Demande d'habilitation d'un Mastère

"International Master of Science on Cyber Physical Systems"

Pour la période : 2020-2021 / 2023-2024

Programme détaillé de la formation

SEMESTRE 1

UEF111: Theory and Algorithms

Course description:

It covers methods to construct algorithms and to analyze algorithms mathematically for correctness and efficiency (e.g., running time and space used). The course starts with definitions of algorithmic efficiency, discusses powerful paradigms for algorithm design, defines the theory of NP-completeness, and presents current approaches for coping with intractability, including approximation and randomized algorithms.

Course objectives:

The main objectives are:

Introducing of formal techniques to support design and analysis of algorithms.

Emphasizing on both the underlying mathematical theory and practical considerations of efficiency. Asymptotic analysis of time complexity. Algorithms and advanced data structures for searching and sorting lists, Graph algorithms, Complexity of algebraic operations, Introduction to complexity theory.

Content:

Basics of Algorithm Analysis.:

1 Preliminaries

2 mathematical background,

3. Notations: Big-O notation Omega, and Theta

4 algorithms analysis.

Recursion and Induction: Recursive procedures, proofs by Induction, recursion trees

Sorting:

1 Insertion search,

2 selection sort, Quicksort,

3 merge sort,

4 heapsort,

5 low bound of comparison of keys, 6 comparison of sorting algorithms, 7 shellsort,

8 Radix sort.

Graphs algorithms:

1 Definition and implementations,

2 Searching, connected components,

3 Topological sorts,

4 path problems,

5 spanning trees,

6 Network Flow,

7 Matching.

Algorithm Design techniques:

1 Greedy algorithm,

2 divide and conquer,

3 dynamic programming,

4 randomized algorithms.

Introduction to complexity Theory:

1 Complexity classes P and NP,

2 NP-completeness,

3 some NP-complete problems.

UEF112: Optimization

Course description:

The course presents some of the major techniques used for optimization and discusses multi-objective optimization problems, in which two methods will be explained to deal the multiple objectives. The decomposition of larger problems into smaller ones is illustrated in multilevel optimization. A brief outline of direct and indirect search methods will be given next. The importance of evolutionary algorithms and steps involved will be elaborated with special emphasis on genetic algorithms. The applications of these methods in various domains will be outlined toward the end of this module.

Course objectives:

The main objectives of this course are:

1. Understand and analyze the existence of an optimization problem.
2. Apply and code a wide range of exact and heuristic methods to provide practical solutions for various optimization problems.

Content:

Linear programming

1 Modelling
2 Solvers

Mixed integer linear programming

1 Characteristics
2 Modelling

Combinatorial optimization problem:

1 Travelling salesman problem

2 Assignment problem

3 Bin Packing problem

4 Set covering problem

5 VRP

6 Cutting Problems

7 NP-Completeness

Exact methods:

1 Branching Methods
2 Dynamic Programming

Metaheuristics:

1 Local search methods,

2 Evolutionary algorithms,

3 Hybrid algorithms,

4 Other algorithms.

Multi-objective Optimization:

1 Modelling,

2 Resolution method,

UEF121: Big Data Analytics

Course description:

This course provides the basics of big data analysis. The course begins with a basic introduction to big data and discusses what the analysis of these data entails, as well as associated technical and conceptual challenges. The second part focuses on providing a theoretical and practical introduction to big data, its analysis and associated challenges. The last part of the course includes practical exercises in order to develop and present a big data concept for a specific real-world case and provide a first experience in handling and analyzing large, complex data structures.

Course objectives:

The main goal of this course is to familiarize students with big data analysis as a tool for addressing substantive research questions. The main objectives are:

1. To introduce students the fundamental concepts and characteristics of big data.
2. To introduce students to solve problems associated to big data characteristics.
3. To provide the student necessary tools to implement big data analysis theories and models.

Content:

Introduction

1. Big data: definition and taxonomy
2. Data Structures
3. Handling and Processing Big Data
4. Characteristics of Big Data - 4 V's
5. Examples of Big Data Analytics
6. Methodological Challenges and Problems

Part 2: Data Analytics Lifecycle

1. Data Analytics Lifecycle Overview
2. Phase 1: Discovery
   a. Learning the Business Domain
   b. Resources
   c. Framing the Problem
   d. Identifying Key Stakeholders
   e. Interviewing the Analytics Sponsor
   f. Developing Initial Hypotheses
   g. Identifying Potential Data Sources
3. Phase 2: Data Preparation
   a. Preparing the Analytic Sandbox
   b. Performing ETLT
   c. Learning About the Data
   d. Data Conditioning
   e. Survey and Visualize
4. Phase 3: Model Planning
   a. Data Exploration and Variable Selection
   b. Model Selection
5. Phase 4: Model Building
6. Phase 5: Communicate Results

7. Phase 6: Operationalize

Part 3: Advanced Analytical Theory and Methods

Association Rules

1. A priori Algorithm
2. Evaluation of Candidate Rules
3. Applications of Association Rules
4. Validation and Testing
5. Diagnostics

Regression

1. Linear Regression
    a. Use Cases
    b. Model Description
    c. Diagnostics
2. Logistic Regression
    a. Use Cases
    b. Model Description
    c. Diagnostics

Classification

1. Decision Trees
    a. Overview of a Decision Tree
    b. The General Algorithm
    c. Decision Tree Algorithms
    d. Evaluating a Decision Tree
2. Naive Bayes
    a. Bayes' Theorem
    b. Naive Bayes Classifier
    c. Smoothing
    d. Diagnostics
3. Diagnostics of Classifiers

Case of Text Analysis

1. Text Analysis Steps
2. A Text Analysis Example
3. Collecting Raw Text
4. Representing Text
5. Term Frequency-Inverse Document Frequency (TFIDF)
6. Categorizing Documents by Topics
7. Determining Sentiments
8. Gaining Insights

<u>Students' coursework (practical part)</u>

– Students will work on a real dataset problem an apply all steps of analysis

Part 4: Advanced Analytics-Technology and Tools

MapReduce and Hadoop

1. Analytics for Unstructured Data
    a. Use Cases
    b. MapReduce
    c. 70.7.3 Apache Hadoop
        - The Hadoop Ecosystem
        - Pig

- Hive
- HBase
- Mahout

2. NoSQL

In-Database Analytics

1. SQL Essentials
   a. Joins
   b. Set Operations
   c. Grouping Extensions
2. In-Database Text Analysis
3. Advanced SQL
   a. Window Functions
   b. User-Defined Functions and Aggregates
   c. Ordered Aggregates

UEF122: Software engineering

Course description :

This course provides advanced training in computer science engineering to design, understand, develop and maintain complex software systems. It includes the following topics: agile methods (scrum, XP, UP….), software requirements, project management, verification and validation and testing, computer aided software (case tools), software measurements, software quality.

Course objectives:

The main objectives of this course are:

1. allowing a general understanding of software process models such as unified processes and agile methods.

2. allowing also the understanding of software requirements and the SRS documents.

3. Understanding of the role of project management including planning, scheduling, risk management, etc.

4. Describe data models, object models, context models and behavioural models.

5. Understanding of different software architectural styles

6. Understanding of approaches to verification and validation including static analysis, and reviews.

7. Understanding of software testing approaches such as unit testing and integration testing.

8. Describe software measurement and software risks.

9. Understanding software evolution and related issues such as version management.

10. Understanding quality control and how to ensure good quality software.

Content:

Introduction

- Goals of software engineering
- Basic principles of software engineering methods
- Software quality criteria
- Motivation for requirement engineering
- Motivation for testing

<u>Students' coursework (Internet search)</u>

- Student will use Internet resources to prepare presentations on the testing techniques and also choose one of the case tools to learn

Part 2: Requirement specification

- Study the SRS documents
- How to write well written requirements
- How to write the requirement specification document

<u>Students' coursework (practical part)</u>

- Students will analyze some requirements of well-known IT projects
- They will have to evaluate requirements, their quality and how to improve them
- They will also write a specification document for an example

Part 3: Verification and validation and Testing

Software testing

- Types of tests
- Examples of tests
- Studying different Test tools

<u>Students' coursework (practical part)</u>

- Students will study several test tools such as Selenium using a large set of inputs.

Part 4: Agile methods

- Scrum roles
- Scrum examples
- Scrum principles

<u>**Students' coursework (practical part)**</u>

- Students will apply the agile method scrum on some examples
- Use of scrum tools such as icescrum or orangescrum
- XP principles
- XP explanation
- Up and Rup principles

<u>**Students' coursework (practical part)**</u>

- Students will apply the UP method on some examples

UEF131: Cloud Computing

Course description:

This course aims to provide an overview of cloud computing where fundamental and advanced concepts are introduced. Topics include cloud deployment models, cloud system architectures and X-as-a-Service notion, cloud storage and management, virtualization and resource management. Privacy issues and Security concepts including common cloud security threats and risks are also covered. Students will use and explore cloud computing platforms developed by Google, Amazon and Microsoft. Examples of cloud programming paradigms such as Hadoop's MapReduce are covered. Students are also exposed to recent research topics on cloud computing and carry on presentation on these issues.

Course objectives:

The main objectives of this course are:

1. To introduce various fundamental concepts, technologies and tools of cloud computing.
2. To familiarize students with various cloud computing platforms.
3. To introduce latest tools and technologies used for developing and deploying cloud applications.
4. To provide students with needed knowledge of recent research issues in cloud computing.

Content:

Introduction

- Cloud Computing Fundamentals
  - Basic Concepts and Terminology
  - Goals and Benefits
  - Risks and Challenges
  - Historical developments
  - Cloud enabling technology

Cloud Computing Architecture

- Cloud Characteristics
- Standard cloud model
- Cloud Deployment Models
- Cloud Service Models(XaaS)
- Open cloud services

Cloud Data Storage

- Requirements of data-intensive computing
- Challenges before Cloud Native File System
- Map Reduce Programming Model for High-Performance Processing of Large Data-sets
- Cloud Native File System (general parallel file system, Google file System, …)
- Storage Deployment Models
- Database in the Cloud
- Database-as-a-Service
- Relational DBMS in Cloud
- Non-relational DBMS in Cloud (NOSQL DBMS)
- Commercial NoSQL Databases

Parallel Programming in the Cloud

- fundamental aspects of parallel and distributed programming models.
- Map Reduce
- Spark
- Hadoop

Virtualization

– Virtualization reference model.
– Virtualizing Physical Computing Resources
– Machine/Server Level Virtualization
– Hypervisor
– Operating System Level Virtualization
– High-Level Language Virtual Machine
– Emulation
– Other types of virtualization
– full virtualization and paravirtualization
– Pros and cons of virtualization
– Virtualization security threats and recommendations
– Server virtualization products and vendors
– Virtualization and cloud computing

Cloud and Resource Management

Resource Management

– Policies and mechanisms
– Scaling in the cloud
– Capacity planning
– Load Balancing
– Resource utilization and energy efficiency
– Scheduling algorithms for the cloud

Cloud Management

– Cloud management tools
– Cloud management standards
– Share of management responsibilities
– Cloud service management
– SLA management
– Disaster Recovery in Cloud

Cloud Security

Cloud Security Fundamentals

– Basic Terms and Concepts
– Privacy and Privacy Impact Assessment
– Cloud Security Threats and Risks
– Security of database services
– Operating System Security
– Virtual Machine Security
– Security of Virtualization
– Cloud security mechanisms

Security Reference Model

- Cloud Security Working Groups
- Elements of Cloud Security Model
- Cloud Security Reference Model
- Security Policy
- Trusted Cloud Computing

Cloud Platforms in industry

- Amazon Web Services (AWS)
- Google Cloud and App Engine
- Windows Azure

UEF132: Wireless Communication Networks

Course description:

This Course introduces a comprehensive overview of different Wireless Communication Networks Technology and Standards with an emphasis on the following topics: Satellite Communication Networks, Cellular Wireless Networks, Cordless Systems and Wireless Local Loop, Mobile IP and Wireless Access Protocol, Wireless Local Area Networks Technology (WLANs), Wi-Fi and IEEE Wireless LAN Standards, Bluetooth and IEEE Standards, Personal Area Networks (PANs) and Ad hoc networks.

Course objectives:

This Course aims to enhance the skills of graduate level students in the field of Wireless Communication Networks Technology and Standards, so that, they become able to define future research directions and topics in this field.

Content:

Part 1: Introduction & Technology Background

- Wireless Comes of Age
- The Global Cellular Network
- The Mobile Device Revolution
- Future Trends
- The Trouble With Wireless
- Transmission Fundamentals
- Communication Networks
- Protocols and the TCP/IP Suite

Part 2: Wireless Communication Technology

Overview of Wireless Communication

- Spectrum Considerations
- Line-Of-Sight Transmission
- Fading in the Mobile Environment
- Channel Correction Mechanisms
- Digital Signal Encoding Techniques
- Coding and Error Control
- Orthogonal Frequency Division Multiplexing (OFDM)
- Spread Spectrum

The Wireless Channel

- Antennas
- Spectrum Considerations
- Line-Of-Sight Transmission
- Fading in the Mobile Environment
- Channel Correction Mechanisms

Signal Encoding Techniques

- Signal Encoding Criteria
- Digital Data, Analog Signals
- Analog Data, Analog Signals
- Analog Data, Digital Signals

Orthogonal Frequency Division Multiplexing (OFDM)

- Orthogonal Frequency Division Multiplexing
- Orthogonal Frequency Division Multiple Access (OFDMA)
- Single-Carrier FDMA

Spread Spectrum

- The Concept of Spread Spectrum
- Frequency Hopping Spread Spectrum
- Direct Sequence Spread Spectrum
- Code Division Multiple Access

Coding and Error Control

- Error Detection
- Block Error Correction Codes
- Convolutional Codes
- Automatic Repeat Request

Part 3: Wireless Local and Personal Area Networks

Wireless LAN Technology

- Overview and Motivation
- IEEE 802 Architecture
- IEEE 802.11 Architecture and Services
- IEEE 802.11 Medium Access Control

Wireless LAN Technology (cont.,)

- IEEE 802.11 Physical Layer
- Gigabit Wi-Fi
- Other IEEE 802.11 Standards
- IEEE 802.11I Wireless LAN Security

Bluetooth and Ad Hoc Networks

- The Internet of Things
- Bluetooth Motivation and Overview
- Bluetooth Specifications
- Bluetooth High Speed and Bluetooth Smart
- IEEE 802.15
- ZigBee
- IEEE 802.11 Ad Hoc Networks

Part 4: Wireless Mobile Networks and Applications

Cellular Wireless Networks

- Principles of Cellular Networks
- First-Generation Analog
- Second-Generation TDMA
- Second-Generation CDMA
- Third-Generation Systems

Fourth Generation Systems and LTE-Advanced

- Purpose, Motivation, and Approach to 4G
- LTE Architecture
- Evolved Packet Core
- LTE Resource Management
- LTE Channel Structure and Protocols
- LTE Radio Access Network
- LTE-Advanced

Mobile Applications and Mobile IP

- Mobile Application Platforms
- Mobile App Development
- Mobile Application Deployment
- Mobile IP

Long Range Communications

- Satellite Parameters and Configurations
- Satellite Capacity Allocation
- Satellite Applications 546
- Fixed Broadband Wireless Access
- WiMAX/IEEE 802.16
- Smart Grid

UEF141: Real-Time Systems

Course description:

The course addresses basic concepts of real-time systems, presents examples of real-time systems, covers real-time systems analysis and design, and gives an in-depth treatment of timing analysis and scheduling. The course is organized around the issue of real-time requirements and their impact on the architecture of a system.

Course objectives:

Student will be able to summarize the issues in real time computing, and explain and give examples of real time operating systems. Student will be able to solve scheduling problems and can apply them in real time applications in industry. Student can also design an RTOS and will be able to interpret the feasibility of a task set to accomplish or not. Analyze the situation of fault occurrence and will be able to apply solutions accordingly.

Content:

Part 1: Introduction

- Structure of real time system
- Need for RTOS Task classes
- Performance measures for real time system: Properties, traditional performance measures, performances, hard and soft deadlines, and Estimating program run times.

Part 2: Real time software

- Embedded software architectures
- Real time operating system: Tasks and task states, shared data and reentrancy
- Difference between pre-emptive and non-pre-emptive tasks

Part 3: Task Scheduling

- Scheduling algorithms: round robin, round robin with interrupts, real time operating system selection,
- CPU scheduling algorithms priority scheduler and the monotonic schedulers
- dynamic scheduling methods: the LST scheduler and the EDF scheduler
- Priority Scheduling, Priority Ceiling and Priority inheritance
- Real time operating system: Tasks and task states, shared data and reentrancy
- semaphores and shared data

Part 4: Real Time Specification

- Overview on the most popular methods of real time specification
- SART analysis
- UML analysis

UEF142: Sensors and actutors

Course description:

This course studies actuators and sensors commonly used in the design of Embedded Systems. A balance between the modeling / analysis and the hardware implementation of these various devices is emphasized. Actual Embedded systems from industry and academia are used to demonstrate actuator and sensor use. Actuators studied include: brushed dc motors, stepper motors, brushless dc motors, solenoids, hydraulic and pneumatic actuators.

Analog and digital sensors studied include: optical encoders, Hall-effect sensors, potentiometers, variable-inductance transducers, permanent magnet transducers, eddy-current transducers, variable-capacitance transducers, and piezoelectric transducers. Smart sensors and actuators are discussed.

Course objectives:

The main objectives of this course are :

1. to equip students with the knowledge and understanding of the operating characteristics and design of a range of sensors and actuator.
2. To learn the various sensors used to measure various physical parameters.
3. to familiarize them with the integration of sensors and actuators into appropriate control systems

Content:

Part 1: Introduction

General Concepts and Terminology,

- Measurement systems,
- Transducers, sensors and actuators, - Signal conditioning and display,
- Interfaces, data domains, and conversion,
- Sensor Characteristics

Part 2 Basis of selection of sensor type

General Input and Output Configuration:

- Interfering and modifying inputs,

Static Characteristics of Measurement Systems,

- Accuracy
- Precision
- Sensitivity,
- Other characteristics: Linearity and resolution,
- Systematic errors,
- Random errors,

Dynamic Characteristics,

- Zero-order measurement systems,
- First-order measurement systems,
- Second-order measurement systems

Other Sensor Characteristics,

- Input characteristics: Impedance, reliability,

Part 3: Sensor types

MOTION, PROXIMITY AND RANGING SENSORS

- Motion Sensors
- Potentiometers, Resolver, Encoders
- Optical, Magnetic, Inductive, Capacitive, LVDT

– RVDT

– Microsyn, Accelerometer.

,– GPS, Bluetooth, Range Sensor

– RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

Signal Conditioning for Resistive Sensors /

– Measurement of Resistance,
– Voltage Dividers,
  Potentiometers,
  Application to thermistors,
  Dynamic measurements,
  Amplifiers for voltage dividers
– Wheatstone Bridge: Balance Measurements
– Wheatstone Bridge: Detection Measurements

FORCE, MAGNETIC AND HEADING SENSORS

- Strain Gage
- Load Cell
- Magnetic Sensors

– Current sensor.

- Inclinometers.

Resistive Sensors

Potentiometers

Strain Gages

– Fundamentals: Piezoresistive elect
– Types and applications,

Resistive Temperature Detectors (RTDs)

Thermistors

– Models
– Thermistors types and applications,
– Linearization

Magneto resistors

Resistive Hygrometers

Resistive Gas Sensors

Liquid Conductivity Sensors

- Smart Sensors , MEMS & Nano Sensors,

Part 4: actuators
Basic Concepts of Actuators

-Electrical actuator (working and application).

  DC motors
  Ac Single-phase motor
  AC poly phase motor.
  Servo Motor
  Stepper motors.

- Hydraulic & Pneumatic actuators (working and application)
  Types of Cylinder.

Direction control valve.

Part 5 Micro-actuators

micro-actuators with different input energies and how they are used

.Electrostatic

• Electro-magnet based

• Thermal

• Chemical

• Piezo-electric

• Shape memory alloy (SMA)

• Smart material-based

• Light-induced

• Electrostatic micromotors

• Electrostatic comb-drive

• Thermal microactuators

• Surface-tension driven fluidic actuators

Part 6: integration of sensors and actuators with embedded systems

integration of sensors and actuators with embedded systems

UET111 : Project Management

Course description:

Avoir une idée sur les concepts du management de projets selon le Project Management Institute (PMI) - Savoir appliquer les concepts du management de projets sur des projets informatiques.

Content:

Chapitre I : Le management de projet selon le PMI

Chapitre II : Management de l'intégration

Chapitre III : Management du contenu

Chapitre IV : Management des délais

Chapitre V : Management des coûts

Chapitre VI : Management de la qualité

Chapitre VI : Management des ressources humaines

Chapitre VII : Management de la communication

Chapitre VIII : Management des risques

Chapitre IX : Management des approvisionnements

UET112: Communication Skills

Course description:

This course is dedicated essentially to prepare students to pass the exam of English skills certification (TOEFL for example)

UEO111: CyberSecurity (privacy and data integrity)

Course description:

As specialized computing devices and applications rapidly proliferate into many aspects of everyday life, including: automotive, household automation, computerized manufacturing, and medicine. This course covers modern security and privacy aspects in Cyber-Physical Systems (CPSs). Therefore, the main objective is for students to identify when security (confidentiality, availability and integrity) is required and to be able to choose and implement right solution in CPSs. The course includes overview of terminology and basic concepts in security and privacy, attaining familiarity with range of CPS security threats, examples of concrete attacks, risk management, security technologies and tools, cryptography, security protocols involving CPS components, security policies and standards, wireless security, intrusion detection and prevention, and selected security topics. The essence of the course concentrates on recent developments in security and privacy in CPSs. As a result of rapid development in this field, the exact list of topics is expected to change every few years.

Course objectives:

- Students can identify major types of threats, risks, attacks and vulnerabilities of information, application, and network security and privacy in Cyber Physical System environments and develop a security model to prevent, detect, and recover from them.

- Students are able to understand and examine how the major security tools, techniques, and approaches such as access control management, firewalls, anti-virus software, intrusion prevention systems, proper backups and restores management systems, and proper secure protocols work in detail for testing, monitoring, tracking and auditing of security threats and vulnerabilities of Cyber Physical Systems and how the security tools can be deployed in practice taking into account associated strengths and weaknesses

- Students can demonstrate ability to independently select and exercise the appropriate practices and technologies necessary to solve concrete problems in cyber and information security related to confidentiality (cryptographic solutions), integrity (authentication such as biometric), availability (for example, intrusion detection solutions), and privacy protection in their homes and professional environments.
- Students are able to design and develop a security architecture for Cyber Physical Systems to ensure service continuity and reliability

- Students are able to design operational security and privacy policies, strategies, and standards and practices for Cyber Physical Systems and recognize the role of management in enforcing security and privacy policies, standards and practices.

- Students can demonstrate capabilities to apply the security and privacy knowledge in new areas within Cyber Physical Systems, in particular cloud computer security, security on the Internet of Things (IoT), and security of blockchain technology applications.

- Student can describe and compare the common cryptographic encryption and decryption algorithms and the tools to ensure data integrity such as hashing, symmetric and asymmetric encryption, certificates, and methods of implementing cryptography.
- Students are able to systematically and independently solve complex problems of research and development in the field of security and privacy of Cyber Physical Systems by analyzing, formulating sub-tasks, and proposing and implementing innovative solutions.
- Students are able to identify and assess security and privacy risks in Cyber Physical System environments to mitigate, avoid, and transfer these risks.

- Students are able to understand the data attributes such as confidentiality, possession or control, integrity, authenticity, availability, and utility, any of which can make it vulnerable to attack.

UEO112: Dependability (Safety, reliability, availability)

Course description:

The course introduces the main terminology, concepts, and principles for designing, measuring, and evaluating, quantitatively, the dependability of CPSs. The main topics are covered in this course: Dependability attributes: availability, reliability, and safety and modelling and analysis approaches for dependability of CPSs. Also, the failure process and fault handling and maintenance with focusing on: first, available effective tools, metrics, and techniques for predicting the hardware and software failure rates and modelling of software failures. Second, applying the effective architectures. Furthermore, evaluating the serviceability of computer networks.

