Motions and Control

Of

Marine Vehicles

DEN462E

Final Project

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All codes are available at this link =
https://colab.research.google.com/drive/1cgLylFj6bw7QvXkZtWvzpenKtEA6KIfe?usp=sharing

Final Project;

Your final project is a continuation of your term project. Using the same set of ship properties (assigned during the term project), you are expected to keep the target heading angle at $\psi_t = 0°$. Previously, you have only used P controller. This time you are expected to use the following controllers in order:

a. PI controller
b. PD controller
c. PID controller

Try to find the best K_I and K_D constants for your case. After doing this, write down the differences you observe for each, compared to the P controller case. Use the following equation for PID control:

$$\delta_s^t = K_P[\psi_c - \psi_t] + K_I[(\psi_c - \psi_t) + (\psi_c - \psi_{t-1})] - K_D[\psi_t - \psi_{t-1}]$$

Given values;

s1	s2	s3	s4	s5	s6
m	knots	L	deg	%	deg/s
115	14	3.25	35	40	0.5

Given values and calculated values from previous project;

Lenght = L = 115 #m

speed_fwd = u = 7.2016 #m/s

speed_loss = 0.4

Steadt_Speed = u_std = 0.45*u #m/s

std = 3.25 #L

Steady_Turning_Diameter = dtc = L*std #m

Steady_Turning_Radius = rtc = dtc/2 #m

rudder_angle = 35 #deg

rb = 0.5 #deg/s

Answer;

In this project I followed these steps;

1- Re-generate my previous code, adding “$\delta s\ t = KP\ [\psi c - \psi t\ ] + KI\ [(\psi c - \psi t\ ) + (\psi c - \psi t{-}1\ )] - KD[\psi t - \psi t{-}1\ ]$” this formula.

2- Adjusting KD and KI values to try to find the best KI and KD constants for my case.
3- Wrtited down the differences I observed for each, compared tto the P controller case.

All graphs;

