Take Home Examination

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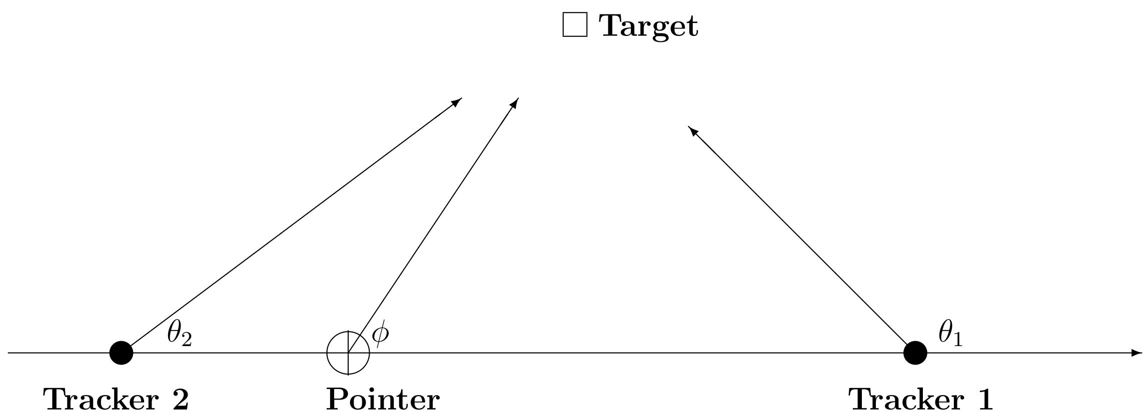
- **The take home examination considers a target tracking control problem in which a set of image trackers attempts to estimate the position of the target while the laser pointer is to control its axis to point to the target based on the measurements from the trackers. Such an example can be seen in industrial control and air defense.**
- **For simplicity, the two-dimensional problem is considered.**
- **The trackers are located at $(50, 0)$ and $(-20, 0)$ while the laser pointer is located at $(0, 0)$. The angles are defined so that 0 degree is to the positive x direction and 90° is to the positive y direction.**

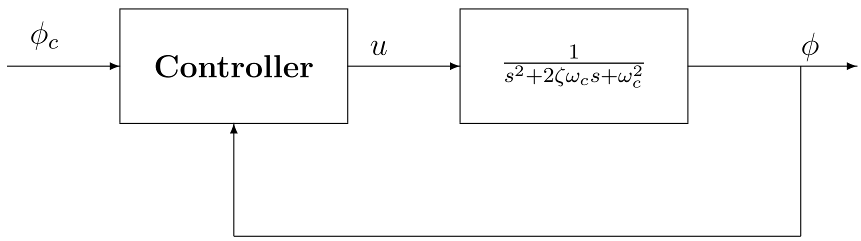


- **Each tracker can measure the angle with respect to the target. Such measurements are subject to noise. The first problem is to estimate the trajectory of the target as a funciton of time (by applying the Kalman filter technique). The measurements of the trackers are provided in the attached file `data.mat` which can be loaded into matlab. Here, `tracker1` contains the time (`tracker1.time`) and the angle measurement θ_1 (`tracker1.angle`) with respect to the target. The time is in the unit of sec and the angle is in radian. In the data, an `NaN` stands for not-a-number which means that the measurement is not available. Similarly, `tracker2` contains the time and angle measurement θ_2 of the second tracker. The first homework is to estimate the trajectory of the target. Your homeowrk report should contain (at least) the estimated target position (in x and y) as a function of time and the variance of each estimated position.**
- **The second problem is to control the laser pointer to point to the target. The angle of the laser pointer is related to the angle command by a second order system**

$$\ddot{\phi} + 2\zeta\omega_c\dot{\phi} + \omega_c^2\phi = u$$

where u is the control signal and ϕ is the angle of the pointer. The feedback control sytsem is depicted in the following figure in which ϕ_c is the command.

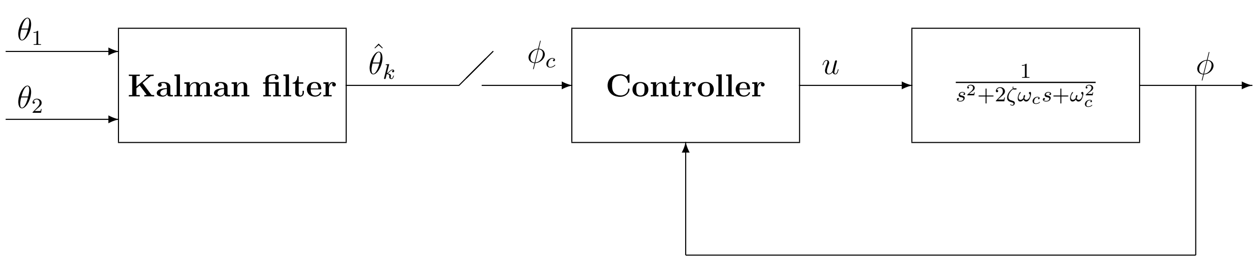
Suppose that $\zeta = 0.2$ and $\omega_c = 0.8$, design an output feedback controller so that the steady-state error (with respect to step input) is zero and the settling time is as small as possible.



- Tune the controller so that the zero steady-state error and settling time performance are accpetable when $0.1 < \zeta < 0.3$ and $0.5 < \omega_c < 1.2$. Complete the table:

Condition	Steady-state error	Settling time
$\zeta = 0.2$ and $\omega_c = 0.8$		
$\zeta = 0.1$ and $\omega_c = 0.5$		
$\zeta = 0.1$ and $\omega_c = 1.2$		
$\zeta = 0.3$ and $\omega_c = 0.5$		
$\zeta = 0.3$ and $\omega_c = 1.2$		

- Combine your Kalman filter and controller as shown in the figure in which $\hat{\theta}_k$ is the estimated angle from the pointer at time instant k. As the control system is in continuous time and the filter is in discrete-time, you may have to insert a sampling and hold in between. Now at any time instant, if both measurements are available and the control response is also available, you will then be able to find three points that correspond to the intersections, forming a triangle. Compute the area of the triangle at every time instant.



- The homework report is due on December 15, 2015.

Final Oral Presentation

- **Find a paper (or several papers) and make a report.**
- **The paper is from IEEE Transactions from 1999 - 2015.**
- **The title of the paper should contain (robust or robustness) plus (control).**
- **Please send your paper to me first.**
- **The final oral presentation is scheduled on December 29, 2015 and January 5, 2016.**