SEMESTRE 2

UEF211: Machine learning

Course description:

Machine learning can be described as the artificial generation of knowledge from experience, where an artificial system will learn from examples. The technology will not just memorize, but will recognize and learn specific patterns and laws relating to the natural phenomena.

This course provides the fundamentals of machine learning applied on image processing, pattern recognition text and video analysis. After getting the basics of machine learning by training and deploying neural networks, common aspects and architecture of deep learning applied to objects detection, text analysis and pattern recognition will be provided. Evaluation protocol and model validation are focused too.

Course objectives:

The main objectives of this course are:

1. To introduce student's fundamentals in machine learning.
2. To get skills on common machine learning models used to solve problems on image, video, text and sound.
3. To provide student experience for implementing computer vision and pattern recognition applications (web and mobile).

Content:

Part 1: Basics of machine learning

Introduction to machine learning

7. Context
8. Applications
1. Machine learning
2. Image classification : supervised learning/regression
3. Data driven approach : Representation
4. Model selection/Validation/Parameters
   • Overfitting and underfitting
   • Generalization
5. Back propagation Fundamentals

Part 2: Convolutional neural network

8. Visual Signal Perception
   a. Neural Networks for Images
   b. Convolutional layers
   c. Activation layers
   d. Softmax classifier
   e. Pooling layers
   f. Fully connected layers
   g. Loss layers
   h. Regularization
   i. Batch normalization
   j. Alexnet case study
   k. Visualizing ConvNets
   l. Transfer learning Samples

Part 3: Reinforcement learning

- Reinforcement Learning paradigm: state, environment, action, agent, reward, next step?
- Markov Decision Processes
- Q-Learning

- Solving for the optimal policy
- Gradient Descent, Stochastic Gradient Descent, Optimizers
- Case Study : modelling and Solving game
- Training a Q-network
- REINFORCE algorithm
- Recurrent Attention Model (RAM)

Part 4: Recurrent Neural Networks

1. DL with RNN for speech recognition, handwriting recognition,
2. sequence data analysis, series data
3. Details of RNN

- (Sequence to Sequence) learning,
- forward RNN,
- backward RNN,
- representation techniques
- FRNN (Fully Recurrent NN),
- LSTM (Long Short-Term Memory)
- Embedding, Projection, Word2vec, sequence-to-sequence
- RNN, NLP, Image Processing Attention, Image Captioning

Part 5: Evaluation / Cross validation

1. Class/output variables and values
2. Attribute/input variables and values
3. Supervised vs unsupervised
4. Classification vs regression
5. Training sets, testing sets, seens and unseens
6. Various types of error
7. Cross-validation protocols
8. Evaluating Performance, Energy efficiency, Parallelism, Locality,
9. Memory hierarchy, Roofline model

Part 6: Applications

- Chatbots,
- Image Classifiers,
- Object Detection,
- Autonomous Driving,
- Sentiment Analysis in Text,
- Sentiment Analysis in Speech,
- Speech Synthesis,
- Price Predictions,
- Chatbots,
- Video Classifiers,
- Action Recognition

UEF212: Computer Vision

Course description:

This course provides the fundamentals of computer vision, image processing, pattern recognition and video analysis. A first the, course covers the basics of the image formation process. Then, the course includes topics of image such as filtering, the Fourier transform, wavelets, geometric transformations and feature detection. The last part of the course is focused on motion analysis and video processing. Topics of this part include mainly: motion estimation, object detection tracking. The course presents also typical computer vision applications such as image segmentation, object recognition, face detection, vehicle and people tracking.

Course objectives:

The main objectives of this course are:

1. To introduce students fundamental problems in image processing and computer vision.
2. To introduce students the major methods, and techniques of computer vision and pattern recognition.
3. To provide the student with programming experience from implementing computer vision and object recognition applications.

Content:

Part 1: Basics of Computer Vision

Introduction to Computer Vision

9. Context
10. Applications

IMAGE FORMATION

6. Geometric primitives and transformations
   a. Geometric primitives
   b. 2D transformations
   c. 3D transformations
   d. 3D rotations
   e. 3D to 2D projections
7. Lighting
   a. Light in Space
   b. Light at Surfaces
8. Sampling and aliasing
9. Color
   a. Color Spaces
   b. Trichromacy and Color Spaces

Part 2: Image Filtering

9. LINEAR FILTERS
   m. Linear Filters and Convolution
   n. Shift invariant linear systems
   o. Spatial Frequency and Fourier Transforms
   p. Sampling and Aliasing
10. NON-LINEAR FILTERS AND FEATURES
   a. Filters as Templates
   b. Mathematical morphology: erosion and dilation
   c. Corners and Orientation Representations
   d. Advanced Smoothing Strategies and Non-linear Filters
   e. Median Filters

Part 3: Feature detection and Image segmentation

Feature detection

6. Feature descriptors

7. Feature matching
8. Edge detection
9. Lines (Hough transforms)

Texture

9. Representing Texture
10. Homogeneity
11. Synthesis by Matching Histograms of Filter Responses
12. Synthesis by Sampling

Image segmentation

1. Active contours
2. Split and merge
    a. Watershed
    b. Region splitting
    c. Region merging
    d. Graph-based segmentation

Part 4: Recognition and Classifiers

4. Geometric alignment
5. Large databases
6. Category recognition
    a. Bag of words
    b. Part-based models
7. Recognition with segmentation
8. Learning and large image collections
9. Object detection
    a. Face detection
    b. Pedestrian detection
10. Face recognition
    a. Eigenfaces
    b. Active appearance and 3D shape models

Classifiers

1. Feature Selection
2. Principal Component Analysis
3. Neural Networks
4. The Support Vector Machine

Part 5: Motion and Tracking

Motion

10. Basics: flow and correspondence
11. Optical flow-based motion estimation
12. Quadrature filter techniques
13. Correlation and matching
14. Modeling of flow

Object tracking

1. Tracking as an Abstract Inference Problem
    a. Linear Dynamic Models and the Kalman Filter
    b. Linear Dynamic Models
2. Kalman Filtering

3. Non-Linear Dynamic Models
4. Particle Filtering
5. Applications : Vehicle Tracking, Finding and Tracking People

Part 6: Video Segmentation

Segmentation by Clustering

1. Segmentation Using Simple Clustering Methods
2. Clustering and Segmentation by K-means

Segmentation by Graph-Theoretic Clustering

Applications

1. Background Subtraction
2. Shot Boundary Detection
3. Finding Skin Using Image Color

UEF221: Control Systems

Course description:

Modeling, analysis and design of cyber-physical systems (CPS). The course serves as an introductory graduate level-class for students interested in CPSs in general, and control and optimization of CPSs in specific. The fundamentals of CPSs are covered in the class, with emphasis on the control and the optimization aspects. Covered CPS topics include: linear and non-linear systems theory and design, state-estimators, fault-tolerant controllers and observers, optimal control and networked control systems

Course objectives:

Students are expected to have a good understanding of the basic principles governing CPSs' operation and a reasonable depth related to a specific CPS topic that relates to their projects:

1. state-estimation,
2. networked control systems
3. optimization
4. observer-design of linear and nonlinear systems
5. multi-time scale operation
6. CPS applications in smart-grids and robotics

Content:

Part 1: CPS Review & Background

Introduction

- Course introduction
- Prerequisites
- major applications

Part 2: Linear & Nonlinear Networked Systems

- Recent relevant theories on linear and nonlinear systems

Part 3: State Observation & Estimation of CPSs

- Dynamic state estimation of dynamic CPSs

Part 4: Optimal Control of CPS

-Linear quadratic regulator,

-optimal state-feedback control,

-principle of optimality

Part 5: Networked Control Systems

- Recent results on networked control systems
- fault detection,
- cyber-attacks

<u>Students' coursework (practical part)</u>

applications in smart-grids

UEF222: Embedded platforms

Course description:

This course is structured to combine lectures, case studies and tutorials for the students to gain an in-depth understanding of fundamental concepts and knowledge in embedded/cyber-physical systems.

This course presents an overview of: design flow, special characteristics with respect to specification techniques and modeling, embedded hardware, standard software, evaluation and validation, mapping of applications to execution platforms, optimizations and testing of embedded/cyber-physical systems.

