PhD (CS)

New Course Outline

Table 1. Ph.D. courses with new course codes

Old Course Code	New Course Code	Course Title	Remarks
CS811	CS8101	Computational Syntax and Discourse	-
CS812	CS8102	Corpus and Natural Language Engineering	-
CS813	CS8103	Automatic Translation	-
CS820	CS8104	Advanced Wireless Sensor Networks	-
CS830	CS8105	Network Traffic Engineering	Course Renamed from "Computer Networking II"
CS831	CS8106	Advanced Network Security	-
CS840	CS8107	Information & Web Semantics	-
CS841	CS8108	Advanced Ontology Engineering	-
CS843	CS8109	Information Visualization	-
CS850	CS8110	Topics in Databases	-
CS851	CS8111	Advanced Object-oriented Methods	-
CS860	CS8112	Advanced Computer Graphics	-
CS863	CS8113	Special Topics in Computer Science	-
CS864	CS8114	Computational Morphology	-
CS865	CS8115	Topics in Data Warehousing and Business Intelligence	-
CS866	CS8116	Text Mining	-
CS867	CS8117	Topics in Data Mining	-
CS868	CS8118	Advanced Topics in Wireless Networks	-
CS869	CS8119	Cloud Computing	-
CS870	CS8120	Emerging Themes in Agile Software Development	Course Renamed from “Agile Methodologies and Applications”. Course Contents Revised
CS871	CS8121	Software Measurement and Metrics	-
CS872	CS8122	Advanced Software Architecture	Course Renamed from “Software Architecture”
CS873	CS8123	Software Engineering Ontologies	-
CS874	CS8124	Software Process Improvement	-
CS875	CS8125	Advanced User Interface Design and Development	-
CS876	CS8126	Software CASE Tools and Applications	-

Old Course Code	New Course Code	Course Title	Remarks
CS877	CS8127	New Trends in Software Engineering	Course Renamed from “Special Topics in Software Engineering”
CS879	CS8128	Context Aware Computing	-
CS880	CS8129	Digital Forensics	-
CS881	CS8130	Social Web	Course Contents Revised
CS882	CS8131	New Trends in Wireless Sensor Networks	Course Renamed from “Special Topics in Wireless Sensor Networks”
CS883	CS8132	Embedded Systems	-
CS884	CS8133	Localization techniques in Wireless Sensor Networks	-
CS885	CS8134	Middleware in Wireless Sensor Networks	Course Renamed from “Middleware-II”
CS886	CS8135	Special Topics in Information Security	-
CS887	CS8136	Special topics in computer networks	-
CS888	CS8137	Special Topics in Human Language Technology	-
CS889	CS8138	Advanced Topics in Real-Time Systems	-
CS891	CS8139	Distributed Real-Time Java Systems	-
CS892	CS8140	Real-Time Scheduling Theory	-
-	CS8141	Smart Device-To-Device Communication	New Course
-	CS8142	Green Software Engineering	New Course
-	CS8143	Enterprise Architecture and Integration	New Course
-	CS8144	High Performance Computing	New Course
-	CS8145	Fault Tolerance in Computing	New Course
-	CS8146	Semantic Data Storage and Management	New Course
-	CS8147	User Experience Design	New Course
-	CS8148	Ambient Assisted Living	New Course
-	CS8149	Soft Computing	New Course
-	CS8150	Modeling and Simulation	New Course
-	CS8151	Wireless Sensor Network Security and QoS	New Course
-	CS8152	Medical Image Analysis	New Course
-	CS8153	Face and Gesture Recognition	New Course
-	CS8154	Deep Learning in Computer Vision	New Course
-	CS8155	Advanced Computer Vision	New Course

Old Course Code	New Course Code	Course Title	Remarks
-	CS8156	Medical Image Registration	New Course
-	CS8157	Advanced Deep Learning	New Course
-	CS8158	Deep Learning in Natural Language Processing	New Course
-	CS8159	Advanced Human Computer Interaction	New Course
-	CS8160	Advanced Learning Technologies	New Course
-	CS8161	Serious Games	New Course

Table 4.4. Dropped/Archived Ph.D. courses

Course code	Course Title
CS844	Web Information Retrieval and Mining
CS845	State-of-the-art in Software Technology
CS852	Advanced Software Engineering and Design
CS861	Pattern Recognition
CS862	Computer Vision
CS878	Mobile Based Augmented Reality
CS890	Advanced Topics in Parallel Programming

CS8141 **Smart Device-To-Device Communication** **Credit hours: 3**

Course Description: Device to device communication is an emerging technology with multi-folded benefits. It provides various advantages in the form of energy efficiency, data offloading and caching in the cellular networks. Machine type communication (MTC), which is one of the enabling technologies of 5th Generation (5G) network, can also be seen as a special case of smart D2D communication. This course will also address the fundamental concepts and potential research areas in the next generation networks.

Aims and Objectives: The students will be familiar with:

- Potentials of D2D communication in ubiquitous environment.
- Challenge induced such as resource allocation and interference management when deploying D2D communication in cellular environment.
- State of the art in the field of next generation networks.

Course Contents: Device to device (D2D) communication protocols and method, interference management and system capacity, self-organizing device discover, energy efficient cognitive and

cooperative D2D communication, resource management, challenges and advantages in multi-hop D2D communication including restricting two-hop scenario, Quality improvement in real time applications, short range communication, D2D mobility measurements, modelling and management, LTE-A SAE architecture for D2D technology, lightweight security, different D2D technologies for public safety, PMR radio, vehicular communication, M2M communication, and eHealth, standardization activities and business model for D2D.

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* (Latest ed.). Wiley.
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* (Latest ed.). Prentice Hall.

CS8142	**Green Software Engineering**	**Credit Hours: 3**

Course Description: Green software engineering is an emerging research field which aims at creating, using, and disposing the energy-efficient software in an environment friendly manner with less negative impacts. The research community strongly believes that the energy efficiency and sustainability of the software can be improved by modifying the existing software engineering methods. This course will familiarize the scholars to identifies and map such methods for green and sustainable software development.

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

- Identify the research types, research goals, software engineering research topics, accepted validation methods and publication that are used in the field of green and sustainable software engineering.
- Summarize the body of knowledge in the field of green and sustainable software engineering and provides a platform to conduct future research.

Course Contents: Introduction to Green in Software Engineering, Environments, processes and construction which include Green Software Engineering Environments, Processes for Green and Sustainable Software Engineering, Constructing Green Software Services: From Service Models to Cloud-Based Architecture, Economic Aspects of Green ICT, Green Software Quality Factors, From Requirements Engineering to Green Requirements Engineering, Towards Green Software Testing, Green Software, Green Software and Software Quality, A Decision-Making Model for Adopting Green ICT Strategies, and Participation and Open Innovation for Sustainable Software

Recommended Material

1. Calero, C. (2016). *Green in software engineering* (Latest ed.). S.l.: Springer International PU.

CS8143	Enterprise Architecture and Integration	Credit Hours: 3

Course Description: In this capstone course you will build upon the ICT knowledge gained throughout the degree program by developing skills in enterprise architecture planning (EAP) and in enterprise application integration (EAI). Using EAP, you will learn to create architectures that define and describe the data, applications, and technology needed to support organizations. In applying EAI, you will gain experience in creating strategic business solutions using Web services and middleware to integrate the functionality of an organization's existing applications, commercial packaged applications, and new code.

Aims and Objectives: To introduce:

- Enterprise Application Integration (EAI) Technologies and Strategies
- Enterprise and e-Government Portals for Integrated Access to Enterprise Resources
- Web Services and Service-Oriented Architecture (SOA) Business Process Management (BPM) Concepts for Real-Time Enterprise Integration
- Evolving Enterprise Integration Strategies to Enterprise Architecture

Course Contents: Conceptual, logical, component, and operational views of Enterprise Information Architecture, Fundamental Problems in Large-Scale Application Integration, Information service lifecycle management, Systems Integration, Service Oriented Architecture (SOA) and Enterprise Service Bus (ESB), Integration with Legacy Systems: Challenges and Approaches, Deployment of Large-Scale Systems in the Real World.

Reference Material

1. Finkelstein, C. (2006). *Enterprise Architecture for Integration* (Latest ed.). Norwood: Artech House.

CS8144	High Performance Computing	Credit Hours: 3

Course Description: The course will study high performance computer architectures, including modern parallel processors, and will describe how an algorithm interacts with these architectures.

It will also look at practical methods of estimating and measuring algorithm/architecture performance.

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

- Transform algorithms in the computational area to efficient programming code for modern computer architectures;
- Write, organize and handle programs for scientific computations;
- Use tools for performance optimization and debugging;
- Analyze code with respect to performance and suggest and implement performance improvements;
- Report on performance analysis in clear and correct writing.

Course Contents: Algorithmic models (the view from Berkeley); Computational models (Flynn's taxonomy); Communication models (interconnects, message passing); Memory models (NUMA etc); Single-computer technologies (vector/SIMD computing via AVX/SSE, multi-core computing via OpenMP, many-core computing via OpenCL); Multi-computer technologies (cluster computing via MPI); Other approaches (cloud, distributed and redundant file systems, load balancing, check-pointing); Design and implementation of parallel algorithms and libraries.

Reference Material

1. Eijkhout, V., Chow, E., and Geijn, R. V. (2015). *Introduction to High Performance Scientific Computing* (Latest ed.). Raleigh, NC: Lulu.
2. Hager, G., Wellein, G. (2010). *Introduction to High Performance Computing for Scientists and Engineers (*Latest ed.). Norwood: Artech House.

CS8145	**Fault Tolerance in Computing**	**Credit Hours: 3**

Course Description: This course highlights the concepts of fault tolerance in computing. In this course, we study the causes of computer system failures (impairments to dependability), techniques for ensuring correct and timely computations despite such impairments, and tools for evaluating the quality of proposed or implemented solutions.

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

- Understand the risk of computer failures
- Know the different advantages and limits of fault avoidance and fault tolerance techniques
- Be aware of the threat from software defects and human operator error as well as from hardware failures
- Understand the basics of redundant design;
- Be able to specify the use of fault tolerance in the design of application software

- Understand the relevant factors in evaluating alternative system designs for a specific set of requirements
- Be aware of the subtle failure modes of "fault-tolerant" distributed systems, and the existing techniques for guarding against them

Course Contents: Introduction to fault tolerant systems, hardware fault tolerance, information redundancy, software fault tolerance, N- version programming, recovery block approach, exception handling, software reliability models, checkpointing, fault tolerance in real-time systems, fault tolerance in safety critical systems.

Reference Material

1. Koren. I. Krishna, M. (2014). *Fault-Tolerant Systems* (Latest ed.). Morgan Kaufmann Publishers Inc.
2. Lee, P. A. (2013) *Fault Tolerance: Principles and Practice* (Latest ed.). Morgan Kaufmann Publishers Inc.

CS8146	**Semantic Data Storage and Management**	**Credit Hours: 3**

Course Description: This course will enable students to make more informed decisions in an increasingly complex IT environment. It builds a strong understanding of underlying operating systems concepts for storage and prepares you to learn advanced concepts, and technologies.

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

- Semantically enriching operating systems storage mechanisms.

Course Contents: Introduction to Semantic Data Management, Data and Metadata Management, File Systems, Introduction to Distributed Systems, Searching, The Semantic Web Languages, Modeling Web Data Storage, Semantic Web Data Management, Reasoning in the Semantic Web, Semantic Web Data Querying, Ontologies in Practice, Semantic Desktop, Social Semantic Desktops, Desktop Search Engines, Semantic File Systems.

Reference Material

1. Abiteboul, S., Manolescu, I., Rigaux, P., Rousset, M. C., and Senellart, P. (2011). *Web data Management (Latest ed.).* Cambridge University Press.
2. De Virgilio, R., Giunchiglia, F., and Tanca, L. (2010). *Semantic web information management: a model-based perspective* (Latest ed.). Springer Science and Business Media.

CS8147	**User Experience Design**	**Credit Hours: 3**

Course Description: This course is primarily aimed at the User Experience Design field, but also for Digital Media Practice, Information Design, Web Development and Engineering, as preparation for development of efficient, effective and satisfying user experiences, particularly associated with multi-channel, multi-platform customer-facing services and applications. The module focuses upon engineering approaches to an individual's interaction with computers at work, particularly in the contexts of information seeking, shopping, and co-ordination. The course focuses upon evaluation and prototyping from the perspectives of behavioral science and information technology. It extends diverse background disciplines towards a broad and integrative understanding of explicit, structured and knowledge-based User Experience Design.

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

- Evaluate user's experiences that are focused upon screen output and task outcomes.
- Design screen-based input and output (visual content) to fit a user work situation.
- Prototype graphical user interfaces and visual content.
- Research user needs and the implications of modality and social conduct for interaction and experience.
- Analyze multi—modal interaction, groups of users, their communications, activities and contexts of use with respect to rich media.

Course Contents: Qualities of Use and User Experience, Usability Science, Techniques for Obtaining Qualitative Information from Users, Ethical Issues, Diagnosing User Difficulties, Prototyping Graphical User Interfaces, Designing GUIs for User Experience Style guides, Designing Data Intensive Systems (Visualization), Designing Keyboards and Touch Input and Accessibility, Cognitive Models of Users, Modeling Tasks (Searching, Learning) and Complex Work Domains and Mobile Contexts, Modeling Distributed Cognition and Co-ordination, Understanding Contexts of Use, Remote and Mobile User Research, Designing User Experience (In Context), Participatory Design, Design for Speech-based and Gestural Interaction, Design for Virtual and Augmented Reality, Designing Mobile Experiences and Smart Environments, Designing for Multiple Channels, Branded Experiences, Designing for Participation (online communities and social computing), Evaluating User Experience, Formative Evaluation, Evaluating Mobile Interaction, Speech-based Interaction, Evaluating Perceptions (brands), Content Strategy, Experience with Crafting Online Content with User Needs in Mind, Interaction Design, Planning and Designing and Prototyping Interactions Common, Interaction Design (IxD) Methodologies.

Reference Material

1. Dix, A.J., Finlay, J.E., Abowd, G.D., & Beale, R. (2006*). Human-Computer Interaction(4th ed.).* Prentice-Hall Europe.
2. Albert, W., & Tullis, T. (2013*). Measuring the user experience: collecting, analyzing, and presenting usability metrics.* Newnes.
3. Caddick, R., & Cable, S. (2011). *Communicating the user experience: A practical guide for creating useful UX documentation.* John Wiley & Sons.

CS8148	Ambient Assisted Living	Credit Hours: 3

Course Description: Ambient Assisted Living (AAL) focuses on the use of information and communication technologies (ICT) to support people's health and safety, increasing their autonomy and well-being, by means of providing services from the automatic supervision of medication to intelligent monitoring. AAL is one of the major emerging technology markets of the moment, offering the potential to enable and empower citizens in their daily lives using state-of-the-art technologies. Known as 'assistive technologies' in some areas, AAL facilitates everyday activities for people who require care and support, augmenting their quality of life and assisting their independence. This course introduces students with the fundamental concepts of AAL, technological infrastructure of AAL, tools and software used in AAL, and ethics in AAL. Students will understand how this technology works, how data is processed to inform individuals and how these systems can be integrated into society to improve life in general.

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

- Seek employment in new markets.
- Working in a range of areas related to Ambient Assisted Living including roles developing AAL systems, designing and developing AAL products, working with AAL users, acting as a consultant to AAL companies or other organizations.
- Designing and developing AAL application for numerous domains including health and social care.

Course Contents: Introduction to AAL, Demographic Trends, Economic Trends, Technology Trends, Barriers for Deployment of AAL, Technological Infrastructure in AAL, AAL Systems Composition, Reference Architecture, Domain Modeling, Domain Modeling, AMI Applications, Software in AAL, AAL4Persons, AAL for Health, Rehabilitation and Care, Personal and Home Safety and Security, Personal Activity Management, Bio-robotic Systems and AAL, Person-Centered services, Ethics in AAL, Privacy and Security Challenges, AAL in the Community, Social Inclusion, Ambient Intelligence, Emergence of Ambient Intelligence, Contributing Technologies, Sensing, Reasoning, Modeling, Activity Prediction and Recognition, Activity Models, Spatial and Temporal Reasoning, Human–Computer Interaction, Context Awareness, Natural Interfaces, Home Care Domain System, Smart Home, Health Monitoring and Assistance, Hospitals, Transportation, Emergency Services, Education, Workplaces, Mobile Assistance in AAL, Augmented Reality, Mobile and Wearable Sensors, Pattern Recognition and Computer Vision, Mobile Activity Recognition, Context Modeling, Location and Identity Identification.

Reference Material

1. Garcia, N. M., and Rodrigues, J. J. P. (Eds.). (2015). *Ambient Assisted Living (Latest ed.)*. CRC Press.

2. Eberhardt, B. (2011). *Ambient assisted living (Latest ed.)*. R. Wichert. Berlin: Springer.
3. Augusto, J. C. (2012). *Handbook of ambient assisted living: Technology for healthcare, rehabilitation, and well-being (Latest ed.)*. IOS press.

CS8149	**Soft Computing**	**Credit Hours: 3**

Course Description: Soft Computing refers to a collection of computational techniques in computer science, artificial intelligence and engineering disciplines which attempt to study, model and analyze complex problems - those for which more conventional methods have not yielded low cost, analytic and complete solutions. Unlike conventional computing, soft computing techniques are tolerant of imprecision, uncertainty and approximations.

Aims and Objectives: The objective of the course is to design and develop intelligent systems in the framework of soft computing, and apply to some general and scientific application-driven environments. Students who successfully complete this course will be able to:

- Have a general understanding of soft computing methodologies, including artificial neural networks, fuzzy sets, fuzzy logic, fuzzy clustering techniques and genetic algorithms.
- Study neuro-fuzzy control and inference systems.
- Have an insight into the genetic algorithms and computing, one of the powerful techniques to tackle hard optimization problems.
- Design and development of certain scientific and commercial application using computational neural network models, fuzzy models, fuzzy clustering applications and genetic algorithms in specified applications.
- Study all these techniques from the point of view of the WWW.

