MS (CS)

New Course Outline

Table 1. Revised MS Courses (Course Codes are not final)

Old Course Code	New Course Code	Course Title	Remarks
Core Courses			
CS711	CS7101	Research Methods for Computer Science	-
CS712	CS7102	Statistical Analysis	-
CS713	CS7103	Introduction to Mathematical Logic	-
Related Courses			
CS731	CS7201	Theory of Computation	-
CS732	CS7202	Advanced Algorithm Analysis	-
CS733	CS7203	Advanced Operating Systems	-
CS734	CS7204	Advanced Computer Architecture	-
CS735	CS7205	Middleware	Course Renamed from “Middleware-1”
CS736	CS7206	Advanced Databases	-
CS737	CS7207	Data Warehousing	-
CS738	CS7208	Data Mining	-
CS739	CS7209	Database Security	-
CS740	CS7210	Distributed System Components	-
CS741	CS7211	Advanced Networking	-
CS742	CS7212	Cloud Security	Course Renamed and Course Contents Revised
CS743	CS7213	Opportunistic Networks	Course Renamed and Course Contents Revised
CS744	CS7214	Wireless Networks	-
CS745	CS7215	Network Performance Evaluation	-
CS746	CS7216	Semantic Web	-
CS750	CS7217	Web Mining	-
CS751	CS7218	Ontology Engineering	-
CS752	CS7219	Description Logic	-
CS760	CS7220	Morphology of Natural Language	-
CS761	CS7221	Syntax of Natural Language	-
CS762	CS7222	Corpus Linguistics	-

Old Course Code	New Course Code	Course Title	Remarks
CS763	CS7223	Machine Translation	-
CS764	CS7224	Mobile Ad Hoc Networking	-
CS765	CS7225	Network Management and QoS Provisioning	-
CS766	CS7226	Business Intelligence	-
CS768	CS7227	Advanced Wireless Network Security	-
CS769	CS7228	Wireless Sensor Networks	Course Contents Revised
CS770	CS7229	Empirical Methods in Software Engineering Research	-
CS771	CS7230	Software Requirements Engineering	-
CS773	CS7231	Emerging Technologies in Software Engineering	-
CS775	CS7232	Agile Software Development	-
CS776	CS7233	Software System Quality	-
CS777	CS7234	Software Configuration Management	-
CS778	CS7235	Software Engineering Laboratory	-
CS780	CS7236	Real-Time Systems	-
CS781	CS7237	Parallel Programming for Multicores	-
CS782	CS7238	Concurrent and Real Time Programming	-
-	CS7239	Data Science	New Course
-	CS7240	Smart Device Communications	New Course
-	CS7241	Software Engineering in Society	New Course
-	CS7242	Software Maintenance, Evolution, and Re-Engineering	New Course
-	CS7243	Engineering Privacy in Software	New Course
-	CS7244	GPU Programming	New Course
-	CS7245	Parallel Algorithms Design and Analysis	New Course
-	CS7246	Realtime Stream Processing	New Course
-	CS7247	Linked Open Data	New Course
-	CS7248	Virtual and Augmented Reality	New Course
-	CS7249	Advanced Web Technologies	New Course
-	CS7250	Digital Libraries	New Course
-	CS7251	Information and Communication Technology (ICT) Accessibility	New Course
-	CS7252	Wireless Ad hoc Networks	New Course

Old Course Code	New Course Code	Course Title	Remarks
-	CS7253	Introduction to Computer Vision	New Course
-	CS7254	Advanced Digital Image Processing	New Course
-	CS7255	Automatic Speech Recognition	New Course
-	CS7256	Image Compression	New Course
-	CS7257	Advanced Machine Learning and Neural Networks	New Course
-	CS7258	Mathematics for Imaging	New Course
-	CS7259	Pattern Recognition	New Course
-	CS7260	Technology Enhanced Learning	New Course
-	CS7261	Mobile Interventions and Persuasive Technologies	New Course
-	CS7262	Interaction Design	New Course
-	CS7263	User Centered Research and Evaluation	New Course

Table 2. Dropped/Archived MS courses

Archived Course Code	Archived Course Title
CS747	Information Architecture
CS749	Information Retrieval
CS753	Soft Computing
CS754	Web Engineering
CS767	Mobile Application Development
CS772	Advanced Software Project Management
CS774	Usability Engineering
CS779	Information Security

Revised MS Courses

CS7212	Cloud Security	Credit Hours:3

Course Description: Cloud computing infrastructure have become a mainstay of the IT industry, opening the possibility for on-demand, highly elastic and infinite compute power with scalability and supporting the delivery of mission-critical secure enterprise applications and services. This course provides the ground-up coverage on the high-level concepts of cloud landscape, architectural principles, techniques, design patterns and real-world best practices applied to Cloud service providers and consumers and delivering secure Cloud based services. The course will describe the Cloud security architecture and explore the guiding security design principles, design patterns, industry standards, applied technologies and addressing regulatory compliance requirements critical to design, implement, deliver and manage secure cloud based services. The course delves deep into the secure cloud architectural aspects with regards to identifying and mitigating risks, protection and isolation of physical & logical infrastructures including compute, network and storage, comprehensive data protection at all OSI layers, end-to-end identity management & access control, monitoring and auditing processes and meeting compliance with industry and regulatory mandates. The course will leverage cloud computing security guidelines set forth by ISO, NIST, ENISA and Cloud Security Alliance (CSA).

Aims and Objectives: Students successfully completing this course should be able to:

- Understand fundamentals of cloud computing architectures based on current standards, protocols, and best practices intended for delivering Cloud based enterprise IT services and business applications.
- Identify the known threats, risks, vulnerabilities and privacy issues associated with Cloud based IT services.
- Understand the concepts and guiding principles for designing and implementing appropriate safeguards and countermeasures for Cloud based IT services
- Design cloud services that meets essential Cloud infrastructure characteristics – on demand computing, shared resources, elasticity and measuring usage.
- Design security architectures that assures secure isolation of physical and logical infrastructures including compute, network and storage, comprehensive data protection at all layers, end-to-end identity and access management, monitoring and auditing processes and compliance with industry and regulatory mandates

Course Contents: Fundamentals of Cloud Computing and Architectural Characteristics, Cloud deployment models Public, ,Cloud Computing Roles Risks and Security Concerns, Guiding Security design principles for Cloud Computing, Secure Isolation Comprehensive data protection,

End-to-end access control Monitoring auditing, Quick look at CSA, NIST and ENISA guidelines for Cloud Security, Common attack vectors and threats, Data protection for Confidentiality and Integrity , Common attack vectors and threats , Encryption, Data Redaction, Tokenization, Obfuscation, PKI and Key , Management, Assuring data deletion , Data retention, deletion and archiving procedures for tenant data, Data Protection Strategies, Enforcing Access Control for Cloud Infrastructure based Services, Monitoring, Auditing and Management, Introduction to Identity Management in Cloud Computing, Cloud Computing Security Design Patterns, Policy, Compliance & Risk Management in Cloud Computing.

Recommended Material:

1. Winkler, J. R. (2011*). Securing the cloud: cloud computer security: techniques and tactics* (Latest ed.). Amsterdam: Elsevier.
2. Erl, T., Cope, R., & Naserpour, A. (2015). *Cloud computing design patterns* (Latest ed.). New York: Prentice Hall.

CS7213	**Opportunistic Networks**	**Credit Hours:3**

Course Description: The purpose of the course is to expose students to emerging networking protocols and technologies in the field of opportunistic and challenged networks. This course will enable students to select research topics for their MS thesis.

