MHRD SCHEME ON GLOBAL INITIATIVE OF ACADEMIC NETWORKS (GIAN)

Soft Sensor Development using State & Parameter Estimation Techniques and their Applications
11.07.2022 – 16.07.2022

Organized by Department of Instrumentation Engineering, MIT Campus, Anna University, Chennai-44
Venue : Educational Multimedia Research Centre (EMMRC), CEG Campus, Anna University, Chennai-25

Last Date for Registration 31.05.2022

Course Overview

This 1-credit course consisting of 20 lecture hours and 10 tutorials (10 hours), for a period of 1-week, jointly by Professor Bhushan Gopaluni (University of British Columbia, Canada) and Professor J. Prakash (Department of Instrumentation Engineering, Madras Institute of Technology Campus, Anna University) is intended to introduce students (UG, PG and Research Scholars) and practitioners the recent developments that have taken place in the area of soft sensing using state & parameter estimation schemes. This course will help students and practitioners to design and implement soft sensors using linear and non-linear state and parameter estimators.

Who should attend this course?

The course is suitable for Under-graduate and Post-graduate students in Engineering, Engineers working in industry, faculty members and Research Scholars.

Course Objectives

This short course covers all the essential theoretical and practical aspects of soft sensing and state & parameter estimation schemes. The specific objectives are as follows:

- To introduce technical terms and nomenclature associated with soft sensing using state & parameter estimation schemes.
- To lay foundation for the systematic approach to design and implement state and parameter estimators for linear systems using Kalman filter.
- To design and implement state and parameter estimators for non-linear systems using Kalman update based filters such as extended Kalman filter, unscented Kalman filter and ensemble Kalman filter.
- To design and implement state & parameter estimators for non-linear systems using Particle filters.
- To design and implement state & parameter estimators for constrained non-linear systems using moving horizon estimation schemes and constrained Kalman update based filters.
- To design and implement state & parameter estimators for non-linear systems using EM algorithm and Gaussian-sum filters.
- To design and implement multiple-model approach based non-linear state and parameter estimation scheme for non-linear systems.

Pre-requisites & Schedule

Basic knowledge of Probability & Statistics, Linear Algebra, Signal Processing, Random Processes and Process Control System. The following topics will be discussed in this 1-week course:

Day	Time	Session	Topic
11/07/2022 Monday Day-1	08.30 AM - 08.45 AM		Inaugural Function
	08.45 AM - 09.45 AM	Lecture-1	Overview of soft sensing and state & parameter estimation schemes and their applications in Process Systems Engineering **Prof. Bhushan Gopaluni**
	09.45 AM - 10.45 AM	Lecture-2	State and parameter estimation scheme for linear systems – Introduction to Bayesian State Estimation **Prof. Bhushan Gopaluni**
	10.45 AM - 11.45 AM	Lecture-3	State and parameter estimation scheme for linear systems – Introduction to Least-squares estimator **Prof. J. Prakash**
	12.15 PM - 01.15 PM	Tutorial-1	Hands-on session/Discussions/ Solving assignments/Quiz on the Topics covered in Lecture-2 **Prof. Bhushan Gopaluni / Prof. J. Prakash**
	01.15 PM - 02.15 PM	Tutorial-2	Hands-on session/Discussions/ Solving assignments/Quiz on the Topics covered in Lecture-3 **Prof. J. Prakash**
12/07/2022 Tuesday Day-2	08.30 AM - 09.30 AM	Lecture-4	State and parameter estimation scheme for linear systems - Kalman filter Derivation – Part-1 **Prof. Bhushan Gopaluni**
	09.45 AM - 10.45 AM	Lecture-5	State and parameter estimation scheme for linear systems - Kalman filter Derivation – Part-2 **Prof. Bhushan Gopaluni**
	10.45 AM - 11.45 AM	Lecture-6	State and parameter estimation scheme for non-linear systems – Extended Kalman filter **Prof. J. Prakash**
	12.15 PM - 01.15 PM	Tutorial-3	Hands-on session/Discussions/ Solving assignments /Quiz on the Topics covered in Lectures-4 & 5 **Prof. Bhushan Gopaluni / Prof. J. Prakash**
	01.15 PM - 02.15 PM	Tutorial-4	Hands-on session/Discussions/ Solving assignments /Quiz on the Topics covered in Lecture-6 **Prof. J. Prakash**
13/07/2022 Wednesday Day-3	08.30 AM - 09.30 AM	Lecture-7	Introduction to Particle filters **Prof. Bhushan Gopaluni**
	09.45 AM - 10.45 AM	Lecture-8	Design of Soft Sensors– Case Studies **Prof. Bhushan Gopaluni**
	10.45 AM - 11.45 AM	Lecture-9	State and parameter estimation scheme for non-linear systems – Unscented Kalman filter **Prof. J. Prakash**
	12.15 PM - 01.15 PM	Tutorial-5	Hands-on session/Discussions/ Solving assignments/Quiz on the Topics covered in Lectures-7 & 8 **Prof. Bhushan Gopaluni/ Prof. J. Prakash**
	01.15 PM - 02.15 PM	Tutorial-6	Hands-on sessions/Discussions/ Solving assignments / Quiz on the Topics covered in Lecture-9 **Prof. J. Prakash**
14/07/2022 Thursday Day-4	08.30 AM - 09.30 AM	Lecture-10	Constrained state and parameter estimation schemes – Moving Horizon Estimation. **Prof. Bhushan Gopaluni**
	09.30 AM - 10.30 AM	Lecture-11	Industrial case studies will be presented to demonstrate the power and utility of soft-sensing and state & parameter estimation schemes. **Prof. Bhushan Gopaluni**
	10.45 AM - 11.45 AM	Lecture-12	State and parameter estimation scheme for non-linear systems - Ensemble Kalman filter. **Prof. J. Prakash**
14/07/2022 Thursday Day-4	12.15 PM - 01.15 PM	Tutorial-7	Hands-on session/Discussions/ Solving assignments/Quiz on the Topics covered in Lecture-10 **Prof. Bhushan Gopaluni / Prof. J. Prakash**
	01.15 PM - 02.15 PM	Tutorial-8	Hands-on session/Discussions/ Solving assignments on the Topics covered in Lecture-12. **Prof. J. Prakash**
15/07/2022 Friday Day-5	08.30 AM - 09.30 AM	Lecture-13	EM algorithms for state and parameter estimation – Part-1 **Prof. Bhushan Gopaluni**
	09.30 AM - 10.30 AM	Lecture-14	Constrained state and parameter estimation schemes– Constrained Kalman updated based filters – Part-1 **Prof. J. Prakash**
	10.45 AM - 11.45 AM	Lecture-15	Constrained state and parameter estimation schemes– Constrained Kalman updated based filters – Part-2 **Prof. J. Prakash**
	12.15 PM - 01.15 PM	Tutorial-9	Hands-on session/Discussions/ Solving assignments on the Topics covered in Lecture-13 **Prof. Bhushan Gopaluni / Prof. J. Prakash**
	01.15 PM - 02.15 PM	Tutorial-10	Hands-on session/Discussions/ Solving assignments on the Topics covered in Lectures-14&15 **Prof. J. Prakash**
16/07/2022 Saturday Day-6	08.30 AM - 09.30 AM	Lecture-16	EM algorithms for state and parameter estimation – Part-2 **Prof. Bhushan Gopaluni**
	09.30 AM - 10.30 AM	Lecture-17	State and parameter estimation scheme for non-linear systems - Gaussian-sum filters **Prof. J. Prakash**
	10.45 AM - 11.45 AM	Lecture-18	Multiple-model approach based non-linear state and parameter estimation scheme and its applications – Part-1 **Prof. J. Prakash**
	12.15 PM - 01.15 PM	Lecture-19	Multiple-model approach based non-linear state and parameter estimation scheme and its applications – Part-2 **Prof. J. Prakash**
	01.15 PM - 2.15 PM	Lecture-20	Summary of the Topics Covered in this Course **Prof. J. Prakash**
	02.15 PM - 02.45 PM		Valedictory Function & Course Feedback