Course Contents: Introduction, Tools, Fuzzy Reasoning, Fuzzy Inference, Genetic Algorithms and its Applications, Fuzzy Logic, Applications, Neural Networks and its Applications, Learning (Supervised/Unsupervised, etc), Clustering and Classification, Case-based Reasoning and its Applications, Hybrid Systems, Adaptivity, Techniques Usages, Knowledge Management.

Reference Material

4. Pratihar, D. K. (2013). *Soft computing: fundamentals and applications*. Alpha Science International, Ltd.
5. Ma, Z. (2007). *Soft computing in ontologies and semantic web* (Vol. 204). Springer Science and Business Media.
6. Harwood, C. J. (2013). *Soft Computing and Intelligent Systems: Theory and Applications (Latest ed.)*. Kybernetes.
7. Tiwari, A., Knowles, J., Avineri, E., Dahal, K., and Roy, R. (2010). *Applications of soft computing: Recent trends (Latest ed.)*. Springer Science and Business Media.

CS8150	Modeling and Simulation	Credit hours: 3

Course Description: This course emphasizes the development of modeling and simulation concepts and analysis skills. The main goal is to design, program, implement, and use computers to solve complex systems/products analysis problems regarding wireless sensor networks. The key emphasis is on problem formulation, model building, data analysis, solution techniques, and evaluation of alternative designs/processes in complex systems/products. Overview of modeling techniques and methods used in decision analysis, including Monte Carlo simulation and systems dynamics modeling are presented.

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

- To apply modern software packages to conduct analysis of real world scenarios.
- To understand the technical underpinning of modern computer simulation software.
- The ability to apply the appropriate analytical technique to a wide variety of real world problems and data sets.
- To summarize and present the analysis results in a clear and coherent manner

Course Contents: Introduction to Simulation and Modeling, Discrete-Event Simulation, Alternative Approaches to Modeling and Simulations; Review of Basic Probability and Statistics; Estimation of Means, Variances, and Correlations, Confidence Intervals and Hypothesis Tests for the Mean. The Laws of Large Numbers; Random number generators; Simulation of discrete, continuous probability distributions and empirical distributions; tests on simulated distributions, simulation of models of arrival processes, Poisson Processes, Batch Arrivals, tests on generators, Markov- Chain Monte-Carlo simulations; Variance-Reduction Techniques.

Reference Material

1. Law, A.M. and Kelton, W.D., (2008). *Modeling and Analysis* (Latest ed.). McGraw Hill.
2. Banks, J., Carson, J.S., and Nelson, B.L., (2013). *Discrete-event System Simulation* (Latest ed.). Prentice Hall International, ISBN: 9781292037264.
3. Relevant research papers

CS8151	Wireless Sensor Network Security and QoS	Credit Hours: 3

Course Description: This course covers advanced topics in wireless sensor network security and Quality of service (QoS). The course cover WSN basics, network architecture with typical scenarios, Quality of Service (concept, issues and parameters), QoS management and Security

(including trust, security, privacy, key management, symmetric and asymmetric cryptography concepts, deployment scenarios using symmetric encryption, possible attacks and secure routing). The goal of this class is not only to convey the significance of the area and the achievements, but also to provide a basis upon which students can start their research work in the area of Security and QoS. Each student should complete a semester long course project related to security and QoS.
Aims and Objectives: Students successfully completing this course should be able to:

- Understand the basics of security and quality of service.
- Particular design challenges of secure routing protocol that provides high QoS.
- Explore the recent trends of security and QoS in the field of WSN.
- Deployment scenarios that enables student to start working in this area.
- Complete long course project related to security and QoS.

Course Contents: WSN applications and challenges. WSN architecture (node architecture and network architecture), Programming basic WSN node. Network architecture, typical scenarios, distributed WSN, design principles, energy efficiency issues. Protocols for WSN (Layer 2 and Layer 3 protocols and addressing structures, data centric approach etc), QoS issues in WSN, QoS parameters and network performance, throughput, and network convergence. QoS metrics dependency on maximizing performance. Security aspects of WSN (Symmetric vs Asymmetric cryptography concepts, Trust, Security, and Privacy). Key management in WSN. WSN deployment with Symmetric encryption, data aggregation, data gathering and reporting. Secure routing in WSN.

Reference Material

1. Karl, H., and Willig, A. (2006). *Protocols and Architectures for Wireless Sensor Network* (Latest ed.). Wiley Publishers, ISBN: 0-470-09510-5.
2. Ravi, T. (2014). *QOS issues in Wireless Sensor Networks* (Latest ed.). LAP Lambert Academic Publishing, ISBN-10: 3659621366.
3. Stalling, W. (2016). *Cryptography and Network Security: Principles and Practice* (7th ed.). Pearson: ISBN-10: 0133354695.

CS8152	**Medical Image Analysis**	**Credit Hours: 3**

Course Description: Medical image analysis is the technique and process of the interior of a body for clinical analysis and medical intervention. This is an important area for practical and research point of view. This course is intended to give students adequate breadth in medical image analysis.

Aims and Objectives: After completing this course:

- After completing this course, students will gain an understanding of the methods and algorithms for analysis in medical imaging.

- Students will be able to apply such knowledge using tools like MATLAB.

Course Contents: Medical modalities, biomedical image processing and analysis, MATLAB image processing toolkit, image formation, electromagnetic radiation in medical imaging, medical image reconstruction, segmentation, reprocessing and enhancement, image processing, analysis, and classification, image registration, image visualization, current and future trends in medical image analysis.

Reference Material

1. Dhawan, P. (2011). *Medical Image Analysis* (2nd ed.)., Wiley-IEEE Press, 978-0-470-62205

CS8153	**Face and Gesture Recognition**	**Credit Hours: 3**

Course Description: A variety of pattern recognition techniques have been proposed to solve the problem of face recognition. This course will give students familiarity with various face and gesture recognition techniques and tools.

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

- To understand the tools and techniques for face and gesture recognition.
- To compare and implement common face and gesture recognition algorithms.

Course Contentss: Face and gesture recognition is an advanced technology that utilizes the intrinsic physiological or behavioral traits of individuals for machine-based automatic and reliable identification. It attracts much attention due to the increasing demand for the security, privacy, and health care-related human-centered applications. This course covers the state-of-the-art face and gesture recognition technologies, including face/human detection, face/body tracking, face recognition, head/body pose estimation, expression recognition, body language recognition, gait analysis, hand/body/eye gesture, action/activity analysis, and so forth. Multimodal, multimodality, and soft-biometric frameworks will also be discussed. Fundamental knowledge covered by the course includes pattern recognition, feature extraction, classifier, probabilistic models, image processing, and machine learning. Tools and techniques for practical face and gesture recognition system design as well as hands-on exercises and projects will be provided.

Reference Material

1. Bourkai, T. (2016). *Face Recognition: Across the Imaging Spectrum*, (Latest ed.). ISBN-13: 978-3319284996
2. Moue, D. (2010). *Machine Based Intelligent Face Recognition*. Springer; ISBN 3642007503 ISBN 13 978-3642007507

3. Datta, A. K., Datta, M., Banerjee, P. K. (2015). *Face Detection and Recognition: Theory and Practice* (Latest ed.). Chapman and Hall/CRC, ISBN-10 1482226445 ISBN-13: 1482226446
4. San, Z. L. (2011). *Handbook of Face Recognition* (Latest ed.). Springer; ISBN-10 038740595X, ISBN-13 978-0387405957

CS8154	**Deep Learning in Computer Vision**	**Credit Hours: 3**

Course Description: Deep learning is a hot topic in pattern recognition research. It has many uses, e.g., in the areas of natural, language processing, speech recognition, and computer vision. This course focuses on deep learning tools and techniques for solving computer vision problems. Students will review current literature and identify issues in current deep learning approaches to computer vision. They are expected to gain an insight into this approach and think about other and better deep-learning based solutions.

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

- To know an application of the deep learning model
- To appreciate the limitations and strengths of the model in the area of computer vision.
- To enable the students to think about other applications of deep learning in computer vision.

Course Contents: Semantic Image Segmentation with Deep Convolutional Nets and Fully Connected CRFs, Highway Networks, Deep Residual Learning for Image Recognition, Rich feature hierarchies for accurate object detection and semantic segmentation, Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Network, Stereo Matching by Training a Convolutional Neural Network to Compare Image Patches, Learning to Compare Image Patches via Convolutional Neural Network, Designing Deep Networks for Surface Normal Estimation, Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks, Generating Images from Captions with Attention, Simultaneous Deep Transfer Across Domains and Task, Predicting Deep Zero-Shot Convolutional Neural Networks using Textual Descriptions: Recognition with Recurrent Neural Networks: Modeling words, describing videos, Image-based QA, Text-based QA, Sentiment Analysis, and other topics.