Course objectives:

Upon completion of this course, the students should be able to: (1) understand the hardware and software components as well as their development cycles, (2) understand the deployment of embedded processors and supporting devices in real-world applications, and (3) interpret application specifications and make practical recommendations on resource selection for embedded systems.

Content:

- **Introduction to Embedded Systems**
  Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems
- **Growing importance of cyber-physical & embedded systems**
- **Common characteristics of Embedded Systems:**
  Reliability, Maintainability, Availability, Safety, Security, Efficiency
- **Application areas and examples**
  Logistics, Smart buildings, Authentication systems, Industrial automation, Medical systems, Telecommunication, Railways, Avionics, Automotive electronics
- **classifications of embedded systems**
- **Embedded system architecture**
- **Requirements for specification & modeling**
- **Appropriate models of computation**
- **Early design phases:**
  text, use cases, time-distance charts, sequence charts Time-Distance Charts -
- **Communicating finite state machines (CFSMs):**
- **dataflow:**
  scope, Kahn process networks (KPN)
  synchronous (or "static") data flow, SDF, Simulink, RTW, Labview
- **Petri nets:**
  condition/event nets, place transition predicate/transition nets, evaluation
- **Discrete Event Modelling,**
  System C, VHDL, Verylog
- **Von-Neumann langages**
  CSP, Ada,Java

- **Inputs**
  Sensors, Discretisation of time, Fourrier Approximation of signals, A/D converters
- **Processing units**
  microcontrollers, Multiprocessor Importance of energy efficiency, Special purpose HW very expensive, Energy efficiency of processors, Code size efficiency, Run-time efficiency, DSP, Multimedia processors systems on a chip (MPSoCs),Reconfigurable logic, Field programmable gate arrays (FPGAs)
- **Memories**
  Memory Hierarchies, ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems,
- **Communication**
  Embedded Communication Protocols

USB and CAN Bus
Embedded Ethernet:
Wireless Embedded Networking

- **Output**
  D/A converter, Sampling theorem, PWM
- **secure hardware**

- **Embedded C**
- **Embedded operating systems**
- **ERIKA**
- **Resource access protocols**
  (Priority inversion, Priority inheritance)
- **Embedded Linux**
  Embedded linux structure and size, Flash memory File systems, µClinux,
- **Hardware abstraction layers**
- **Middleware**
  COBRA, POSIX Threads, UPnP, DPWS
- **real-time data bases**
- **Co- Design Issues**
  Co- Design Models, Architectures, Languages, A Generic Co-design Methodology.
  Co- Synthesis Algorithms: Hardware software synthesis algorithms: hardware – software partitioning distributed system cosynthesis.
- **Prototyping and Emulation**
  Prototyping and emulation techniques,
- **Compilation Techniques and Tools for Embedded Processor Architectures**
  Modern embedded architectures, embedded software development needs, compilation technologies, practical consideration in a compiler development environment.
- **Application Specific Instruction Sets**
  Programmable Hardware FPGA – Basic Structure, FPGA - Classification
  ASICs, System-on-Chip
- Performance evaluation
- Quality Metrics
- Energy and Power Models
- Dependability and Risk Analysis (Briefly)
- Simulation
- Rapid prototyping and Emulation
- Formel verfication (briefly)
- Definition of Scheduling Problems
- Scheduling for Uniprocessors
- Scheduling for independent jobs on identical Multiprocessors
- Dependent jobs on homogeneous
- Multiprocessors
- Dependant jobs on heterogenous Multiprocessors
- High-Level Optimisations
- Task Level Concurency Mnagement
- Compiler for embedded systems
- Power and thermal management
- Test procedures
- Evaluation of test Pattern sets and system robustness
- Design for testability

UEF231 : Industrial Communication Protocols

Course description:

With the introduction of the Internet of Things (IoT) and cyberphysical system (CPS) concepts in industrial application scenarios, industrial automation is undergoing a tremendous change. This is made possible in part by recent advances in technology that allow interconnection on a wider and more fine-grained scale.

This course focuses on industrial automation networks. It builds upon knowledge and skills developed in undergraduate courses on data communication systems typically covering traditional local area network protocols such as Ethernet and higher level protocols such as TCP/IP. The major differences between industrial networks and traditional computer networks are considered in detail. Factors influencing the choice of industrial communication protocols for given applications are analyzed and Quality of Service (QoS) parameters are deduced and evaluated.

Course objectives:

On successful completion of this course students should be able to:

1. Explain the rationale behind the technological development of industrial networks from telemetry systems to modern SCADA systems
2. Identify and explain the reasons behind the differences between industrial network communication protocols and the protocols used in general computer networking.
3. Investigate the relevance and applicability of the seven layer OSI model to commonly used industrial protocols such as EthernetIP, Modbus, Profibus and DNP3
4. Compare and Evaluate the relative strengths and weaknesses of different industrial protocols for particular applications.

Select an industrial protocol and use it in an application such as building services, power systems automation, water treatment and factory automation

Content:

Part 1: Introduction

Introduction

Modern instrumentation and control systems; Open systems interconnection (OSI) model; Protocols; Standards

Part 2: Industrial Data Communication Methodology

Architectures

Common problems and solutions; General comments on troubleshooting; a specific methodology; Grounding/shielding and noise; Sources of electrical noise; Electrical coupling of noise; Shielding; Cable ducting or raceways; Cable spacing, Earthing and grounding requirements; Suppression techniques; Filtering

Wired Industrial Communications

EIA-232 Interface Standard,

EIA-485 Interface Standard

Current loop and EIA-485 converters

UEF232 : Mobile Communication NetWorks

Course description:

This course provides a comprehensive overview of the mobile communication networks. The course starts with a brief history of the mobile communications, the evolution of the mobile generation technology, and introduces the multiple access techniques. The cellular concept is also discussed in detail featuring frequency reuse, channel allocation strategies, interference management, handoff strategies, power control, traffic intensity, and cellular capacity improvement techniques. The mobile radio propagation large-scale and small-scale path losses are analyzed, and the link budget design is calculated based on different path loss and fading models. The course mainly focuses on the specifications, key features, network structures, and radio resources management of the key mobile communication systems (namely: GSM, UMTS and LTE-A).

Course objectives:

This course aims to provide the students with a basic understanding of :

1. The main principles and architectures of the existing mobile communication networks.
2. The limitations of the mobile channels (such as: handoff, interference, and capacity issues) and the currently deployed solutions.
3. The evaluation of the existing mobile communication networks capacity.
4. The requirements of the future generations of wireless systems.

Content:

Part 1: Introduction

- History of mobile communications
- Evolution of mobile radio communications
- Cellular telephone systems

Multiple Access Techniques:

- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
- Code Division Multiple Access (CDMA)
- Space Division Multiple Access (SDMA)
- Polarization Division Multiple Access (PDMA)

Part 2: System Design Fundamentals

The Cellular Concept:

- Frequency reuse
- Channel assignment strategies
- Handoff strategies
- Prioritizing handoffs
- Practical handoff considerations

Interference in Cellular Systems:

- Co-channel interference
- Adjacent channel interference
- Channel planning and frequency allocation
- Power control

Cellular System Capacity:

- Trunking and Grade of service (GOS)
- Traffic intensity
- Trunked systems (blocked calls cleared and blocked calls delayed)
- Erlang charts (Erlang B and Erlang C)
- Capacity of trunked systems

Improving Coverage and Capacity:

- Cell splitting
- Cell sectoring
- Microcell zone concept

Part 3: Mobile Radio Propagation

Large-Scale Path Loss:

- Free space propagation model
- The basic propagation mechanisms (reflection, diffraction, and scattering)
- Link budget design
- Log-distance path loss model
- Longley-rice model
- Okumura model
- Hata model
- Walfisch and Bertoni model

Small-Scale Path Loss:

- Small-scale multipath propagation
- Doppler shift
- Small-scale fading
- Frequency selective fading
- Fast fading
- Slow fading
- Rayleigh fading distribution
- Clarke's model for flat fading
- Two-ray Rayleigh fading model

Part 4: Existing & Emerging Cellular Communication Systems

GSM:

- History of GSM
- GSM services
- GSM specifications and key features
- GSM bands
- GSM network architecture
- GSM channels and frame structure
- Radio resources management
- GSM operation
- Call flow scenarios (mobile terminating call and mobile originating call)

