Proposal for a New Course

Department of Computer Science and Engineering
Indian Institute of Technology, Kanpur

Course number: IS202
Course title: Fundamentals of Data Engineering – Part III (Things)
Course prerequisites: ESC202
Course credits: [12] (2-0-6-0)
Course duration: Full semester
Course type: DC
Proposing instructors: Purushottam Kar and Indranil Saha
Other faculty members interested in teaching the course:
Other departments interested in the proposed course: None

Course description:
a. *Objectives*: Interfacing with cyberphysical devices is a critical step in building autonomous systems. This course will introduce techniques to interface with cyberphysical devices using Python libraries as well as controlling virtual robotic agents using simulators. The course will also offer hands-on experience in conducting small-scale experiments involving cyberphysical data sources and agent simulators.
b. *Logistics*: The course will serve as a DC for IS UG students (BT, double major), and as a DE for PG students (MT, MS, PhD) of the CSE and IS departments and CSE UG students (BT, double major, ML minor). The course may be offered one or more times every academic year depending on demand and availability of resources.
c. *Content*: There will be an equivalent of 24 lectures of 50 minutes each and 24 labs of 3 hours each. A weekly breakup of lecture and lab content is given below.
d. *Evaluation*: Evaluation will use a combination of graded lab exercises, lab exams, take- home assignments and projects, and traditional sit-down quizzes and exams.

Weekly breakup of content: Numbers in square brackets [] against each topic indicate the number of lectures/labs for that topic.

Lecture content (24 lectures):
1. Cyberphysical systems (CPS) [3]:
    a. Introduction: physical process/plant sensors, controllers, actuators, IoT “edge” devices, smart devices and assistants (Alexa, Echo, Nest)
    b. Communication: types of media, interconnections between CPS devices, device-to-device messaging protocols such as MQTT
    c. Applications: sensing aspects of CPS, data collection from physical processes and processing via embedded devices, CPS applications and vulnerabilities

2. Introduction to Computer Architecture Design [18]:
    a. Fundamentals of Digital Logic [3]: Boolean algebra, combinational and sequential circuits, number representation and computer arithmetic (fixed and floating point)
    b. Basic building blocks for the ALU [3]: Adder, Subtracter, Shifter, Multiplication and division circuits.
    c. Processor [6]: Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards.
    d. Memory [3]: Memory technologies, Memory hierarchy: register file, cache, main memory and secondary storage
    e. I/O interfaces [3]
3. Simulators [3]: Introduction to robotics simulators e.g. ROS, Gazebo.

Lab content (24 labs):

1. Single-board computers (SBC) [8]
    a. Familiarization: popular SBCs e.g., Arduino, Raspberry Pi, system-on-chip (SoC)
    b. Physical interface: use of breadboards, jumper wires, ports, data lines and power lines, connecting external components such as sensors, actuators, best practices e.g., avoiding/detecting short-circuits or loose connections
    c. Digital interface: reading datasheets, Python-based IDEs to interface with SBCs by reading digital inputs, reading analog inputs, sending commands
2. App development [6]
    a. Simple “Hello World”-style apps such as creating an array of blinking LEDs
    b. Pipelining SBC data into pretrained AI/ML models to create apps
    c. Reading time series data from an air-quality sensor via SBC, building a web app detecting elevated particulate matter levels, say due to incense burning
3. Familiarization with simulators and agent programming [10]
    a. Introduction to robotics simulators such as ROS, Gazebo
    b. Controlling simulated autonomous virtual robotic agents

Lab equipment: PCs with internet connectivity and appropriate software (browsers, Python runtime with libraries, and robotics simulators, software to interface with cyberphysical systems etc) will be needed. Lego Mindstorms kits and device packages will need to be procured with Raspberry Pi/Arduino units (for instance [link]), AQ sensors say PM sensors, cameras, and peripherals such as breadboards, jumper cables, resistors, LEDs, antennae, etc. The number of device packages will be decided keeping in mind class strength. Extra packages will be acquired to account for spontaneous device malfunction, deterioration etc.

Short summary for inclusion in the Courses of Study booklet: The course will introduce techniques used to interface with cyberphysical systems.

Textbook: There will be no textbook for this course.

Course proposer: Purushottam Kar and Indranil Saha
Date:

Convener DPGC:
Date:

The course is approved/not approved

Chairperson, SPGC
Date: