

Tutorial 6

Question 6 Motion Issues (Robotics)

- (a) What is feed forward compensation? Why is feed forward compensation extensively used in multi-axis robot servo control? (6 marks)
- (b) With reference to a typical servo loop control block diagram in a multi-axis robot with rotary joints, explain how feed forward compensation is used to (i) counteract the gravitational force, (ii) to reduce the centrifugal force effect, and (iii) reduce the trajectory error during acceleration and deceleration. (12 marks)
- (c) For a multi-axis robot, trajectory motions performed in one axis will affect the motion dynamics of the other axes. Based on your answer in (b) show how feed forward compensation can be used to decouple motion interferences between axes. Assume that the multi-axis robot has 3 rotary joints. (7 marks)

Feedforward Compensation

Add additional compensation in the forward path of a feedback servo system. The signal comes from the command, and not from the feedback sensor device.

Why it is extensively used in robotics

- Due to the structure of robots, there is always coupled interferences between axis
- The structure, kinematics of the robot is known before hand. Therefore the right amount of feedforward compensation can be predicted
- Most of the compensation signals are derived from the derivatives of position (e.g. velocity, force). Obtaining these information from the command (rather than the sensor) is more noise free
- Due to practical restrictions, putting too many sensors on a robot is not feasible

NO. (6) b

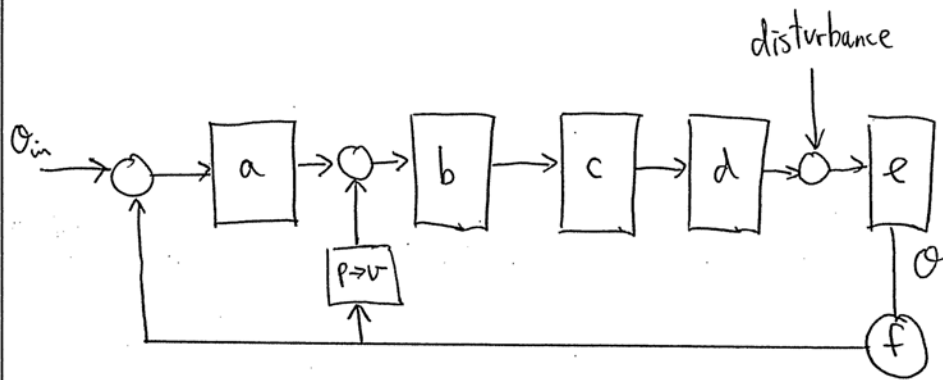
A robotic servo drive (one axis)

- a : position controller
- b : velocity controller
- c : current (force) drive
- d : motor
- e : load
- f : position encoder

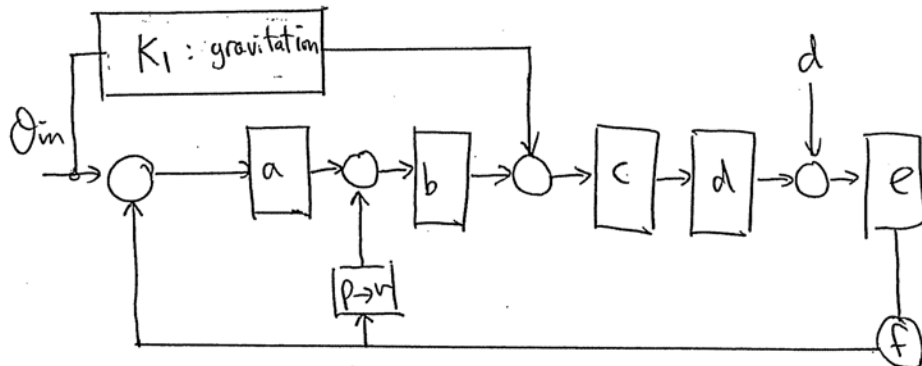
$P \rightarrow V$: position to velocity conversion

$K_1 \dots K_n$: kinematic translation

$V \rightarrow a$: velocity to acceleration conversion

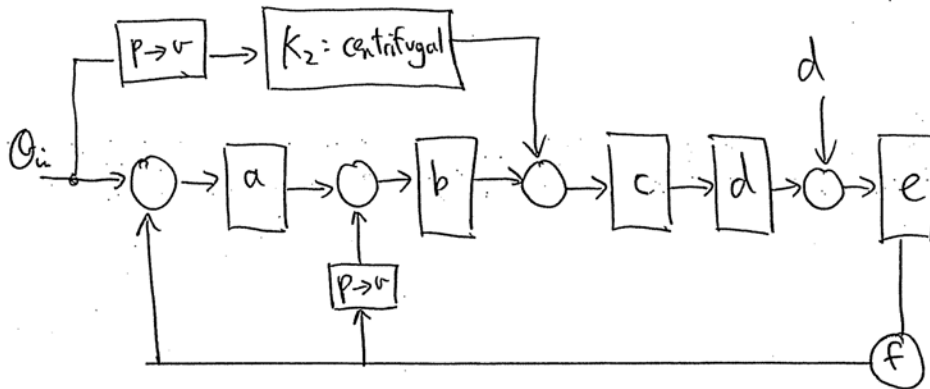


normal servo loop



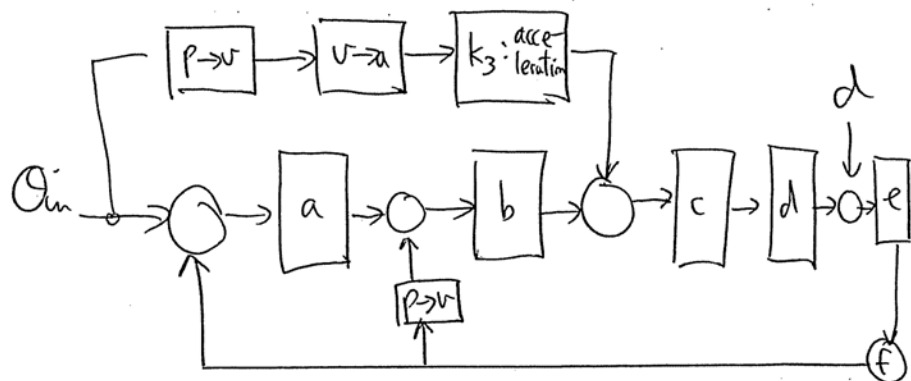
gravitation f.f. compensation

(add explanation)



centrifugal velocity
f.f. compensation

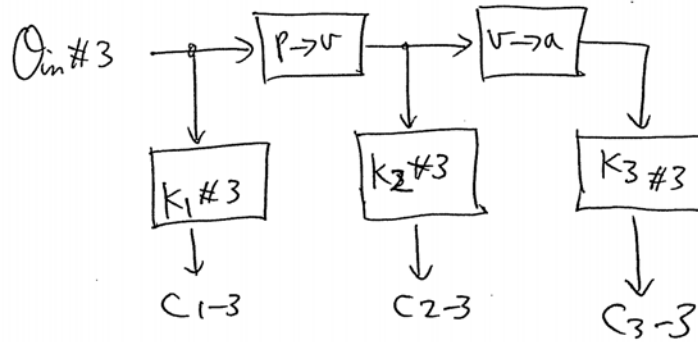
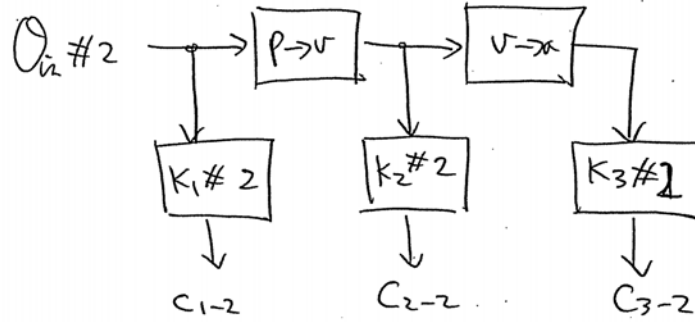
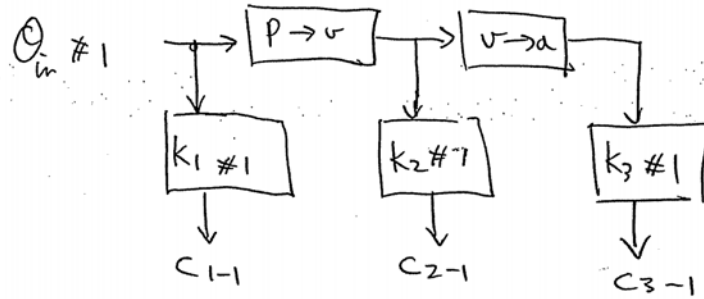
(add explanation)



acceleration/deceleration
f.f. compensation

(add explanation)