Evolution of GSM:

- HSCSD
- GPRS
- EDGE

UMTS:

- Overview of UMTS network
- UMTS services and key features
- UMTS network architecture
- WCDMA
- Radio resources management
- UMTS evolution

LTE and LTE-Advanced:

- History of 3GPP LTE (evolution and adoption)
- LTE specifications and key features
- LTE network architecture
- Radio resources management
- LTE multiple access techniques (OFDMA and SC-FDMA)
- Enhanced multi-antenna support (MIMO technology)
- LTE-Advanced

5G Technology:

- Historical background
- Standardization activities
- Requirements and key performance indicators
- 5G system concept
- The 5G architecture
- Spectrum and regulations
- Channel propagation
- The 5G radio-access technologies
- Interference management in 5G
- Mobility management in 5G

Security in Cellular Systems:

- Security requirements
- GSM security features (authentication, confidentiality, and anonymity)
- Limitations of GSM security
- Security enhancements in UMTS (Data integrity and mutual authentication)
- LTE security features
- Security in 5G networks

UEF241: Mobile and Ubiquitous Computing

Course description:

This course explores the area of ubiquitous computing (and allows students to work on a variety of small technology projects. Students will be exposed to the basics of building Ubiquitous systems, emerging new research topics, and advanced prototyping techniques. This course incorporates a combination of topics covering a wide variety of disciplines that impact ubiquitous computing. These include human-computer interaction (HCI), machine learning, embedded systems, signal processing, tangible computing, electronics, and sensors. The emphasis is on developing deeper understanding of the functioning of mobile wireless networks, mobile sensing, pervasive computing and applications of mobile systems. The course examines these systems both from a technical perspective, as well as in terms of interdisciplinary applications, thus touches upon machine learning, computer network analysis, and healthcare. Students are introduced to development tools and techniques for building mobile systems and their understanding is reinforced through practical work in modern technology.

Course objectives:

The course aim is to provide students with an excellent ground in the concepts, technologies and skills, and development strategies, used in building mobile and ubiquitous computing systems.

1. Describe and discuss the emerging topics (vision, motivation, challenges) of pervasive and ubiquitous computing as well as context-aware computing and their applications.
2. Explain and show the ability to implement concepts related to the design and utilization of smart (mobile) systems.
3. Understand the major concepts and components of wireless and mobile networks
4. Describe and discuss the next generation mobile systems (e.g., smartphones, tablets) and their application areas.
5. Demonstrate basic knowledge in developing smartphone applications using various platforms, toolkits, APIs and third-party libraries.
6. Develop and research in the different topics related to ubiquitous computing such as Sensing and Basic Electronics; Tangible Computing; Wearable Computing; Sustainability and Technology …

UEO211: Distributed control systems

Course description:

This course is concerned with distributed control systems (DCS) as well as with its supervisory control and data acquisition (SCADA) based on the recent trends in globalization, mobile devices, remote operations, and system integration. The course won't only cover the most important components of DCS in detail, but also its operation, networking, HMI, and alarms as well. Different topics such as latest developments in process controllers, and state-of-the-art DCS organization and operation, networking, HMI, and alarms, maintenance and troubleshooting, and advanced process controllers are covered. Moreover, students will be familiar with latest trends in DCS such as industrial Internet, Internet of Things, Mobile and remote devices.

Course objectives:

At the end of the course, students are capable to review and understand sensors, instrumentation, and process control. They will be equipped with knowledge about how DCS organization and operation are carried out. They will be able to summarize the most important networking, HMI, and alarm features of DCSs. In addition to that, they will be updated with maintenance and troubleshooting procedures and issues, and also with the most up-to-date advanced process controllers in DCSs in addition to the latest trends related to DCSs.

Content:

Part 1: Course Introduction

- Review of topics, policies,
- The Overview of Distributed Control Systems (DCS)
- DCS: The basic concepts
- The selection criteria and the DCS specifications
- The concept of security hierarchy and the control system
- Implementation Overview for DCS

Part 2

- The concept of DCS Hardware
- Description: Block diagram
- The Overview: Hardware
- Definition and introduction: Communication
- The Overview of Redundancy and the hardware security

Part 3

- Brief overview: DCS Software
- The configuration for the control system
- Configuration for the controller
- The concept of Function block configuration

Part 4

- The overview and explanation: DCS Accessories
- Management of the alarm system
- The Reporting concept
- Diagnostics features
- The standard DCS Systems

UEO212: Human Machine Interaction

Course description:

This course is concerned with designing interactions between human activities and the computational systems that support them, with constructing interfaces to afford those interactions, and with the study of major phenomena surrounding them.

Interaction between users and computational artifacts occurs at an interface which includes both software and hardware. Thus, interface design impacts the software life-cycle in that it should occur early; the design and implementation of core functionality can influence the user interface for better or worse.

HCI draws on a variety of disciplinary traditions, including psychology, ergonomics, computer science, graphic and product design, anthropology and engineering.

The course considers a variety of methods that can be applied to the design and evaluate interactive systems. The emphasis of the course is on practical understanding, application and evaluation of HCI concepts and methods.

Course objectives:

At the end of this course the students will be capable to design and evaluate human-centered user-interfaces for the visualization of information and different kind of systems based not only on computer capabilities, but also on human-factors including different cognitive engineering models and human perception.

Content:

Part 1: Introduction

Introduction and Human Computer Interaction

- Good and Poor Design
- What is Interaction Design?
- The User Experience
- Understanding Users
- Accessibility and Inclusiveness
- Usability and User Experience Goals

Cognitive Aspects

- What is Cognition
- Cognitive Frameworks

Design Process

- Process of interaction design
- Design, prototyping and construction
- Direct manipulation/mental model
- Graphic design
- Information design and data visualization

Interfaces

- Interface Types
- Natural User Interfaces and Beyond - Which Interface?

Part 3: Designing and Conducting Experiments

Designing and Conducting Experiments

- How to design experiments
- How to analyze study data
- How to learn and iterate from studies

Part 4: Tools & the Future

Tools & the Future

- Software tools
- Social software
- Design for collaboration and communication

SEMESTRE 3

UEF311 : Knowledge Management

Content:

I. Introduction
I.1. Historique
I.2. Aperçu sur les systèmes experts
I.3. L'intelligence dans les données
I.4. Cycle de vie d'un processus d'extraction des connaissances
I.5. Du data mining au big data
I.6. Exemples d'applications
II. L'extraction des connaissances à partir des données
II.1. Les étapes d'un processus d'extraction de connaissances
II.2. Préparation et nettoyage des données
II.3. Enrichissement des données
II.4. Codage et normalisation des données
II.5. Fouille de données
II.6. Validation et intégration des connaissances
III. La modélisation descriptive
III.1. Description des données pour l'extraction des connaissances
III.2. Les règles d'association
III.3. Les méthodes de regroupement
III.3.1. La notion de ressemblance
III.3.2. La méthode des K -means
III.3.3. La classification hiérarchique
IV. La modélisation prédictive

UEF312 : Anomaly Detection

Course description:

This course provides the fundamentals of …. At first, the course introduce the anomaly detection problem: definition and types of anomalies, types of data, related problems… Then, the course includes the main approaches of anomaly detection approaches (classification, clustering, startiscal, graph…). The last part of the course is focused anomaly detection applications in real-world problems such as Intrusion and Security, big Data, financial applications, text and social media's data, medical applications.

Course objectives:

The main objectives of this course are:

1. Introducing the anomaly detection problem, key challenges and applications, and to survey the different anomaly detection approaches and real-world problems.
2. Providing the elementary skill of creating an anomaly detector and investigate its achievements.