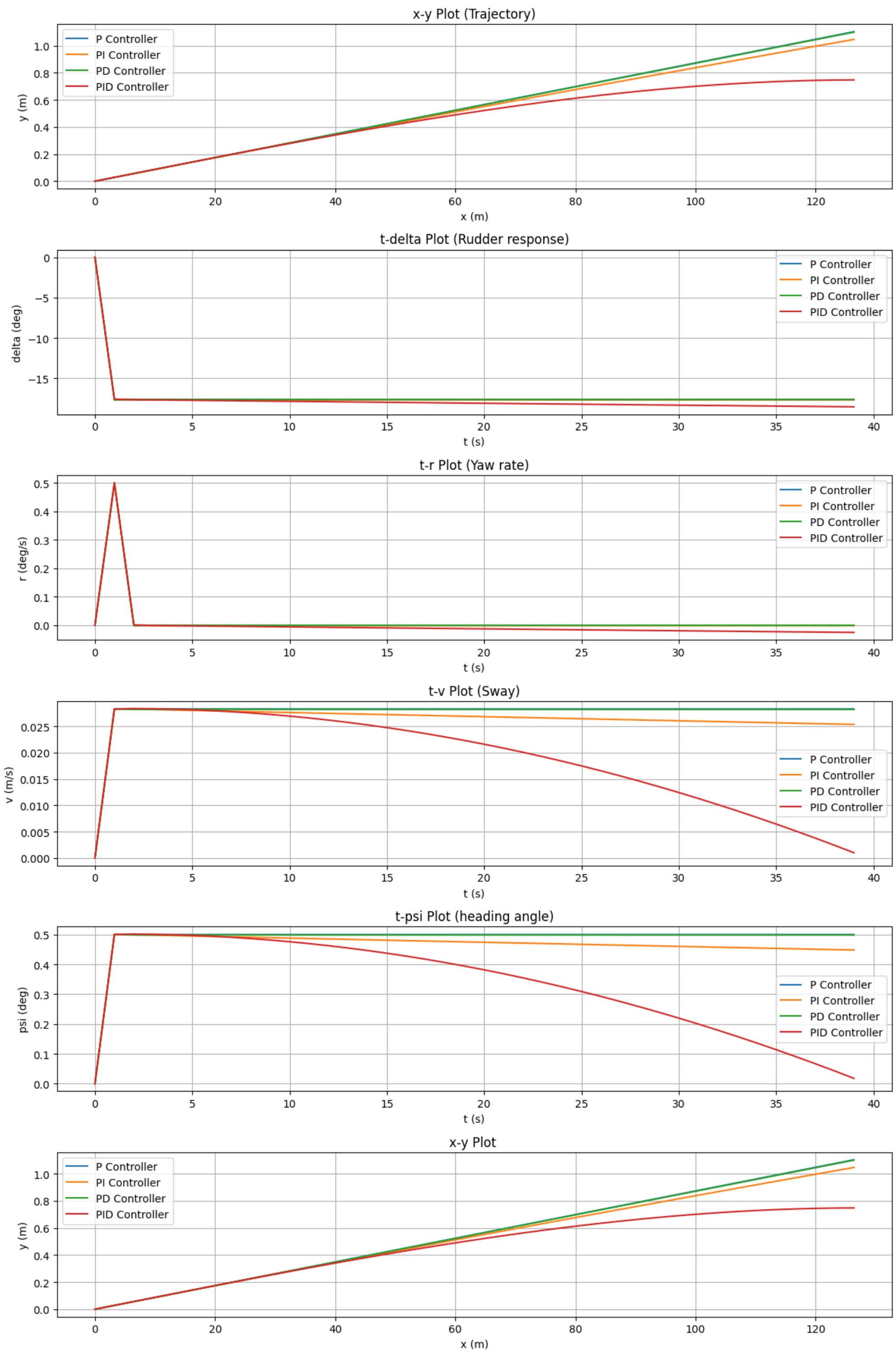

Figure 1. All the graphs

PI Controller:

- It was observed that the equilibrium error decreased faster due to a higher gain of integration (KI),

- It became clear that a high KI value can lead to over-correction of the equilibrium error over time and cause overshooting,

- PI provides a faster stabilization, but some overreaction can be observed.

PD Controller:

- A higher derived gain (KD) value provides a fast correction response.

- Due to the fast response time, the balance error is reduced more quickly.

- A high KD value can cause excessive pulsations and vibrations.

PID Controller:

- Balancing is achieved using both integral (KI) and derived (KD) gains, as can be seen from the formula,

- The balancing error is quickly reduced and a more stable balance is achieved,

- It provides a more balanced and precise control compared to PI and PD controllers,

To sum up;

It can be seen that P, PI, and PD controllers are observing the generally same movement, while the PID controller is acting differently, in general. Integral gain, abbreviated KI, establishes the impacts of the integral component and accounts for accumulated error to eliminate the steady-state error. KD, or derivative gain, stabilizes the system by considering how the error changes. The reason why controllers are moving differently is KI and KD values. These 2 values are directly affecting PID's movement. In the heading angle graph PID controller forces to ship into 0 value which is good. In the end, I decided that KI = 0.05 and KD = 0.1.

About graphs;

1. x-y Plot (Trajectory): According to the controller types (P, PI, PD, and PID), this graph illustrates the impact of the controller outputs in x and y coordinates. The path the vehicle takes is represented by a trace for each sort of controller. The PID controller draws a nicer trace than the others.

2. t-delta Plot (Rudder response): This graph shows how, for each controller type, the steering angle (delta) at the controller outputs varies over time. For each controller type, the time-varying delta value is displayed.

3. t-r Plot (Yaw rate): This graph illustrates how each type of controller's yaw rate (r) at the outputs varies over time. The shift in direction of the watercraft is referred to as the yaw rate. The graph displays each controller type's time-varying value of r.

4. t-v Plot (Sway): This graph depicts how the lateral velocity (v) at the controller outputs changes over time depending on the controller type. Lateral velocity is the horizontal motion of a watercraft. The graph depicts how the value of v changes over time for each controller type.

5. t-psi Plot (heading angle): For each controller type, this graph depicts how the heading angle (psi) at the controller outputs evolves. The heading angle describes how the boat is oriented. The graph depicts the evolution of the psi value of each controller type over time.

6. x-y Plot: This graph depicts the influence of controller outputs in x and y coordinates based on controller type. Each controller type has a trace that represents the path the watercraft takes. The graph depicts the motion of the watercraft, which is comparable to the others.

These graphs demonstrate how the motion of the vehicle is impacted by various controller types. Because it can adjust to the goal value more quickly than other controller types, the PID controller performs better than the others.