Aims and Objectives: The primary objective of this course is to:

- Expose graduate students to the exciting new research topics in networking.
- Motivate graduate students to take up research work in the new and exciting areas in networking.

Course Contents: Overview of packet switching networks and devices, route lookup algorithms, signaling protocols, Delay Tolerant Networks (DTN), DTN routing, DTN protocol stack, DTN architecture, DTN protocols, Bundle Layer, Bundle Protocol, Vehicular Adhoc Networks (VANETs), VANETs architecture, VANETs protocol stack, VANETs routing, VANETs security, WAVE, Dedicated Short Range Communication (DSRC). QOS in DTN, QOS in VANETs, Intelligent Transport System (ITS), ITS applications, ITS architecture, ITS protocol stack, ITS security.

Recommended Material:

1. Rodrigues, J. (2015). *Advances in delay-tolerant networks (DTNs): architecture and enhanced performance* (Latest ed.). Amsterdam: Woodhead Publishing.
2. Hartenstein, H., & Laberteaux, K. (2010). *VANET: vehicular applications and inter-networking technologies*. Chichester: Wiley. (Latest ed.)

CS7228	**Wireless Sensor Networks**	**Credit Hours:3**

Course Description: Wireless Sensor Networks have received tremendous attention over past few years. These networks seek to extend the long-arm of the internet by connecting it to the rich tapestry of the physical world using sensors. Recent technology advancements (low-power radios, MEMS sensors) have opened up the potential for dense and potentially large-scale deployments, where many sensors co-ordinate to accomplish a sensing task. The vast potential for this research area has been demonstrated by numerous scientific and commercial applications that have emerged in recent years, as well as by the number of industrial and research institutions working in this area. Recent research directions include environmental sensing and prediction (CENS, CASA), seismic and structural monitoring (CENS). Commercial interests include factory automation, power monitoring and energy conservation through distributed climate control, and others. Many exciting applications will be emerging soon.

This course is intended to provide students with an in-depth understanding of systems and algorithmic issues in wireless sensor networks and networked embedded systems. Reading research papers, writing critiques, and class presentations will also be included.

Aims and Objectives: Students successfully completing this course should be able to:

- learn the fundamental concepts of sensor network design,
- learn sensor network protocols, mechanisms, and algorithms to implement sensing systems, design, program, simulate, and experiment with sensor network software and hardware, investigate different research issues.

Course Contents: Introduction to WSN, WSN Platforms, Mac Layer, Link Layer, Topology Control, Clustering, Time Synchronization, Localization, Routing, Tracking, In-Network Querying, Security in WSN, Network support and management, Industrial WSN protocols, WSN network design and implementation, Application development in WSN

Recommended Material:

1. Poellabauer, C., & Dargie, W. (2013). *Fundamentals of wireless sensor networks*). Hoboken, N.J.: Wiley. (Latest ed.)
2. Extensive use of latest online resource.

CS8120	Emerging Themes in Agile Software Development	Credit Hours: 3

Course Description: This course is based on agile software development methodologies, not only it emphasizes agile development concepts but also identifies and elaborates diverse concepts related with software development which may benefit from agility. It focuses on latest trends and uses of agile in project management, distributed development, and information technology operations. The course will provide an extensive reading into latest trends and research in practical aspects of agile software development.

Aims and Objectives: The course is aimed to:

- Create a deep understanding of the concept behind agility in software development.
- Explore latest distinctive trends in agile development and project management.

Course Contents: Agile concepts, The Agile life cycle and artifacts, Agile Technologies, distributed agile teams and development: issues and solutions, Agile enterprise architecture, Team dynamics, Business intelligence, Enterprise agility, Agile project management, Agile leadership, Agile adoption and Agile transformation: why change? Agile tailoring, the role of agile architect, planning agile with fixed constraints, Continuous deployment and continuous experimentation, concept of *continuous value delivery*. *Integration of UX teams with cross functional agile teams, Agile risk management, R*etrospectives. Balancing agility and discipline. Concept of DevOps, Stress of agile. Agile coaching, Case studies and experience reports on latest agile trends. CASE tools for Agile development.

Reference Material

1. Cohn, M. (2013). *Succeeding with agile: software development using Scrum* (Latest ed.)
2. Upper Saddle River, NJ: Addison-Wesley. Extensive use of latest online resource

CS8130	Social Web	Credit Hours: 3

Course Description: From Twitter to Facebook and all the way back to email, social computing is one of the biggest forces on the Internet. The course is about understanding key issues around social web, a field of study concerning with using computing techniques and artifacts to support, mediate, and understand aspects of social behaviors and social interactions. Today, numerous instances and models of social web are prevalent among end-users, such as Wikipedia, social networking sites (e.g. Facebook), micro blogging (e.g., Twitter), photo sharing (e.g. Flickr), instant messaging (e.g. MSN) and so on. The flourishing of social web raises the needs to obtain deeper understanding about how these technologies influence human behaviors, and to figure out how to

improve existing designs and devise new models based on the understanding of human behaviors in technological contexts. It is the state-of-the-art of social web research and practice to take both technical and human factors into consideration, and perform analyses and design at the level of "socio-technical systems", which are abstract systems consisting of both technical components (e.g., the software layer of Facebook) and people interacting with one another over the mediation of technologies (e.g. users of Facebook). This course will guide students to take a close look at some prominent ways that this approach functions in the world today, and to understand certain principles and techniques of social web.

Aims and Objectives: When students complete this course, they will be able to:

- Understand important features of social web.
- Design and prototype new social computing systems.
- Analyze data left behind in social media.
- Understand the research issues in this field.
- Understand the range of social web applications and concepts.
- Understand and apply concepts of computational models underlying social web.
- Carry out simple forms of social analytics, involving network and language models, applying existing analytic tools on social information.
- Design and launch social web applications.
- Understand the broad aspects of, and implement, richer social web models in social computing applications.
- Evaluate emerging social web applications, concepts, and techniques in terms of key principles.

Course Contents: Social Web Evolution and State-of-the-Art, Social Relationships, Social Network Analysis, Mobility and Social Context, Human Computation, Crowd-sourcing, Incentive Mechanisms, Markets and Prediction Markets, Gamification, Computational Models, Organizations, Social Norms, Argumentation, Social Informatics, Emergence, Social Computing in the Large, Social Interpretation of Information, Socio-technical Systems, Security, Common Threads, Open Problems, Status and Trends, Distributed Collaboration and Online Communities, Sharing Content, Trading and Playing, Discussions and Socialization, Blogs and Wikis, Wikipedia Social Networking, Dealing with Free Riding and Malicious Behavior, Search Engine Optimization, Business Models for Social Media, Secure Social Networks, Web Services, Cloud Computing and Peer-2-Peer Systems, Multi-Agent Systems, Streaming Systems.

Reference Material

1. Tsvetovat, M., & Kouznetsov, A. (2011). *Social network analysis for startups: finding connections on the social web* (Latest ed.) O'Reilly Media, Inc.
2. Steen, M. V., (2010). *Graph theory and complex networks: an introduction* (Latest ed.). Maarten Van Steen.

3. Dasgupta, S. (2009). *Social computing: concepts, methodologies, tools, and applications: concepts, methodologies, tools, and applications* (Latest ed.). IGI Global.
4. Papadopoulou, P. (2010). *Social computing theory and practice: interdisciplinary approaches*. IGI Global. (Latest ed.)

New courses

CS7239	Data Science	Credit Hours: 3

Course Description: Data Science is a dynamic and fast growing field at the interface of Statistics and Computer Science. The emergence of massive datasets containing millions or even billions of observations provides the primary motion for the field. Such datasets arise, for instance, in large-scale retailing, telecommunications, and internet social media. This course emphasizes on techniques for working with large-scale data. Specific topics covered will include statistical modeling and machine learning, programming languages, "big data" tools, and real world topics and case studies.

Aims and Objectives: Students successfully completing this course should be able to:

- Use statistical methods and visualization to quickly explore data
- Apply statistics and computational analysis to make predictions based on data
- Apply basic computer science concepts such as modularity, abstraction, and encapsulation to data analysis problems
- Implement data-intensive computations on cluster and cloud infrastructures using MapReduce
- Effectively communicate the outcome of data analysis using descriptive statistics and visualizations

Course Contents: What is data science, Data science vs (Data mining, Machine learning, Big data, statistics), Introduction to Relational and non-relational databases, A crash course of any tool (e.g., R language, Python, WEKA), Computing simple statistics (Means, variances, standard deviations, weighted averaging, modes, quartiles), Simple visualizations (Histograms, Box plots, Scatter plots, Time series, Spatial data), Case study (Weather or Medical data), The prediction task, Prediction algorithms (Decision trees, Rule learners, Linear/logistic regression, Nearest neighbour learning, Support vector machines), Experimental setup (Training, tuning, test data, Holdout method, cross-validation, bootstrap method), Measuring performance of a model (Accuracy, ROC curves, precision-recall curves, Loss functions for regression), Interpretation of results(Confidence interval for accuracy, Data discretization (Unsupervised discretization, Supervised discretization), Data transformations, Introduction to Probabilities and Rule of Bayes and Conditional Independence, Graphical representation (Independence and correlation), Introduction to Exploratory Data Mining, Association discovery, Clustering, Case Studies in Data Science.

Reference Material

1. Grus, J. (2015). *Data science from scratch: first principles with Python* (Latest ed.). Beijing: O'Reilly.
2. Staton, J. (2013). Introduction to data science (Latest ed.). Syracuse University, New York.
3. Leek, J. (2015). *The elements of data analytic style* (Latest ed.). Beijing: O'Reilly.

CS7240	**Smart Device Communications**	**Credit Hours: 3**

Course Description: This course provides the introduction to the fundamental concepts of smart device communications which is responsible for data transmission among applications, services, and smart devices. Smart device communication plays an important role in the cellular networks especially in the presence of bandwidth craving applications.

Aims and Objectives: The students will be familiar with:

- The fundamental concepts about smart devices communication
- The basic architecture and working
- The challenges and issues faced in the implementation of smart device communication

Course Contents: Fundamentals and analysis of D2D communication in LTE-A band, indoor positioning, LTE in unlicensed, LTE enhancements for Machine-Type Communication, Elevation Beamforming / Full-Dimension MIMO, Indoor positioning. LTE-Advanced Pro, the fundamental requirements of D2D deployment, the standardization activities of Rel 13 and beyond of LTE-A, D2D control such as full, loose and hybrid, various D2D scenarios such as coverage(in coverage, partial coverage and out of coverage), usage areas (same cell and different cells), the advantages of using D2D communication with and without the base station support, the challenges and benefits of using D2D communication in mm Wave band, capacity analysis of cellular networks employing data offloading and caching using D2D communication, the effects of using D2D communication in femto cells and as relay devices, cooperative and non-cooperative communication in D2D context, interference management induced using D2D communication. Energy Efficiency, Location Services (LCS), Mission Critical Data over LTE, Mission Critical Video over LTE, Flexible Mobile Service Steering (FMSS), Multimedia Broadcast Supplement for Public Warning System (MBSP), enhancement for TV service, massive Internet of Things, Cell Broadcast Service (CBS).

. **Reference Material**

1. Mumtaz, S., & Rodriguez J. (2014). *Smart device to smart device communication* (Latest ed.). Springer International Publishing.
2. Poslad, S. (2009). *Ubiquitous computing: smart devices, environment, and interactions.* Wiley. (Latest ed.)
3. Lingyang, S., Zhu, H., & Xu C. (2014). *Resource management for device-to-device underlay communication* (Latest ed.). Springer International Publishing.
4. Rappaport, T. S., Heath Jr. R. W., Daniels, R. C., & Murdock J. M. (2014). *Millimeter wave wireless communications.* Prentice Hall. (Latest ed.)

CS7241	**Software Engineering in Society**	**Credit Hours: 3**

Course Description: The course addresses the role and impact of software engineering in society. The emphasis is placed on new trends in software development, in which software is only a part of a larger system, and its development is tackled within the specific disciplines (environmental, social, medical, engineering, etc.).

Aims and Objectives: After completing the course students will be able to:

- Understand use of software applications in different paradigms and scenarios
- Implications of software use and maintenance under different circumstances
- challenges and issues which are faced in those applications but are not there in normal software development and application scenario

Course Contents: Innovative, and inspiring research and development with a clear impact on Software Engineering challenges, directions, methods, and tools. Engagement with a broad spectrum of disciplines including, but not limited to Life Sciences (for example, Health Informatics, Biotechnology); Environmental Sciences (for example, Ecology, Climate Change); Computing and Engineering (for example, HCI, IoT, AI, Data Science, Distributed Computing), Design (for example, Sustainable Design, Architecture, Urban Planning), The Arts (e.g. Digital Art, Performing Arts), Research directions towards new development models, tools, and methods for specific application environments

Reference Material

1. Finkelstein, C. (2006). *Enterprise architecture for integration* (Latest ed.) Norwood: Artech House. Latest research papers.

CS7242	Software Maintenance, Evolution, and Re-Engineering	Credit Hours: 3

Course Description: Change is an inherent property of all software systems and software development life-cycles. Systems that have long passed the life expectancy envisioned by their initial developers have accumulated many changes because of the maintenance of defects, advancements in technology, and new business needs.

Aims and Objectives: The course aims to:

- introduce the challenges presented by existing systems and examine various reverse engineering and forward engineering techniques for evolving systems.
- explores the concepts of software evolution and reengineering and introduces approaches and support tools used to extract the information from existing software systems.
- introduce various principles of software reuse and reverse engineering techniques are presented and researched through research papers.

Course Contents: Principles and techniques of software maintenance. Impact of software development process on software justifiability, maintainability, evolvability, and planning of release cycles. Use of very high-level languages (VHLL) and dependencies for forward engineering and reverse engineering. Achievements, pitfalls, and trends in software reuse, reverse engineering, and re-engineering.

Reference Material

1. Jarzabek, S. (2007). *Effective software maintenance and evolution* (Latest ed.). Hoboken: CRC Press.
2. Reifer, D. (2012). *Software maintenance success recipes* (Latest ed.). Boca Raton, FL: CRC Press.

CS7243	Engineering Privacy in Software	Credit Hours: 3

Course Description: This graduate-level course covers the methods and tools needed to design systems for privacy with a specific focus on the requirements, design and testing stages of the software development lifecycle.

Aims and Objectives: The students will understand how to**:**

- Integrate privacy into the software engineering lifecycle phases
- Collect, analyse and reconcile system requirements in a privacy-sensitive ecosystem
- Evaluate software designs based on privacy principles and privacy requirements

- Interface with software developers on critical privacy issues

Course Contents: *Requirements:* express and analyze system and privacy requirements, privacy principles, privacy patterns and privacy controls as a source of requirements knowledge, Goal-based analysis to refine privacy goals into functional, privacy-enhancing system specifications. Privacy threat and risk analysis to apply different risk models to explore privacy threats, vulnerabilities and mitigations, *Design:* students identify and evaluate alternative design strategies to implement requirements, Architecture vs. Policy, Data Lifecycle, Evolution & Adaptability: effects of privacy, including deployment, maintenance and upgrades that risk violating privacy requirements.

Reference Material

1. Lamsweerde, A. V. (2009). *Requirements Engineering: From System Goals to UML Models to Software Specifications* (Latest ed.). New Jersey: John Wiley & Sons, Inc.
2. Latest research from online sources.

CS7244	**GPU Programming**	**Credit Hours: 3**

Course Description: This course will cover programming techniques for the General Processing Unit (GPU). The course will introduce parallel computing language for GPUs, i.e. CUDA or OpenCL. Beyond covering the programming model and syntax, the course will also discuss GPU architecture, high performance computing on GPUs, parallel algorithms, libraries, and applications of GPU computing. Problem sets will cover performance optimization and specific GPU applications in numerical mathematics, medical imaging, finance, and other fields.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the architecture and programming model for GPUs
- Learn how to program using GPUs.
- Understand how to optimize code using GPUs,

Course Contents: GPU architecture, integrated GPUs, multiple GPUs, address spaces, CPU/GPU interactions, kernels, functions and modules, streams and events, host memory, arrays and texturing, types of memory and its usage, CPU/CPU concurrency, kernel execution, syntax, blocks, threads, warps, lanes, streaming multiprocessors, multiple GPUs, texturing.

Reference Material

1. Wilt, N. (2013). *The CUDA handbook: a comprehensive guide to GPU programming* (Latest ed.). Upper Saddle River (N.J.): Addison-Wesley.

2. Eberly, D. H. (2015). *GPGPU programming for games and sciences* (Latest ed.). Boca Raton: CRC Press.

CS7245	Parallel Algorithms Design and Analysis	Credit Hours: 3

Course Description: Design and analysis of parallel algorithms: fundamental parallel algorithms for sorting, arithmetic, matrix and graph problems, and additional selected topics. Emphasis of the course will be on general techniques and approaches used for developing fast and efficient parallel algorithms.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand basic principles of parallel and distributed computing and with parallel and distributed algorithms and their time complexity.
- Understand basic principles and possibilities of algorithm parallelization.

Course Contents: Models of Parallel Computation, data parallel model, task graph model, work pool model, master slave model, pipeline or producer consumer model, hybrid models, Parallel Random Access Model (PRAM), parallel prefix , list ranking, graph algorithms, contention resolution, sorting algorithms, numerical algorithms, scientific algorithms, DAG models, memory models, asynchronous computation, synchronization primitives, performance metrics for parallel systems, modeling the cost of parallel algorithms, lower-bounds.

Reference Material

1. Boxer, L., & Miller, R. (2013). *Algorithms sequential and parallel: a unified approach* (Latest ed.). Boston, MA: Cengage. JáJá, J. (2001). *An introduction to parallel algorithms* (Latest ed.). Boston, MA: Addison-Wesley.
2. Casanova, H., Legrand, A., & Robert, Y. (2009). *Parallel algorithms* (Latest ed.). Boca Raton: CRC Press.

CS7246	Realtime Stream Processing	Credit Hours: 3

Course Description: This course provides the fundamentals of real-time stream processing paradigm. It introduces the key components of this paradigm, including the distributed system infrastructure, the programming model, the design patterns, and the realtime streaming analytics.

Aims and Objectives: Students successfully completing this course should be able to:

- Capturing real-time data
- Processing real-time data
- Aggregating data
- Monitor streaming in realtime

Course Contents: Introduction to stream processing, application development, large-scale development, visualization and debugging, architecture of a stream processing, design principles and patterns for stream processing applications, stream analytics

Reference Material

1. Andrade, H. C., Gedik, B., & Turaga, D. S. (2014). *Fundamentals of stream processing: application design, systems, and analytics* (Latest ed.). Cambridge: Cambridge University Press.
2. Ellis, B. (2014). *Real-time analytics: techniques to analyze and visualize streaming data* (Latest ed.). Indianapolis: John Wiley & Sons.

CS7247	**Linked Open Data**	**Credit Hours: 3**

Course Description: We are surrounded by data everywhere. By helping us to make better decisions, data plays a central role in our daily lives. An ever-increasing number of data sources, driven by individuals and organizations, contribute to this data deluge by sharing their data with others. However, data is locked up behind proprietary, unreliable, and even unstable programming interfaces that prevent us from optimally making use of it. Linked Data has the potential to revolutionize the way we discover, access, integrate, and use data; just in the way the World Wide Web has revolutionized the way we consume and connect documents. This course will introduce students with the basic principles, standards, and technologies of Linked Open Data to enable data sharing and reuse on a massive scale across multiple platforms and enterprises. This course will introduce students with the tools and methods for querying linked data and for representing rich ontologies that help define data-rich domains. Held together by ontologies, i.e. knowledge representations based on Semantic Web technologies, Linked Data serves as the central building block of the emerging Web of Data.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the Semantics representation, Resource Description Framework (RDF).
- Understand the Ontology, Web Ontology Language (OWL); metadata; vocabularies.
- How to publish and consume the Linked Data.
- Applications of linked open data.

Course Contents: Linked Data and the Web of Data, Moving from Open Data to Linked Data, Power and Role of Linked Open Data, Origins of Linked Open Data, Linked Data Paradigms,

Dereferencing, Ontology as a Shared Model of Objects, Properties and Relationships in a Domain, OWL (Web Ontology Language), Description Logic, Meta-Models, Re-use, Relationship to Vocabulary, Taxonomies, Linked Data Vocabularies and Ontologies, Metadata, URIs and URLs as the Foundation of the Semantic Web, RDF & RDFs Data Model, Dataset Based on Domain Ontology, RDF Serialization Formats (RDF/XML, Turtle),Triple stores, Named Graphs, Querying RDF with SPARQL, SPARQL Query Language, SPARQL Endpoints, Publishing Linked Data, Publishing Models on the Web, Open Linked Data, Enterprise Linked Data, Linked Data Mashups and Applications, Consuming and Visualizing Linked Data, Web-Based JavaScript Clients, JSON-LD, D3 Visualization, Applications of Linked Open Data in Specific Domains, Linked Data Tools.

Reference Material

1. Bauer, F., & Kaltenböck, M. (2011). *Linked open data: the essentials* (Latest ed.). mono/monochrom, Vienna.
2. Ordóñez de Pablos, P. (2013). *Cases on open-linked data and semantic web applications* (Latest ed.). IGI Global.
3. Bryl, V., & Tramp, S. (2014). *Linked open data-creating knowledge out of interlinked data: results of the LOD2 project* (Latest ed.). Heidelberg: Springer.
4. Heath, T., & Bizer, C. (2011). *Linked data: evolving the web into a global data space* (Latest ed.). Morgan & Claypool.

CS7248	**Virtual and Augmented Reality**	**Credit Hours: 3**

Content Description: Virtual reality (VR) and augmented reality (AR) are expected to be the next big computing environment due to the rapid uptake and development of the area over the past few years. Virtual and augmented reality are already being integrated into a number of industries such as healthcare, tourism advertising, entertainment, automotive, gaming, education and space industries. The varying scope of industries showcases how crucial it is that we train graduates in this space and put them at the forefront of this incredibly exciting and innovative field that is VR/AR. This course provides a comprehensive curriculum that targets the key areas of virtual reality (VR) and augmented reality (AR). This course presents the algorithms and techniques required to develop and deploy virtual reality and augmented reality applications. The course will cover VR and AR hardware, stereoscopic vision, VR software development, 3D user interfaces and presence.

Aims and Objectives: When student successfully complete this course, they will be able to:

- Understand the elements, architecture, input and output devices of virtual and augmented reality systems.
- Be able to develop and evaluate 3D interactive applications involving stereoscopic output, virtual reality hardware and 3D user interfaces.

Course Contents: VR as a Discipline. Basic Features of VR systems. Architecture of VR systems, VR Hardware, VR Input Hardware, Tracking Systems, Motion Capture Systems, Data Gloves. VR Output hardware, Visual Displays, Stereoscopic Vision, Fundamentals of the Human Visual System, Depth Cues, Stereopsis, Retinal Disparity and Parallax, Synthesis of Stereo pairs, Pipeline for Stereo Images, Haptic Rendering, Haptic Sense, Haptic Devices, Algorithms for Haptic Rendering, VR Software Development, Challenges in VR Software Development, Windowing, Viewing, Input/Output and Networking Issues, Master/Slave and Client/Server Architectures, Cluster Rendering, VR Juggler and XVR, AR Software Development, AR software, Camera Parameters and Camera calibration, Marker-based Augmented Reality, Pattern Recognition, AR Toolkit, 3D User Interfaces, Why 3D User Interfaces, Major User Tasks in VE, Interaction Techniques for Selection, Manipulation and Navigation. 3DUI Evaluation, Presence (concept, definition, measurement, and applications).

Reference Material

1. Vince, J. (2012). *Essential virtual reality fast: how to understand the techniques and potential of virtual reality* Latest ed.). Springer Science & Business Media.
2. Gao, F. (2012). *Design and development of virtual reality application system* (Latest ed.). Tsinghua Press.
3. Craig, A. B. (2013). *Understanding augmented reality: concepts and applications* (Latest ed.). Newnes.
4. Haller, M. (2006). *Emerging technologies of augmented reality: interfaces and design* (Latest ed.). IGI Global.

CS7249	Advanced Web Technologies	Credit Hours: 3

Course Description: In the past twenty years, the Web has transformed society and changed the way we work, trade, learn, do science, organize our lives, and play. The Web is, on the one hand, a network of interlinked computers, protocols, and software and, on the other hand, a socio-cultural phenomenon that influences law, the media, business, science, etc. To shape and work with the current and future forms of the Web, we need to understand its underlying design principles and concepts, relevant issues and techniques, and how these interact and influence each other. The fast changing nature of the Web means that such a deep understanding is essential to understand the latest developments and their potential. This course will familiarize students with modern Web technologies that contribute to the efficient use of the Internet as a global resource, which means working with different types of data, structured and unstructured, and the development of Web applications that are accessible to a large number of users using different client applications.

Aims and Objectives: By the end of the course, as a minimum, the student will be able to:

- Understand advance web technologies and applications of these technologies for the designing and implementation of web applications.

- Understand and use the basics of the XML based technologies, and Web Services and the implementation of Web Services for Service Oriented Architecture (SOA).
- Use XML and XML based technologies.
- Design and implement user interfaces based on the AJAX and web mashup technologies.

Course Contents: Basic XML technologies, XML Parser, XML Namespace, XML Document Type Definition (DTD), XML Schema, XML Validator, Simple API for XML, XML Path Language (XPath), Extensible Stylesheet Language Transformation (XSLT), Extensible Stylesheet Language Formatting Objects (XLink, XPointer, XInclude, and XBase), Web Sevices with Simple Object Access Protocol (SOAP) and Web Service Desciption Language (WSDL), Universal Description Discovery and Integration (UDDI),AJAX technology with JavaScript Programming and Document Object Model (DOM), AJAX integration with XML, Creating Web Application using Web Mashups, Web 2.0 Technologies, JQUERY, JSON, Bootstrap, Basics of Search Engine Optimization (SEO).

Reference Material

1. Right, C. (2015). *XML Programming: The Ultimate Guide to Fast, Easy, and Efficient Learning of XML Programming (Operating System, Projects, XML Programming, DTD's, HTML5, JavaScript)* (Latest ed.). CreateSpace Independent Publishing Platform.
2. Benz, B., & Durant, J. R. (2004). *XML Programming Bible* (Latest ed.). John Wiley & Sons.
3. Sikos, L. (2014). *Web standards: mastering HTML5, CSS3, and XML* (Latest ed.). Apress. Newcomer, E. (2002). *Understanding web services: XML, Wsdl, Soap, and UDDI* (Latest ed.). Addison-Wesley Professional.
4. Rosen, M., Lublinsky, B., Smith, K. T., & Balcer, M. J. (2012). *Applied SOA: service-oriented architecture and design strategies* (Latest ed.). John Wiley & Sons.

CS7250	**Digital Libraries**	**Credit Hours: 3**

Course Description: This course examines both theoretical and practical aspects of digital library activities, focusing largely on technological and socioeconomic issues. It aims to develop a broad understanding of digital libraries, including basic concepts, types and formats of digital content, the creation and organization of digital libraries, underlying technologies, the preservation of digital content, access management of digital library resources, and social and economic factors. It will demonstrate and exemplify current activities in the digital library field, and will give students up-to-date, hands-on experience in a rapidly developing field. Students will plan and create fully operational models for real-life digital library activities.

Aims and Objectives: When students complete this course, they will be able to:

- Get an overview of current digital library programs and activities, both in North America and internationally.
- Get familiarized with the major techniques and software used in the creation and maintenance of digital libraries.
- Evaluate the major components of digital libraries by considering their supporting technologies and social-economic factors.
- Examine the social, economic, cultural, and political issues related to digital libraries and their services.
- Get professional track, plan and create a small-scale, but useful and functional, digital library.
- Do research track, review a practical (or research) problems associated with digital libraries and develop a valid approach to solve it.

Course Contents: Introduction and Overview to Digital Libraries, Digital Content: Image Digital Content: Text, Metadata and Markup, Metadata for Representing and Organizing Digital Objects, Basic Elements of Dublin Core for Digital Objects, Functionalities of the Major Components of XML, Creating Simple XML Documents for Describing Digital Objects), Digital Content, Time-Based Formats (Audio and Video), Digital Objects and System Architecture Digital Objects and DOI, Major Components of Digital Libraries, Digital Library Architecture, SOA and Digital Libraries, Digital Library Software, Knowledge Organization Schemes and Content Organization, User Interface, Usability and Evaluation, Access in Digital Libraries, Digital Preservation, Repositories and Archives, Social and Economic Factors, Social Life of Documents, Social Impacts of DL, Social Issues in Designing and Developing DL, Access Management, Human Factors of Digital Libraries, Digital Librarians.

Reference Material

1. Lesk, M. (2005). *Understanding digital libraries* (2nd ed.). Elsevier. (or Latest ed.)
2. Reese, T., & Banerjee, K. (2008). *Building digital libraries: a how-to-do-it manual* (Latest ed.). Neal-Schuman Publishers.
3. Calhoun, K. (2014). *Exploring digital libraries: foundations, practice, prospects* (Latest ed.). Facet Publishing.
4. Ashraf, T. (2012). *Design, development, and management of resources for digital library services* (Latest ed.). IGI Global.