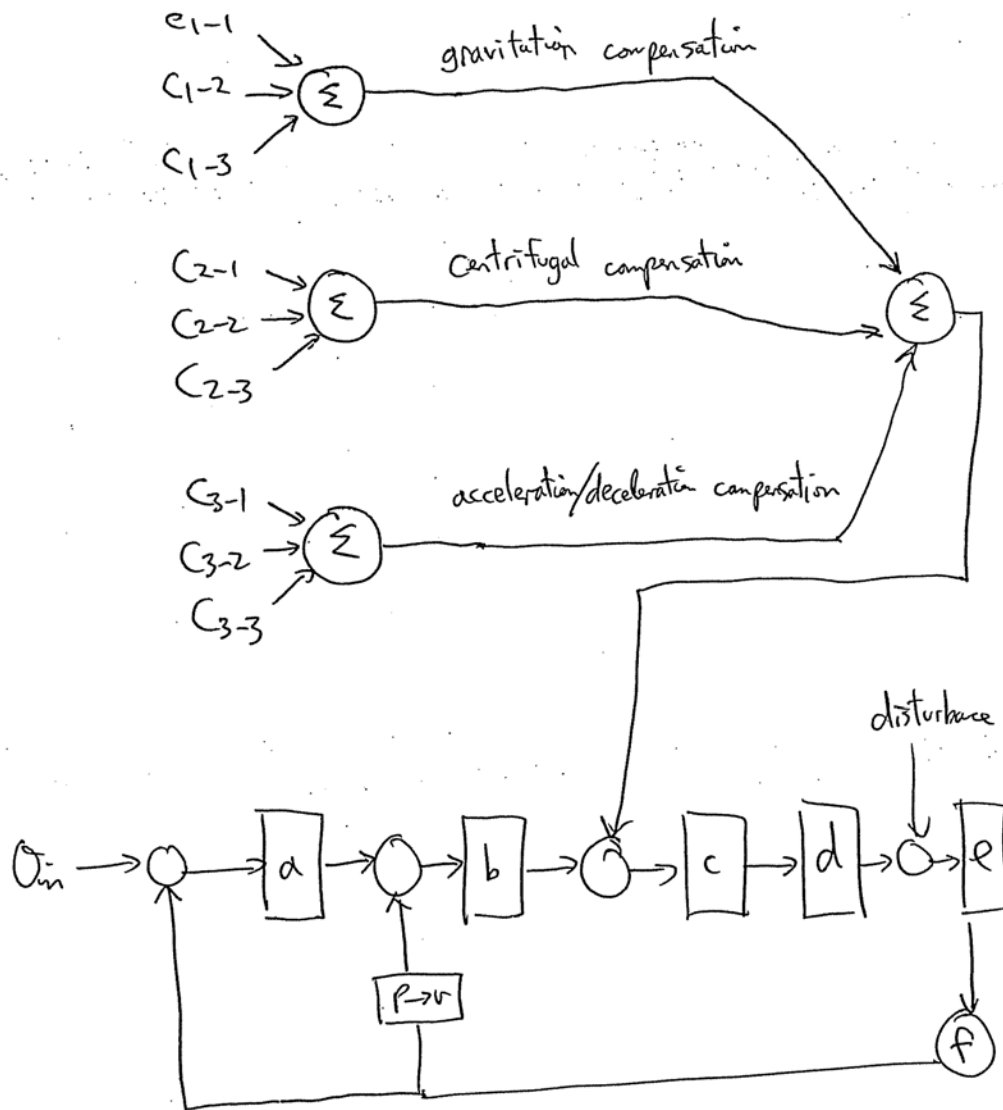
For axis #1 of a 3 axis robot, to compensate and decouple the centrifugal force, gravitational force, and acceleration/deceleration force.



functional blocks
to obtain the
compensation values

(P.T.O.)

(add more explanation)



putting ff compensation into the control loop.

(add explanation)