Content:

Part 1: Introduction to Anomaly Detection

1. What are anomalies
2. Applications of anomaly detection
3. Related problems
4. Key challenges
5. Types of input data
6. Types of anomalies
7. Taxonomy of approaches
8. Evaluation of an anomaly detector

Part 2: Anomaly Detection Approaches

1. Classification based
    a. Rule based
    b. Neural Networks
    c. SVM
2. Nearest Neighbor based
    a. Density based vs. Distance based
    b. k-NN Global Anomaly Score
    c. Local Outlier Factor (LOF)
    d. Connectivity based Outlier Factor (COF)
    e. Local Outlier Probability (LoOP)
    f. Influenced Outlierness (INFLO)
    g. Local Correlation Integral (LOCI)
3. Clustering based
    a. Cluster based Local Outlier Factor (CBLOF)
    b. Local Density Cluster based Outlier Factor (LDCOF)

4. Statistical
    a. Parametric
    b. Non-parametric
    c. Outlier detection on temporal data
5. Model based
    a. FDI
    b. DX
6. Graph based
    a. Static graphs, Dynamic graphs
    b. Feature, proximity, community based
    c. Rational learning based
    d. Decomposition based
    e. Real-world applications

Part 3: Applications of Anomaly Detection

1. Anomaly Detection in BIG DATA
2. Intrusion and Security
3. Financial Applications
4. Web Log Analytics
5. Medical Applications
6. Text and Social Media
7. Anomaly detection for autonomous robots

UEF321: Network Optimization

Course description:

In this course a modern theory of optimization for dynamic networks is presented. The focus is on computer and wireless networks, including networks with time varying channels, mobility, and randomly arriving traffic. Applications to operations research and economics are also considered. The general theory of optimization is developed for constrained optimization of time averages. This is applied to problems such as queue stability, network utility maximization, efficient energy allocation, profit maximization, inventory control, stock market trading, and other problems involving dynamic decisions.

Course objectives:

This course aims to educate the students how to solve many of the most important network optimization problems: (1) How is efficiently transport some entities from one point to another in a network, given a number of limiting constraints, such as the capacity of the communication links of the network. (2) The general optimization problems which can be approached in many different ways, using linear programming, operations research theory, discrete simulation, and using algorithmic approaches. (3) Some of the fundamental concepts, algorithms and applications of network optimization theory.

Content:

Part 1: Introduction

- Queueing Theory and Optimization Theory.
- General Stochastic Optimization Problems.
- Lyapunov Drift and Lyapunov Optimization.
- On General Markov Decision Problems.

Performance Metrics in Networks

- Network Delay.
- Blocking Probability
- Convexity Properties
- Average Number of Hops
- Network Congestion
- Network Cost
- Network Resilience Metrics
- Network Utility and Fairness in Resource Allocation.

Part 2: Routing problems

Routing problems

- Flow-Path Formulation
- Optimality Analysis
- Flow-Link Formulation
- Destination-Link Formulation
- Destination-Based Routing
- Convexity Properties of Performance Metrics.
- Problem Variants

Part 3: Optimization Problems

Shortest Path Algorithms

- Types of Shortest Path Problems and Algorithms.
- Shortest Paths From A Single Source.
- All Shortest-Paths Algorithms
- The k-Shortest Path.

Minimum-Cost Flow Algorithms

- Basic Properties of Minimum-Cost Network Flow Problems.
- Combinatorial Algorithms for Minimum-Cost Network Flows.
- The Simplex Method for Minimum-Cost Network Flows.
- The Transportation Problem

-Flows with Gains

Maximum Flow Algorithm

-Flow-Augmenting Paths.

-Maximum-Flow Algorithm.

-Extensions and Modifications.

-Preflow-Push Algorithms for Maximum Flow.

-Dynamic Flow Algorithms

Part 4: Scheduling

Dynamic scheduling examples

- Scheduling for stability
  - The S-only Algorithm and ma
  - Lyapunov Drift for Stable Scheduling
  - The “Min-Drift” or “Max-Weight” Algorithm
  - Iterated Expectations and Telescoping Sums

Optimizing Time Averaging

-Opportunistic Scheduling

-Approximate Scheduling

-Dynamic data compression

-Efficient energy allocation.

Part 5: Convex Sets. Convex Functions

Convex Sets. Convex Functions

- Convex Sets
- Convex and Concave Functions.
- Convexity in Differentiable Functions.
  - Strong Convexity/Concavity.
  - Convexity in Non-Differentiable Functions.
  - Determining the Curvature of a Function.
  - Sub-level Sets.

UEF322: IoT Porgramming

Course description:

This course aims to acquire the competences to develop IoT applications (SaaS applications and smart products, as well as design, develop and implement IoT applications.

Course objectives:

1. Design and program some IOT based devices and prototypes
2. Secure the elements of an IoT device
3. Design an IoT device to work with a Cloud Computing infrastructure.

Content:

Developing Internet of Things & Logical Design using Python:

- Introduction,
- IOT Design Methodology,
- Scripting and Programming with IoT Data
- Installing Python, Python Data Types & Data Structures,
- Control Flow,
- Functions, Modules
- File Handling, Date/ Time Operations, Classes,
- Python Packages
- Machine Learning / Artificial Intelligence
- IoT Data Analysis in the Cloud

Implementing IoT, IOT Physical Devices & Endpoints:

- What is an IOT Device,
- Exemplary Devices and Boards
- Embedded Operating Systems
- Linux and Windows-Based IoT
- Linux on Raspberry Pi,
- Cloud-based Data Collection
- Interfaces and Programming

IoT reliability, security, and privacy

- IoT security overview
- Security frameworks for IoT
- Privacy in IoT networks
- IoT characteristics and reliability issues
- IoT governance
- TinyTO: two-way authentication for constrained devices in the Internet of Things
- Chapter 14: Obfuscation and diversification for securing the internet of things (IoT)
- Future research directions

UEF323: Internet of Things (Architecture, network , security)

Course description:

This course gives a foundation in the Internet of Things, including Introduction to IoT, the components, tools, and analysis by teaching the concepts behind the IoT and a look at real-world solutions, its applications, architectures, and technologies, logical Design of IoT, physical design of IoT, IoT Enabling Technologies, IoT & deployment templates, IoT and M2M, Big Data in IoT Systems, IoT Security Techniques, Domain Specific IoTs (Home Automation – Cities – Environment – Energy – Retail – Logistics – Agriculture – Industry – Health & Lifestyle)

Course objectives:

1. Understand the definition and significance of the Internet of Things.
2. Discuss the architecture, operation, and business benefits of an IoT solution.
3. Examine the potential business opportunities that IoT can uncover.
4. Understand constraints and opportunities of wireless and mobile networks for Internet of Things.
5. Explore the relationship between IoT, cloud computing, and big data.
6. Identify how IoT differs from traditional data collection systems.
7. Use real IoT protocols for communication
8. Design & develop IOT Devices.

Content:

Introduction and Concepts:

- What Is the Internet of Things?
- Potential & challenges
- Machine to Machine / User-less Communication
- Common Use Cases
- Components of an IoT Solution
- Physical Design of IOT,
- Logical Design of IOT
- Open Source and Commercial Examples
- Competing Standards for IoT
- IOT Enabling Technologies, IOT Levels.
- IoT specialization: Industrial, Medical/Healthcare, Automotive, Energy/Utilities, Financial
- Brainstorming IoT Utilization

Domain specific applications of IoT

- Home automation,
- Cities, Environment, Energy
- Health & Life Style
- Industry applications,
- Surveillance applications,
- Retail, Logistics
- Agriculture
- Other IoT applications

Acquiring Data

- Traditional Data Storage
- Analog and Digital I/O Basics
- Analog/digital sensors
- Sensors and Data Collection Points
- Embedded Platforms / Microcontrollers
- Software Development
- Device Security: Physical and Logical
- Connectivity Options

- Connecting Sensors to the Cloud

IoT & M2M

- M2M, Difference between IOT and M2M, SDN: (Software defined Networking) and NFV (Network Function Virtualization) for IOT, ,
- Need for IOT Systems Management, Simple Network Management Protocol
- Limitations of SNMP, Network Operator Requirements, NETCONF, YANG,
- IOT Systems management with NETCONF-YANG.