CS7251 Information and Communication Technology (ICT) Accessibility Credit Hours: 3

Course Description: This course provides how to measure an organization's ICT accessibility and assess the importance of maintaining an inclusive workplace for both employees and customers with disabilities. Individuals with disabilities often encounter barriers in accessing electronic information and using digital technologies. In this course, you will learn about the fundamentals of accessibility design in the ICT field. The course emphasis will be on identifying, evaluating and applying strategies and techniques for making electronic information and communication technology services and products in corporate, governmental, and not-for-profit organizations accessible to all users.

Aims and Objectives: When students complete this course, they will be able to:

- Summarize the foundations of ICT accessibility.
- Summarize the principles of accessible ICT design.
- Identify the uses of assistive technology.
- Create accessible documents and multimedia.
- Evaluate and repair websites for accessibility.
- Identify components of ICT accessibility operations

Course Contents: Background Information on ICT Accessibility and the Future of Electronic Information Accessibility, Importance of Design in Accessibility, Value of Container and Content, Evaluation of Compliance, Impact of Assistive Technology on Individuals with Disabilities, Federal Laws Related to Assistive Technology, Mainstream Wearable Technologies and Assistive Technologies, Accessible Documents and Multimedia, Elements of an Accessible Document, Accessibility Standards, Tools to Check Accessibility, Multimedia Captioning and Audio Description Demonstration, Audio Description Standards, Guidelines and Resources, Web Accessibility Evaluation and Design, Web Accessibility Definition and Overview, Understanding Interaction of Web and Users with Accessibility Needs, Evaluating Accessibility Issues via Online Tools, Remediation of Code in Order to Achieve Website Accessibility, and Contribution of HTML5 and ARIA to Website Accessibility, ICT Accessibility Operations, Influence of Market Forces on the Development of Enterprise ICT Accessibility Operations, Challenges Faced by these Enterprises, Enterprise ICT Accessibility Operational Model, Recommended and Suggested Activities for Deeper Exploration and Learning Content.

Reference Material

1. Cunningham, K. (2012). *Accessibility handbook: making 508 compliant websites* (Latest ed.). O'Reilly Media, Inc.
2. Gumata, Y. & Tiwari, A. (2012). *Challenges of ICT accessibility* (Latest ed.). Lap Lambert Academic Publishing.

CS7252 Wireless Ad hoc Networks Credit Hours: 3

Course Description: This course covers advanced topics in ad hoc networking, one of the most challenging fore-fronts of wireless communications. Overview and descriptions of Ad hoc Networks is provided, with emphasis on Wireless sensor networks (WSN). At the end of semester each student will submit a survey report related to the course.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the fundamentals wireless Ad hoc networking
- Understand the current topics in wireless sensor networks both in industry and research point of view.
- Principles of wireless Ad hoc networks and what makes it different from infrastructure networks.

Course Contents: Introduction, applications and challenges to WSN, Mobile Ad hoc Networks (MANETS). Medium access control (MAC) protocols for MANETs Routing protocols for MANETs. Transport protocols and congestion control for MANETs. Security issue in MANETs. Power-efficient MAC protocols for WSNs. Routing and data dissemination in WSNs. Flow and Congestion control in WSNs. Topology control in WSNs. Node deployment and localization in WSNs.

Reference Material

1. Toh, C. K. (2007). *Ad Hoc Mobile Wireless Networks Protocols and Systems* (Latest ed.). Pearson Education Inc. ISBN: 0-470-09510-5.
2. Relevant research papers

CS7253	**Introduction to Computer Vision**	**Credit Hours: 3**

Course Description: This course gives students an introductory insight into theory of computer vision. It focuses on some basic vision issues such as shape and region representation/description as examples of the vision problem. Some advanced topics are introduced.

Aims and Objectives: After completing the courses students should be able to:

- Students will be able to explain the computer vision problem and identify its various forms and types. They will gain acquaintance with tools, methods, and algorithms to handle computer vision tasks. They will be able to implement vision algorithms in MATLAB and other tools.

Course Contents: Image processing: edge detection, segmentation, local features, shape and region description in 2D and 3D. Insight from human vision studies. Representation for vision: object models, synthetic images, matching, gaps, and algorithms. Interference, production system, synthetic networks. Planning spatial reasoning for robot vision.

Reference Material

1. Simon, J. D. Prince. (2012). *Computer Vision: Models, Learning, and Inference* (Latest ed.). Cambridge University Press; 1107011795, 978-1107011793.
2. Szeliski, R. (2011). *Computer Vision: Algorithms and Applications*. Springer; 1848829345, 978-1848829343.
3. Kaehler, A. (2008). *Computer Vision with OpenCV Library* (Latest ed.). O'Reilly Media; IDBN-10: 0596516134, ISBN-13: 978-0596516130.
4. Solem, J. E. (2012). *Programming Computer Vision with Python* (Latest ed.). O'Reilly Media, 1449316549, 978-1449316549

CS7254	**Advanced Digital Image Processing**	**Credit Hours: 3**

Course Description: Advanced Digital Image Processing investigates algorithms and techniques for a variety of imaging applications. The techniques build on the background that is established in the course, Introduction to Digital Image Processing, which focuses on basic image processing methods.

Aims and Objectives: After completing this course:

- Through this course, students will be able to gain a deeper understanding of the vision tasks such as enhancement, segmentation, and object recognition.
- Familiarity with advanced techniques will be gained and theoretical understanding will be enhanced.

Course Contents: Image Enhancement in Spatial Domain, Image Enhancement in Frequency Domain, Image Restoration, Color Image Processing, Morphological Image Processing, Image Segmentation, Object Recognition, Wavelet and Multi-resolution Processing, Feature Detection and Classification.

Reference Material

1. Gonzalez, R. C. and Woods, R. E. (2008). *Digital Image Processing* (3rd ed.), Prentice Hall.
2. Gonzalez, R. C. and Woods, R. E. (2008). *Digital Image Processing Using MATLAB*, Prentice Hall.

CS7255	Automatic Speech Recognition	Credit Hours: 3

Course Description: This course covers the theory and practice of automatic speech recognition (ASR), with a focus on the statistical approaches that comprise the state of the art. The course introduces the overall framework for speech recognition, including speech signal analysis, acoustic modeling using hidden Markov models, language modeling and recognition search. Advanced topics covered will include speaker adaptation, robust speech recognition and speaker identification. The practical side of the course will involve the development of a speech recognition system using a speech recognition software toolkit.

Aims and Objectives: After completing this course, students will be able to:

- Describe the statistical framework used for automatic speech recognition.
- Understand the weakness of the simplified speech recognition systems and demonstrate knowledge of more advanced methods to overcome these problems.
- Describe speech recognition as an optimization problem in probabilistic terms.
- Relate individual terms in the mathematical framework for speech recognition to particular modules of the system.
- Build a large vocabulary continuous speech recognition system, using a standard software toolkit.

Course Contents: Signal analysis for ASR, Statistical pattern recognition (Bayes decision theory, Learning algorithms, Evaluation methods, Gaussian mixture model, and EM algorithm), Hidden Markov Models (HMM), Context-dependent models, Discriminative training, Language models for LVCSR (large vocabulary continuous speech recognition), decoding, robust ASR (Robust features Noise reduction, Microphone arrays), adaptation (Noise adaptation, Speaker adaptation/normalization, Language model adaptation), speaker recognition, history of speech recognition, advanced topics (Using prosody for ASR, Audio-visual ASR, Indexing, Bayesian network), speech recognition applications (including privacy implications).

