ISE 589-006 Introduction to Modern Industrial Automation

Homework Assignment 1

Due: February 2nd, 2023

In industrial automation, sensors are an essential component of a system's performance. Sensors can measure temperature, pressure, or any physical properties and help ensure the system works efficiently. This homework assignment focuses on sensors and how they are used to optimize performance in industrial automation.

Problem 1. **(20 points)**

The Baxter robot manipulator is a revolutionary innovation in industrial robotics. It is an intuitive, reliable, and affordable robot manipulator that can be used for various applications, including pick-and-place operations, machine loading and unloading, assembly operations, parts sorting, and testing. The Baxter robot has two arms- a six-axis articulated arm and a more straightforward four-axis articulated arm- to allow it to perform manipulation tasks efficiently. Its advanced sensors provide precise feedback on its position and path accuracy so it can carry out its task even in challenging environments. Additionally, the Baxter robot is highly safe to work around as it stops automatically if it detects unexpected physical contact with a human or object. With its user-friendly interface, the Baxter robot can easily be programmed and adjusted to fit any application's needs.

Figure 1 Baxter Robot

Given the following desired task:

1. Detecting the presence of the part
2. Detecting the location and orientation of the part
3. Detect the velocity of the workspace.

Determine the best sensors for completing each of the above tasks—things to consider contact vs. non-contact, material properties, performance, and accuracy.

Problem 2. **(25 points)**

To detect an object, a proximity sensor could be the best option. Proximity sensors use radio frequency or infrared waves to detect objects in the vicinity without any physical contact. This makes them ideal for quickly and accurately determining an object's presence. Additionally, they can detect several objects at once and quickly integrate them into existing robot designs. Given the following datasets, which sensor is best suited to detecting an object 2 m away and why? Things to consider, error, range, linearity, etc. (Please show your work)

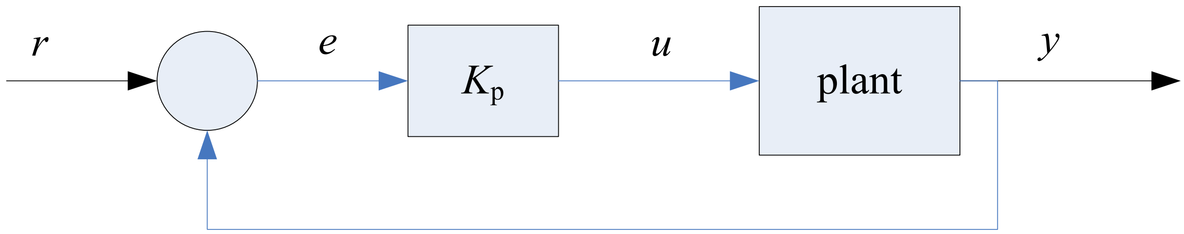
Ideal (m)	**Sensor 1 (m)**	**Sensor 2 (m)**
0	-0.022566824	0.194624823
3.16E-30	-0.022566824	0.194624823
0.06	0.037433176	0.254624823
0.12	0.097433176	0.314624823
0.18	0.157433176	0.374624823
0.24	0.217433176	0.434624823
0.3	0.277433176	0.494624823
0.36	0.337433176	0.554624823
0.42	0.397433176	0.614624823
0.48	0.457433176	0.674624823
0.54	0.517433176	0.734624823
0.6	0.577433176	0.794624823
0.66	0.637433176	0.854624823
0.72	0.697433176	0.914624823
0.78	0.757433176	0.974624823
0.84	0.817433176	1.034624823
0.9	0.877433176	1.094624823
0.96	0.937433176	1.154624823
1	1.099967936	1.263146896
1.06	1.159967936	1.323146896
1.12	1.219967936	1.383146896
1.18	1.279967936	1.443146896
1.24	1.339967936	1.503146896
1.3	1.399967936	1.563146896
1.36	1.459967936	1.623146896
1.42	1.519967936	1.683146896
1.48	1.579967936	1.743146896
1.54	1.639967936	1.803146896
1.6	1.699967936	1.863146896
1.66	1.759967936	1.923146896

1.72	1.819967936	1.983146896
1.78	1.879967936	2.043146896
1.84	1.939967936	2.103146896
1.9	1.999967936	2.163146896
1.96	2.059967936	2.223146896
2	2.055134744	2.115797507
2.06	2.115134744	2.175797507
2.12	2.175134744	2.235797507
2.18	2.235134744	2.295797507
2.24	2.295134744	2.355797507
2.3	2.355134744	2.415797507
2.36	2.415134744	2.475797507
2.42	2.475134744	2.535797507
2.48	2.535134744	2.595797507
2.54	2.595134744	2.655797507
2.6	2.655134744	2.715797507
2.66	2.715134744	2.775797507
2.72	2.775134744	2.835797507
2.78	2.835134744	2.895797507
2.84	2.895134744	2.955797507
2.9	2.955134744	3.015797507
2.96	3.015134744	3.075797507
3	2.953854402	3.245836247

Problem 3. **(25 points)**

We are using the following data acquired from the sensor. Derive a first-order system model G(s) from the response time. Hint determine the steady-state value (Gss) and rise time tau (63.2%) of the final value by plotting the data Excel, MATLAB, etc. We will discuss Kp, the proportional controller, in future lectures.

$$G(s) = \frac{\text{Gss}}{\tau s + 1}$$



time (s)	output
0	0
3.16E-30	1.58E-28
2.01E-04	1.00E-02
0.001206	0.059923
0.006229	0.301971
0.026229	1.153579
0.046229	1.850817
0.066229	2.421667
0.086229	2.889039
0.106229	3.271691
0.126229	3.584981
0.146229	3.84148
0.166229	4.051484
0.186229	4.223421
0.206229	4.364191
0.226229	4.479443
0.246229	4.573804
0.266229	4.65106
0.286229	4.714312
0.306229	4.766099
0.326229	4.808498
0.346229	4.843211
0.366229	4.871632
0.386229	4.894901
0.406229	4.913953
0.426229	4.92955
0.446229	4.942321
0.466229	4.952776
0.486229	4.961336
0.506229	4.968345
0.526229	4.974083
0.546229	4.978781
0.566229	4.982627
0.586229	4.985776
0.606229	4.988355
0.626229	4.990466
0.646229	4.992194
0.666229	4.993609
0.686229	4.994767
0.706229	4.995716
0.726229	4.996493
0.746229	4.997128

0.766229	4.997649
0.786229	4.998075
0.806229	4.998424
0.826229	4.99871
0.846229	4.998944
0.866229	4.999135
0.886229	4.999292
0.906229	4.99942
0.926229	4.999525
0.946229	4.999611
0.966229	4.999682
0.986229	4.999739
1	4.999773

Problem 4. **(30 points)**

Describe the sensor technologies in the following article:

Bin picking for ship-building logistics using perception and grasping systems

Cordeiro, A., Souza, J. P., Costa, C. M., Filipe, V., Rocha, L. F., & Silva, M. F. (2023). Bin Picking for Ship-Building Logistics Using Perception and Grasping Systems. *Robotics*, *12*(1), 15. https://doi.org/10.3390/robotics12010015