Lunch break: 11.45 AM -12.15 PM

Course Registration

Procedure to be followed to register for the 'Soft Sensor Development using State & Parameter Estimation Techniques and their Applications" GIAN course:

Step 1: The registration for this course is only possible through the GIAN web portal. GIAN course registration fee is Rs 500/- (One time payment needed to register the participant details under GIAN and makes the participant eligible to register for any course/courses listed in GIAN).

Step 2: For "Soft Sensor Development using State & Parameter Estimation Techniques and their Applications" course registration, select "Soft Sensor Development using State & Parameter Estimation Techniques and their Applications" while doing the course registration.

Step 3: The course coordinator will shortlist the participants based on the merits of the application and will send separate e-mails to the shortlisted candidates.

Step 4: On receiving the email, the Participants should send the completed registration form (registration format will be shared in mail) with DD to the course coordinator. The course registration fee is as follows:

Student (UG/PG/Research Scholars) : Rs. 1000/-
Faculty Members : Rs. 2000/-
Industry/Research Organization : Rs. 3000/-

The above fee is towards participation in the course, and the course material.

Step 5: The registration fee would be collected in the form of Demand Draft (DD) drawn in favour of **"The Director CTDT, Anna University"** payable at chennai.

Faculty

Ratna Bhushan Gopaluni (M'08) received the B.Tech. degree in Chemical Engineering from the Indian Institute of Technology Madras, Chennai, India, in 1997, and the Ph.D. degree in Chemical Engineering from the University of Alberta, Edmonton, AB, Canada, in 2003. From 2003 to 2005, he worked as an Engineering Consultant at Matrikon Inc. (now Honeywell Process Solutions), during which he designed and commissioned multivariable controllers in British Columbia's pulp and paper industry, and implemented numerous controller performance monitoring projects in the Oil & Gas and other chemical industries. He is currently a Aprofessor with the Department of Chemical and Biological Engineering and an Associate Dean for Education and Professional Development in the Faulty of Applied Science at The University of British Columbia, Vancouver, BC, Canada. He is also an Associate Faculty in the Institute of Applied Mathematics, the Institute for Computing, Information and Cognitive Systems, Pulp and Paper Center and the Clean Energy Research Center. He was the Elizabeth and Leslie Gould Teaching Professor from 2014 to 2017. He is currently an Associate Editor for the Journal of Process Control, The Journal of Franklin Institute and guest editor for process control series at the Canadian Journal of Chemical Engineering. He specializes in data analytics for process industry and has authored over 90 refereed articles in reputed international journals and conferences. Dr. Gopaluni is the recipient of several awards the Province of Alberta Graduate Fellowship, the Captain Thomas Farell Graduate Memorial Scholarship from the University of Alberta, and the prestigious Killam Teaching Prize and the Dean's service medal from The University of British Columbia.

Faculty & Course Coordinator

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