Reference Material

1. Holmes, W. (2001). *Speech Synthesis and Recognition* (2nd ed.). Prentice Hall.
2. Huang, X., Acero, A., Hon, H. (2001). *Spoken language processing: a guide to theory, algorithm, and system development*, Prentice Hall.
3. Rabiner, L., & Juang, B. (1993). *Fundamental of Speech Recognition*. Prentice Hall
4. Gold, B., Morga, N. (1999). *Speech and Audio Signal Processing: Processing and Perception of Speech and Music* (Latest ed.). John Wiley and Sons.

CS7256	Image Compression	Credit Hours: 3

Course Description: Image compression is an important task in image processing. The aim of image compression is to reduce irrelevance and redundancy of image data in order to be able to store or transmit data in an efficient form. The course will cover the main image compression techniques and present the problem in the larger context of digital image processing.

Aims and Objectives: After completing the courses students should be able to:

- To learn different image compression techniques, compare and asses them, and know their strengths and weaknesses.
- Students will be able to implement a technique.

Course Contents: Introduction to Image compression, concepts of image compression, JPEG system, DCT and Hoffman coding, JPEG modes of operation, JPEG syntax, Lossless coding and compression, the DFT and FFT, pyramidal, FAX compression: G3/4, JBIG, Block truncation coding, Fractal coding, morphological image compression, introduction to wavelets, wavelet families, zero-Tree coding, concepts of video coding, H261 video coding, MPEG 1 video coding, MPEG2 scalability, error resilience and concealment, MPEG-4 video coding, H.254 video codec.

Reference Material

1. Sayood, K. (2012). *Introduction to Data Compression*, (4th ed.). Morgan Kaufmann, 9780124157965, 9780124160002
2. Weidong, K. (1995). *Digital Image Compression: Algorithms and Standards* (Latest ed.). Springer 978-1-4757-2361-8.
3. David**, T.,** Michael, M. (2002). *JPEG Image Compression Fundamentals* (Latest ed.). Springer, 978-1-4615-0799-4.

CS7257	Advanced Machine Learning and Neural Networks	Credit Hours: 3

Course Description: This course is a continuation in the study of the philosophy, utility, and models of machine learning, such that students are able to propose original research with potential follow-up in a graduate research program. It attempts to expand the creativity of the students in all aspects of computing.

Aims and Objectives: After completing this course:

- Through this course, students will be able to understand concepts in machine learning and neural networks more thoroughly and at an advanced level.

- Students will gain background knowledge for topics such as deep learning.

Course Contents: Von Neumann bottleneck/neurobiology primer, Advanced Back propagation Concepts, On-line vs. Batch, classification Based Learning, other (Higher Order nets, Ontogenic Nets), hopfield networks, Boltzmann machines, Recurrent Neural Networks (Elman Nets, BPTT, RTRL), Deep Learning, Support Vector Machines (with brief review of Quadric/Higher Order Machines and RBF networks), HMMs (with Baum Welch Learning - EM algorithm), with detailed speech recognition as the example platform, MULTCONS, Hopfield Extensions, Rule Based Learning (Sequential Covering, CN2), Semi-Supervised Learning.

Reference Material

1. Haykin, S. (2009). Neural Networks: A Comprehensive Foundation, (2nd ed.), Prentice-Hall, 0123733501, 978- 0123733501.
2. Hagan, M. T., Demuth, H. B., Beale, M. H., Jesús, O. D., Hagan, M. (2014). *Neural Network Design*, (2nd ed.), 0971732116, 978-0971732117.
3. Rashid, T. (2016). *Make Your Own Neural Network*, *CreateSpace* (Latest ed.). Independent Publishing Platform;
4. Hassoun, H. (2003). *Fundamentals of Artificial Neural Networks*, *A Bradford Book* (Latest ed.). 0262514672, 978-0262514675
5. Raschka, S. (2015). *Python Machine Learning* (Latest ed.). Packet Publishing - ebooks Account,1783555130, 978-1783555130

CS7258	**Mathematics for Imaging**	**Credit Hours: 3**

Course Description: Mathematical modeling is extensively used in image processing. This course will help students build understanding of the mathematical concepts underlying image processing theory and techniques. The course pays attention to topics such as Radon and Fourier transforms, convolution, etc.

Aims and Objectives: After completing this course, students will have:

- a good understanding of the mathematical tools applied in image processing. They will be fluent in topics like Radon and Fourier transforms, convolution, filters, and mathematics of algebraic reconstruction.

Course Contents: X-Rays, The Radon transform, back projection, complex numbers: the complex exponential functions and wave functions, the Fourier transform, the central slice theorem, filtered back projection, the Hilbert transform, filters and convolution: properties and filter resolution, convolution and the Fourier transform, the Rayleigh-Plancherel theorem, convolution in two-dimensional space, low-pass filters, discrete image reconstruction: sampling, discrete low-pass filters, discrete functions and convolution, discrete Radon and Fourier transforms, discrete back

projection, interpolation, Fast Fourier Transform(FFT), matrix forms, fan beam geometry, algebraic reconstruction techniques, MRI, Integrability, matrices, transpose, and factorization.

Reference Material

1. Feeman, T. G. (2015). *The Mathematics of Medical Imaging: A Beginner's Guide*, (2nd ed.). Springer; 3319226649, 978-3319226644.
2. Epstein, C. L. (2007). *Introduction to the Mathematics of Medical Imaging, Society for Industrial and Applied Mathematics*; (2nd ed.). 089871642X, 978-0898716429.
3. Devaney, A. J. (2012). *Tomography and Wavefield Inversion, Mathematical Foundations of Imaging* (Latest ed.). Cambridge University Press; 052111974X, 978-0521119740.

CS7259	Pattern Recognition	Credit Hours: 3

Course Description: This is a beginning course in pattern recognition and focuses on the problem of pattern recognition and the approaches developed to deal with it. The course gives students the necessary background understanding of the theory of pattern recognition for exploring the issue in other areas, e.g., NLP, and Computer Vision.

Aims and Objectives: After completing the courses students should be able to:

- Gain sufficient understanding of the theory of pattern recognition.
- Learn about the broad approaches used to deal with the problem of pattern recognition.
- Apply the knowledge gained in the course to pattern recognition problems in other area.

Course Contents: Mathematics for pattern recognition: curve fitting, probability theory, decision theory, information theory, probability distributions, linear models for regression and classification (emphasis on discriminant functions, probability generative, probability discriminative models), neural networks and kernel methods, graphical models (Bayesian and Hidden Markov Models), mixture models, approximate inference, sampling methods, continuous latent variables (dimensionality reduction and PCA), and sequential data.

Reference Material

1. Bishop, C. (2007). *Pattern Recognition and Machine Learning* (Latest ed.). Springer, 0387310738, 978-0387310732
2. Duda, R. O., Hart, P. E., & Stork, D. G. (2000). *Pattern Classification* (2nd ed.), John Wiley and Sons

CS7260	Technology Enhanced Learning	Credit Hours: 3

Course Description: Information and Communication technologies has revolutionized the learning activities. Technology Enhanced Learning is a broader term that represents use of technologies to facilitate, improve or scale educational activities. This course will introduce students to a range of areas and applications of Technology Enhanced Learning. The main objective of this course is to expose students to the applications of technology in learning for enhanced learning experiences.

