ECE-CT580 Spring 19-20
Homework/Reading Week 3-4

Lecture Material:
Go over posted notes in Week 3 and 3 folder:

- L1-KF
- L2-KF
- K3-Kf
- **Read paper** Understanding the Basic Kalman filter
- **Review** Kalman filter Applications to the point we covered
- **From Week 3 go over the material in the zip file especially**
    - Simple FIR filter,
    - CTDTS - make sure you have the notes for state space from lecture lectuee

Familiarization with Arduino Mega 2560 – this is to be done by each student but you can collaborate with your partner to make sure you have an unserstanding

- Read the material in the zip file Timer_Interrupt_Info, it contains the following:
    - Article on timers interrupts
    - Dr. Peter's lecture on Timers interrupts
    - Code I found using an interrupt time example
    - **Remember to cross check with the Arduino Website** https://www.arduino.cc/ **to resolve any questions or discrepancies**
    - **Some of this material may talk about UNO vs MEGA 2560 so be careful**

HW Problems (these two are individual effort problems)

1) Using the paper Understanding the Basic Kalman filter, write a set of briefing slides that shows the appropriate equations for figures 1 thru 5. This can be hand written or a cut and paste – remember to cite the paper.
2) Fill in the details for equations 10 thru 13 in the paper Understanding the Basic Kalman filter. It might be informative to plot the curves.

Coding Problems: (you can collaborate with your partner – you can turn in the same or different code but cite partner on the cover sheet

Instructor Problem 1: Interrupt with timer

Using the Arduino write a program that computes uses the timer based interrupt. A few ideas follow or you can generate your own.

First some comments/constraints

- Pick a time Ts such as 2ms .or 5 ms. – we want the interrupt to occur every Ts
- Make sure you do not use timers and pins that are associated with timing mills() micros()
- There are issues using SerialPrintln() in the ISR
- Make sure you use global variables

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Idea list (read them all since some comments may go across projects)

1) **RC filter Difference equation**. Implement the DTS solution of the RC filter to a step and plot the results. So the ISR does the update every Ts seconds. Save the data in an array. Make sure you pick a Ts that does not overflow the memory in the Mega Ts = 0.1 may be a good first choice to duplicate the result shown in Week 3. You can explore the use of the Serial Plotter to print it out at the end.

2) **Implement the nulling filter with a sine wave input as discussed in Week 1 Lecture notes.** You need to think about how to do this very carefully. Make sure you don't have an overrun in the ISR if you put the sinewave generator and filter together. For this case you can make the interrupt as long as needed to get over any issues but scale the equations correctly.

3) Blinking LED. This uses the notion of polling. In the main loop check a global variable, if it is high turn on a green led and turn off a red let. If it is low swap led states. In the IRS have a global variable that changes state eqch time the ISR is entered. Select the interrupt interval (Ts) so you can see the LEDs Human perception is about 0.1 sec so pick say 2. Design the main loop so that the system only executes say 100 times.

4) **Multiple timer interrupts.** Design a system that produces multiple timer based interrupts. For example each interrupt is say 2 ms long but interrupt 2 starts at 0.5ms after interrupt 1 and interrupt 3 starts at 1 ms after interrupt 1. You need to figure a way to show this. Slowing it down and haveint lts turn on and off may be one method.

5) Your choice of something that demonstrates timer-based interrupts

Instructor Problem 2: Steady State Kalman filter performance

- Using the notes Kalman filter Applications, duplicate the results shown on pg 21 and 22 using Matlab. Comment out the state prediction and correction equations.
- Return using a larger measurement noise covariance try doubling the standard deviation, what happened, try with a smaller standard deviation (divide by 2) what happens? Present results in a table.

What to turn in:

Document your code with your name, date, sketch/program name, what it does and anything important. Cut and paste into document that shows all code Also include outputs from serial printer if used.

A single document in pdf form with

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- Header page (see next page)
- Answers to HW 1 and HW 2
- Code and discussion for Instructor problems remember to name your partner. Include the schematic/hookup of what you did for Instructor 1 if appropriate.

Keep these Sketches and knowledge of your wiring/setup from instructor problems

Cover sheet follows

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Please submit the filled in cover sheet as the first page of you HW submission.

Last Name:_____ First Name:_____

Students must indicate the status of each problem by:

- **C:** completed,
- **P:** Partially completed,
- **N:** not attempted

Instructor Problem

Problem	Status	Grade/Comments
HW 1 Briefing slides		
HW 2 Details of eq 10 thru 13		
Coding 1 Interrupt via Timer		Partner
Coding 2 Kalman filter With table		Partner

Final Score:_(10 points)