IoT data and knowledge management

- The foundations of stream processing in IoT
- State-of-the-art, Challenges and future directions
- Continuous Logic Processing System
- Collecting and Storage of IoT Sensor Data
- Data Aggregation
- A framework for distributed data analysis for IoT
- Anomaly detection
- Problem statement and definitions
- Distributed anomaly detection
- Efficient incremental local modeling
- Analysis and Visualization of Data
- Use Cases for IoT Data
- How the work together: Cloud and IoT
- Big Data and IoT, IoT Data Collection in the Cloud

IOT Protocols

- Layers, protocols, packets, services, performance parameters of a packet network as well as applications such as web, Peer-to-peer, sensor networks, SWNs
- Transport services: TCP, UDP, socket programming.
- Network layer: forwarding & routing algorithms (Link, DV), IP-addresses, DNS, NAT, and routers.
- Local Area Networks, MAC level, link protocols such as: point-to-point protocols, Ethernet, WiFi 802.11, cellular Internet access, and Machine-to-machine.
- Mobile Networking: roaming and handoffs, mobile IP, and ad hoc and infrastructure less networks.
- Real-time networking: soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements.

Examples:

- Infrastructure (ex: 6LowPAN, IPv4/IPv6, RPL)
- Identification (ex: EPC, uCode, IPv6, URIs)
- Comms / Transport (ex: Wifi, Bluetooth, LPWAN)
- Discovery (ex: Physical Web, mDNS, DNS-SD)
- Data Protocols (ex: MQTT, CoAP, AMQP, Websocket, Node)
- Device Management (ex: TR-069, OMA-DM)
- Semantic (ex: JSON-LD, Web Thing Model)
- Multi-layer Frameworks (ex: Alljoyn, IoTivity, Weave, Homekit)

UEF331: Knowledge and design of APIs

Course description:

Design of APIs in the domain of cyber physical systems. The students are divided into groups and projects are affected to them and they proceed to development of API's

UET311: Research methodologies

Course description:

This course provides a comprehensive overview of the research methodology. It allows the students to explore a phenomenon, solve a problem, study existing works, experiment with a new process, a new solution, a new theory, apply a practical technique. In fact, this course aims to guide Master students towards achieving competence and proficiency in the theory of and practice to research. This fundamental objective can be realized through helping these students to develop the subject of their research, encourage higher level of trained intellectual ability, critical analysis, rigor, and independence of thought, foster individual judgment, and skill in the application of research theory and methods, and develop skills required in writing research proposals, reports, and master thesis It includes the following topics: Familiarization with the different types of conferences and journals in computer science and particularly in cyber security, bringing an aid to students in order familiarize them with the different research subjects in in cyber security, helping them to know the structure of a systematic literature review paper or systematic mapping study and how to write the literature review, presenting to students the structure of the report of the master thesis, introducing to students giving them guidelines on the defense.

Course objectives:

The main objectives of this course are 1) enable Master students understand what research is and what is not. 2) introduce the concept of a research problem- and to discuss what a researchable problem is. 3) evaluate literature, form a variety of sources, pertinent to the research objectives. 4) identify and justify the basic components of the research framework, relevant to the tackled research problem. 5)explain and justify how researchers will collect research data. 6) discuss how to cite sources and what are pertinent references. 7) discuss evaluation sections in research papers and the threats to validity section 8) make the students learn how to highlight the contributions in an academic written work.

Content:

The Research Methodology in Computer Science

- Types of Indexed conferences and classed conferences
- Presentation of the different types of journal ranking types:impact factor, SJR,…..)
- How to write a systematic literature review : SLR
- How to write a systematic mapping study
- Presenting the report structure
- Presenting rules for the defense of the master thesis
- Examples of research papers
- Writing Research Reports and Thesis
- Why the need to write papers and reports?
- Writing a research report
- Writing a technical paper
- Contents of a thesis

UET312: Innovation and entrepreneurship

Course description:

The entrepreneurship and innovation course aims at providing the students with the needed knowledge to take their innovation ideas to the next step and possibly form a small company or a business. The course will cover the main entrepreneurship fundamental topic such as: idea creation, team building, conduct a successful market research, presenting the idea, determining the competitive advantage, idea protection and Intellectual Property (IP) , monetization and different business models, raising funding and approaching investors, conducting a successful financial analysis, writing a business plan, creating a prototype or a proof of concept, launching a betta marketing the idea, receiving the customer feedback and improving the product/service.

Course objectives:

The course aims at providing the essential knowledge needed to allow the students to evaluate their ideas and projects and asses if it can be leveraged into viable startups. The course will guide the students on how to refine their ideas to meet the market demand and compete with other alternative or similar solutions. Further, it will broaden the students' thinking beyond the technical aspects like the marketing, business, financial aspects which are usual not tackled during any technical course.

Content:

Part 1: Introduction

- How to think about innovative ideas?
- What are the main components of a successful business?
- How to think about effective solutions

Part 2: Market needs

Students need to learn the basic marketing strategies such as:

- Define the target market
- List the potential competitors
- Identify their competitive advantage,
- Learn how to conduct a market research study and analysis

Part 3: Building a team

Students will be learned about how to build a team for their prospective startup company. The following main points will be taught:

- The importance of having a team for successfully building a startup company
- How to identify the needed skills needed to build-up a successful startup company
- How to form a successful team
- How to delegate responsibilities among the team members
- How to reward and give incentives/shares to the team members

Part 4: Business Models

Students will be introduced to the major business model types and will be taught how to map their potential startup company to one of these models. Further, students will be guided on how to monetize their ideas and create a business value from an investor point of view.

Part 5: Marketing strategies

Marketing is an essential components needed for any successful startup company. As such, students have to know the difference marketing strategies, channels, methodologies.

Part 6: Finance

Finance is another essential element needed to be able to build and run a successful startup company. The students should acquire a basic information about financial related aspects such as:

- How to prepare a simple financial statement
- How to identify the financial resources and amounts needed to launch and run the startup company.
- Lean how to raise fund and identify different types of funding schemes

Part 7: Business Plan

Students will learn on how to A summarize the main things needed to launch the startup company into one document named as the business plan that describes the idea, identify the market needs and the potential proposed solutions, needed resources, marketing strategies, and the financial support.

UEO311: Distributed Systems

Course description:

This course introduces basic and advanced knowledge to give an understanding how modern distributed cyber-physical systems operate. The course explores recent trends exemplified by current highly available and reliable distributed systems.

The focus of the course is on distributed algorithms and on practical aspects that should be considered when designing and implementing cyber-physical systems. Topics covered during the course are: architectures of distributed systems, process of distributed systems, synchronization and coordination algorithms, replication, and end-to-end system design communication, naming, fault tolerance and security.

Computer based assignments are used extensively to give students practical experience in designing and implementing distributed cyber-physical systems.

Course objectives:

This course unit aims to provide students with a basic understanding of :

1. Characteristics of the distributed cyber-physical systems.
2. Analysis of the computation and communication systems in distributed cyber-physical systems.
3. Design and implement device-level communications prototype real systems under different environments through the course programming lab assignments.

Content:

Part 1: Introduction

- Characteristics of distributed systems
- Middleware and distributed systems
- Design goals of distributed systems including sharing resources
- Types of distributed systems

Part 2: Architectures and Processes

Architectures

- Architecture styles
- Middleware organization
- System architectures

Processes

- Threads
- Network virtualization
- Servers sides processes
- Client side software for distribution transparency
- Servers clustering

Distributed objects and components

- Distributed objects
- From objects to components
- Java RMI and COBRA in distributed cyber-physical projects

Part 3: Communication and naming in distributed systems

Communication

- Foundations of layered protocols
- Communication types
- Remote Procedure Call (RPC) and variations
- Message oriented communication
- Multicast communication

Naming

- Names identifier and addresses
- Structured naming (DNS,NFS)
- Flat naming

– Attribute based naming (Directory services)

Part 4: Coordination in distributed systems

Coordination

– Clock synchronization
– Distributed concurrency control
– Distributed deadlocks
– Mutual exclusion
– Election algorithms
– Location systems
– Gossib based coordination

Part 5: Consistency and replication

Replication

– Reasons for replication
– Data centric consistency models
– Client centric consistency models

Replica management

– Distributed transactions
– Managing consistency contents
– Managing replicated objects
– Consistency protocols

Part 6: Fault tolerance in distributed systems

Fault tolerant

– Process resilience
– Reliable communication
– Spark streaming
– Distributed commit

Recovery

– Transaction recovery
– Checkpoint and message logging
– Recovery new techniques

Part 7: Security in distributed systems

Security policy

– Security principles
– Secure channels
– Access Control

Security management

– Key management
– Secure group management
– Authentication management

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Project and internship