Aims and Objectives: After completing the courses students should be able to

- Have knowledge of a range of range of learning technologies
- Understand many of the theoretical and pedagogical issues which define digital education
- Explore different themes in the field of technology enhanced learning
- Identify various ways of improving students' learning experience and engagement with learning systems
- To design learning systems with appropriate tools to enhance learning experiences.

Course Contents: Introduction to Technology Enhanced Learning, Application areas of Technology Enhanced learning, Intelligent Tutoring System, Adaptive Learning systems, Personalization in Learning System, Learner Model, Concepts Maps, Learning Objects, Learning Object Models. Open Educational Resources, Ontologies for learning systems. Blended Learning, Virtual Learning Environment (VLE), Educational Games, Ubiquitous Learning, Mobile Learning, Gamification in Learning Applications, Learning Analytics, MOOCs, Issues in Online Learning, Learners engagement, Collaborative Learning and Case studies of different learning tools. Smart Learning Spaces, Review of existing popular E-learning applications, Authoring tools for learning materials.

Reference Material

1 Clark, R., (2012). *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning* (Latest ed.). Pfeiffer

2 Mayes, T. and De Freitas, S., (2013). *Technology-Enhanced Learning: the role of theory* (Latest ed.).

3 H. Beetham and R. Shapre. *Rethinking Pedagogy for a Digital Age* (Latest ed.). Abingdon, Taylor and Francis.

4 Other readings will be assigned in class.

CS7261	Mobile Interventions and Persuasive Technologies	Credit Hours:3

Course Description: This course is designed to provide the student with opportunity to understand the emerging field of Persuasive Technologies and how to design and develop persuasive applications in any field of interest.

Aims and Objectives: After completing the course students should be able to

- Understand how human behavior works.
- Under potential strategies for developing applications for behaviour change
- Identify areas of applications of mobile interventions through persuasive applications
- Design and develop strategies for building persuasive mobile and web applications.

Course Contents: Persuasive Technologies, Introduction to Captology, Behavior change support systems, How the Mind Decides What to Do Next, A Simple Model of When, and Why, We Act, The Create Action Funnel, Strategies for Behavior Change, Figuring Out What You Want to Accomplish, Selecting the Right Target Action, Structuring the Action, Moving from Conceptual Designs to Interface Designs, Reviewing and Fleshing Out the Interface Designs, Measuring Impact, Identifying Obstacles to Behavior Change, Persuasive Interfaces, Persuasion and Social Media, Persuasive Games, Implementation Technologies: Mobile Applications, Web Systems, Cloud Technologies. Sensors, Applications of Persuasive Technologies in Education, Health, Behavioural Change, Workplace, E-Commerce.

Reference Material

1 Fogg, B.J. (2002). *Persuasive Technology: Using Computers to Change What We Think and Do, Interactive Technologies* (Latest ed.). Morgan Kaufmann.
2 Fogg, B.J. (2007). *Mobile Persuasion: 20 Perspectives on the Future of Behavior Change* (Latest ed.). Stanford Captology Media
3 Wendel, S., (2013). *Designing for Behavior Change: Applying Psychology and Behavioral Economics* (Latest ed.), O'Reilly Media.
4 Jones, M., (2006). *Mobile Interaction Design* (Latest ed.). Marsden, G, Wiley.

CS7262	Interaction Design	Credit Hours: 3

Course Description: This course aims to give students an understanding of the area of Interaction Design and provide students with knowledge and skills to design usable interfaces. This course discusses different factors that affect the design of interactive hardware and software systems and exposes students to contemporary Human Computer Interaction issues in different application

areas. This course also introduces students to various evaluation techniques for evaluating interactive systems.

Aims and Objectives: After completing the courses students should be able to

- Demonstrate knowledge and understanding of the main concepts (conceptual model, metaphors and paradigms) that influence human-computer interaction
- Understand how to design, prototype and evaluate a user interface for an interactive system.
- Design solutions for interacting computer systems.
- Design usable interfaces
- Use practical skills selecting an appropriate evaluation technique for evaluating interactive system.

Course Contents: What Is Interaction Design? The User Experience, The Process of Interaction Design. Conceptualizing Interaction, Conceptual Models, Interaction Types, Paradigms, Visions, Theories, Models, and Frameworks, Cognitive Aspects, Social Interaction, Emotional Interaction, Interfaces, Interface Types, Participatory Design, Data Gathering, Interviews, Questionnaires, Observation, Data Analysis, Interpretation, And Presentation, Qualitative and Quantitative Analysis, Prototyping, Types of Evaluation, Evaluation Case Studies, Usability Testing, Conducting Experiments, Field Studies, Inspections: Heuristic Evaluation and Cognitive Walkthroughs.

Reference Material

1 Rogers, Y., Sharp, H. and Preece, J. (2014*). Interaction Design: Beyond Human-Computer Interaction* (4th ed.) Wiley and Sons.

2 Dix,A., Beale,R.. (2003). *Human-Computer Interaction* (Latest ed.). Prentice Hall.

3 Shneiderman B. (2004). *Designing the User Interface* (4th ed.) Addison Wesley, (or Latest ed.)

4 Jacko, J.A., (2012). *Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*, (3rd ed). CRC Press.

CS7263	**User Centered Research and Evaluation**	**Credit Hours: 3**

Course Description: This course is designed to provide students with the core knowledge and skills required for conducting research in the area in the Human Computer Interaction. This course introduces techniques and methods used in the evaluation of interactive user-centred system.

Aims and Objectives: After completing the courses students should be able to

- Design, prototype and evaluate usability of interactive system

- Have advanced knowledge and skills in the area of evaluating interactive systems
- Have necessary practical skill to design and conduct experimental research studies in the area of HCI
- Select appropriate HCI Design Methodologies and apply them in the solution of real world design problems
- Select appropriate methodologies for the evaluation of HCI systems and implement these methodologies on real systems and analyse and discuss the results produced
- Have understanding and knowledge of designing quantitative and qualitative studies for evaluating interaction designs

Course Contents: Introduction to Interfaces and Design, Humans and Computers, The basics of Designing, Design and Usability, Evaluation Basics, Establishing Requirements, Design, Prototyping, Mock-ups and Wire framing, Using Scenarios, Data Analysis And Interpretation, Quantitative Evaluation and Qualitative Evaluation, Designing Evaluation Studies, Types of Evaluation, Conducting Experiments, Questionnaires, Interviews, Observation, Evaluation Case Studies, Focus Groups, Usability Testing, Field Studies, Inspections: Heuristic Evaluation and Walkthroughs, Introduction to Statistical Tests, Result Gathering and Interpreting, Tools to Support Data Analysis, Analyzing Quantitative data with SPSS, Analyzing Qualitative data with NVivo, Ethical Issues in Experiment design.

Reference Material

1 Lazar J, (2010). *Research Methods in Human-Computer Interaction* (Latest ed.). Wiley.

2 Rogers, Y., Sharp, H. and Preece, J. (2014). *Interaction Design* (4th ed). Wiley and Sons.

3 *Innovating for People: Handbook of Human-Centered Design Methods* (Latest ed.). LUMA Institute.

4 Kuniavsky, M., Goodman, E., and Moed, A. (2012). *Observing the user experience: a practitioner's guide for user research* (Latest ed.). Amsterdam: Elsevier.

5 Hartson, R., (2012). *The UX Book: Process and Guidelines for Ensuring a Quality User Experience* (Latest ed.). Morgan Kaufmann (Ed.). Elsevier.