Reference Material

1. Good fellow, I., Bengio, Y., Courville, A. (2016). *Deep Learning* (Latest ed.). MIT Press, 0262035618, 978-0262035613.
2. Szeliski, R. (2011), Computer Vision (Latest ed.). Springer, ISBN: 978-1-84882-934-3.

3. Rosebrock, A. (2017) *Deep learning for computer vision with python* (Latest ed.). eBook.

CS8155	Advanced Computer Vision	Credit Hours: 3

Course Description: The course builds on the introductory computer vision course in the preceding programs. Unlike the content in the introductory course, the emphasis in this course is on 3D and 2D recognition for different data.

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

- To understand and explain high-level computer vision tasks such as recognition and tracking.
- To know the relevant techniques and algorithms.

Course Contents: Rigid 2D part recognition, deformable 2D part recognition, rigid 3D part recognition from stereo data, rigid 3D part recognition from range sensing, target detection and tracking in video, and video based behavior classification.

Reference Material

1. Davie, E. R. (2005). *Machine Vision - Theory, Algorithms and Practice* (3rd ed.). Elsevier,
2. Solomon, C. and Breckon, T. (2010). *Fundamentals of Digital Image Processing - A Practical Approach with Examples in Matlab* (Latest ed.). Wiley-Blackwell, ISBN: 978-0470844731.
3. Szeliski, R. (2011). *Computer Vision* (Latest ed.). Springer, ISBN: 978-1-84882-934-3,
4. Morri, T. (2004). *Computer Vision and Image Processing* (Latest ed.). Palgrave.

CS8156	Medical Image Registration	Credit Hours: 3

Course Description: Image registration problem deals with the conversion of different sets of data into one coordinate system. It arises in the fields of computer vision, medical imaging, and automatic target recognition. The registration problem is important in medical imaging from the point of view of clinical analysis and medical intervention. Through this course, students will learn about solution approaches to the registration problem in medical imaging.

Aims and Objectives: After completing this course:

- Students will gain knowledge of the application of image registration methods in the field of medical imaging.

- To understand form and structure of the problem in medical imaging.

Course Contents: Introduction, Mathematical Background, Examples of Medical Image Registration, intensity-based registration and the Insight Toolkit, feature-based registration and the Rensselaer/CenSSIS toolkit, initialization techniques, multi-resolution techniques, mutual information, deformable registration, video sequences and mosaics.

Reference Material

1. Hajnal, J. V., Hill, D. L. G. (2001). *Medical Image Registration* (Latest ed.). CRC Press; 0849300649 978-0849300646
2. Zhou, S. K., Greenspan, H., Shen, D. (2017). *Deep Learning for Medical Image Analysis* (Latest ed.). Academic Press; 0128104082, 978-0128104088

CS8157	**Advanced Deep Learning**	**Credit Hours: 3**

Course Description: Deep learning is an exciting area currently extensively investigated both at application and theoretical levels. It has got many applications. This course intends to give students a deeper and broader knowledge of deep learning.

Aims and Objectives: After completing the courses:

- Students will have a knowledge of the recent developments in the field of deep learning and advanced deep learning.

Course Contentss: Mathematics for deep learning: linear algebra, probability and information theory, numerical computation. Basics of machine learning, deep networks, regularization for deep learning, optimization for training deep models, convolutional networks, recurrent networks, applications of deep learning. Topics in deep learning research: auto encoders, representation learning, probabilistic models of deep learning, approximate inference, and deep generative models.

Reference Material

1. Good fellow, I., Bengio, Y., Courville, A. (2016). *Deep Learning* (Latest ed.). MIT Press, 0262035618, 978-0262035613
2. Rashid, T. (2016). *Make Your Own Neural Networks, CreateSpace* (Latest ed.). Independent Publishing Platform; 1530826608, 978-1530826605

CS8158	Deep Learning in Natural Language Processing	Credit Hours: 3

Course Description: This course focuses on the use of deep learning techniques in the area of natural language processing (NLP). The intended aim of the course is to broaden the knowledge of students about the potential applications of deep learning.

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

- To gain knowledge of deep learning algorithms in the field of natural language processing and think about other applications.
- Students will understand the strength and limitations of deep learning.

Course Contents: Introduction to NLP and Deep Learning, word vector representations, named entity recognition with NN and back propagation, tensor flow, recurrent NNs for large-scale language modeling, GRU and LSTMs for machine translation, recurrent neural networks for parsing and semantic analysis, convolutional neural networks for sentence classification, the future of deep learning for NLP: dynamic memory networks.

