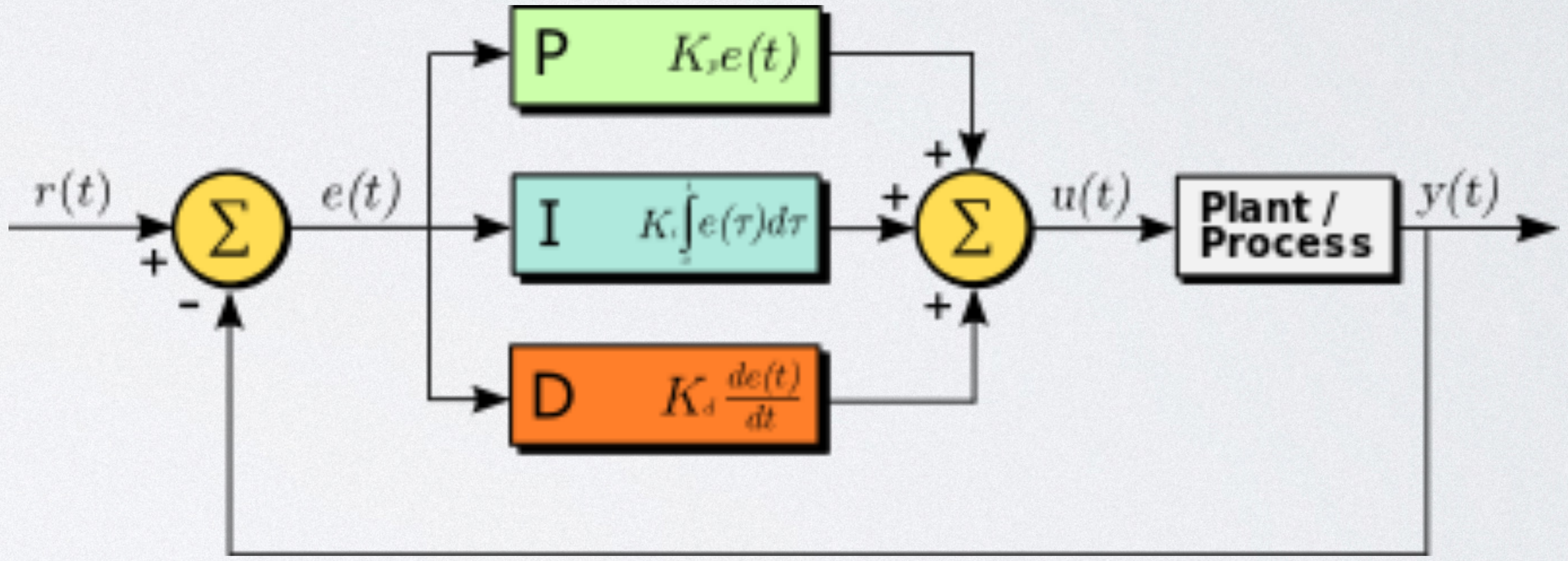
PID CONTROLLERS

- **P**roportional
- **I**ntegral
- **D**erivative

- These controllers control a set of output variables using a feedback mechanism

- In a system we have a output variable with a certain desired value

- The error value (desired-current) is calculated for each iteration which is then processed to send out a new command signal accordingly



PROPORTIONAL

- Returns a value proportional to the current error of a system
- Takes into account the "current" state of the system to send out command signals

$$P = K\,e(t)$$

INTEGRAL

- Sums the error with each iteration
- Eliminates constancy- constant value of error leads to constant output from P controller
- Takes into account the “past” of the system

$$F = K \int e(t)\, dt$$

DERIVATIVE

- Calculates the rate of change of error with each iteration

- Used to prevent offshoot at the desired value of output variable

- Takes into account the “future” of the system

$$F = K \frac{de(t)}{dt}$$

OPTIMISATION

- Optimisation relates to manipulate input variables so as to bring the output variables as close as possible to desired values while adhering to some specific constraints.

- Two broad types of methods:
  1. Gradient based
  2. Gradient free

GRADIENT BASED METHODS

- For continuously derivable and non-noisy functions.
- We slowly move in the direction of the derivative till we reach a minima/maxima
- Can only find a local minima/maxima

GRADIENT FREE METHODS

- Can be used for discrete/noisy functions
- Exhaustive search: look at all of the points in the dataset(very expensive)
- Genetic algorithm: starts with random points and scores them according to objective function. Reproduces new candidates from suitable initial candidates.
- Particle swarm: Same as genetic but also takes into account the i)direction of previous best particle, ii)direction of current best particle and iii)the position and velocity of parent particles

THANK YOU!