FOUNDATIONS OF CYBER PHYSICAL SYSTEMS

PROF. SOUMYAJIT DEY
Department of Computer Science and Engineering
IIT Kharagpur

PRE-REQUISITES : 1. Basic Programming Knowledge
2. Engineering Mathematics

INTENDED AUDIENCE : UG/PG students of CSE/EE/ECE

INDUSTRY SUPPORT : Tier 1 Automotive companies: Robert Bosch Engineering, OEM Automotive companies: TML, BMW, Daimler, Mahindra etc, Govt Labs like DRDO, HAL

COURSE OUTLINE :

Cyber-physical systems (CPS), which consist of physical systems tightly integrated and/or controlled by software, are ubiquitous in many safety critical domains, including automotive, avionics, railways, healthcare, atomic energy, power, and industrial automation. The principles of design and implementation of cyber-physical systems are remarkably different from that of other embedded systems because of the tight integration of real valued and dense time real time systems with software based discrete automated control. The objective of this course is to develop an exposition of the challenges in implementing a cyber-physical system from a computational perspective, but based equally on the principles of automated control. The course aims to expose the student to real world problems in this domain and provide a walk through the design and validation problems for such systems. With the advent of Al techniques, their increased use in CPS is also a promising growth vertical along with the necessity of safety assurance. In this course we also touch upon concepts of Neural Network based decision making for Continuous Systems while guaranteeing safety and stability using control theoretic constraint solving.

ABOUT INSTRUCTOR :

Prof. Soumyajit Dey joined the dept. of CSE, IIT Kgp in May 2013.He worked at IIT Patna as assistant professor in CSE dept. from beginning of Spring 2012 to end of Spring 2013. He received a B.E. degree in Electronics and Telecommunication Engg. from Jadavpur University, Kolkata in 2004. He received an M.S. followed by PhD degree in Computer Science from Indian Institute of Technology, Kharagpur in 2007 and 2011 respectively. His research interests include 1) Synthesis and Verification of Safe,Secure and Intelligent Cyber Physical Systems, 2) Runtime Systems for Heterogeneous Platforms. More specifically, as part of his second research interest, he works on building GPGPU application scheduling frameworks considering both a) embedded real time applications, and b) GPGPU cluster level workloads. He has been successfully running a popular course titled “High Performance Parallel Programming” http://cse.iitkgp.ac.in/~soumya/hp3/hp3.html) in CSE IITKGP for the last three years jointly with Prof. Pralay Mitra.

COURSE PLAN :

Week 1:
i. Cyber— Physical Systems (CPS) in the real world: Industry 4.0, Automotive, Building Automation, Medical CPS
ii. Low power compute platforms for CPS
Week 2: Real time sensing and communication for CPS
i. Sensors, Actuators
ii. CAN protocol in automotive systems
Week 3:
i. Real time task scheduling for CPS
ii. Worst Case Execution Time, Res ponse time analysis of CPS software
Week 4:
i. Dynamical System modeling for CPS
ii. Different notions of stability
Week 5:
i. Controller Desig n (using pole placement)
ii. Delay aware Controller Design
Week 6:
Stability and Control Performance in presence of Platform uncertainties
Week 7:
i. Lyapunov Stability
ii. Barrier Functions
Week 8:
Quadratic Program based Controller Design ensuring Safety and Stability
Week 9:
Neural Network (NN) Based Controllers in CPS
Week 10:
Safety of NN enabled CPS: switching between NN and conventional controllers
Week 11:
State Estimation using Kalman Filter and other techniques
Week 12:
i. False Data Injection (FDI) Attack detection in CPS
ii. Attack Mitigation in C