Reference Material

1. Goldberg, Y. (2015). *A primer of neural network models for natural language processing* (Latest ed.). Academic Press.
2. Socher, R. (2014). *Recursive deep learning for natural language processing and computer vision* (Latest ed.). Prentice Hall Inc.

CS8159	Advanced Human Computer Interaction	Credit Hours: 3

Course Description: This course is designed to provide the student with the core knowledge and skills required for further study and for practical HCI development. This course comprises of emerging issues in the field of Human Computer Interaction and gives students practical and theoretical knowledge in the use of HCI methodologies for both design and evaluation.

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

- Describe the main concepts that influence human-computer interaction
- Explain the main theories of cognition and how these are used when designing interactive systems
- Use the knowledge and skills to conduct further research in the area of Human Computer Interaction.
- Evaluate a design for interacting with a computer system and choose appropriate methods of evaluating an interactive system.
- Demonstrate an understanding of the scope and importance of HCI systems across a range of application domains

Course Contents: Basic Concepts in Human Computer Interaction, Usability paradigm, Usability principles, Interaction paradigms, User Experience and Experience Design, Visualization, Contextual Design, Usability Evaluation, Evaluation Methods in HCI, Prototyping, Quantitative and Qualitative Evaluation, Interview, Case studies, Focus Groups, Heuristic evaluation, Cognitive walkthrough, Participatory design, Observational methods, Questionnaire design. Accessibility (Inclusive Technologies), Ubiquitous Computing, Persuasive Technologies, Social Computing, Wearable Computing, Context-Aware Computing.

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.

4 Cairns, P. and Cox, A. (eds.) (2008). *Research methods for human-computer interaction* (Latest ed.). Cambridge University Press.

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

CS8160	**Advanced Learning Technologies**	**Credit Hours: 3**

Course Description: This course is designed to introduce research students to a range of themes and research areas in learning technologies.

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

- Identify learning technologies and tools in order to enhanced different aspects of students' learning experiences

- Understand the core and emerging research areas in the field of technology enhanced learning
- Understand many of the theoretical and pedagogical issues which define digital education
- Design and propose technology based solutions in wide range of learning situations
- Conduct research in a wide range of emerging fields in the area of technology enhanced learning

Course Contents: Foundations of Technology Enhanced Learning, Educational Technology in the context of Millennium Development Goals, Pedagogical uses of digital technology, Open Educational Resources and Practices, Flipped Classrooms, Personal learning Environments (PLE), Learning at Scale, Massive Open Online Courses (MOOCs), Research issues in MOOCs, Open Learning Methodologies, Practices and Platforms, Gamification in Learning Applications, Designing Educational Games, Educational Data Mining and Big Data. Applications in education. Learning Analytics. Mobile Learning Applications. Learning strategies for mobile and ubiquitous learning. Virtual Reality Applications in Learning. Immersive Interfaces for Engagement and Learning, Computer Supported Collaborative Learning. Tools for formative and summative assessment. Cloud Computing in Education. Technology-Enhanced Assessment. Semantic Web technologies to adapt and personalize the learning experience. Social learning techniques. Reviewing empirical evidences of implications of various educational technologies. Review of latest trends in educational technologies.

Reference Material

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

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

3 H. Beetham and R. Shapre (Eds.). (2013). *Rethinking Pedagogy for a Digital Age* (Latest ed.). Abingdon, Taylor and Francis.

4 Rao, K., (2015). *Universal design for online courses: applying principles to pedagogy* (Latest ed.). Abingdon, Taylor and Francis.

5 Edelen-Smith, P and Wialehua, C. (2015). *Open Learning: The Journal of Open, Distance and e-Learning* (Latest ed.). Prentice Hall Inc.

6 Further reading material will be provided in the form of essays and research papers from leading journals and conferences in the area of technology enhanced learning.

CS8161	**Serious Games**	**Credit Hours: 3**

Course Description: This course examines the role that digital games can play in education as a means to engage students and help them learn a range of topics in a variety of settings. This module introduces students to the field of learning design and Serious Games. The subject introduces the

principles of game design, examines research literature surrounding games and learning, and includes reflective participation in gaming culture.

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

- Demonstrate knowledge and understanding of the key concepts and principles of designing games for learning
- Identify the elements of a serious game
- Have awareness of key research areas in serious games

Course Contents: Introduction to Game Development, Game Design Fundamentals, Introduction to Gamification, Serious Games Design, Level Design, Construction of Choice and Obstacles, Tutorial Systems, Game Challenge Theory and Design, Difficulty vs Punishment and Accessibility vs Contest, Flow (Both Immersive and Adaptive Difficulty), Systems, Dynamics, and Mechanisms, The Mechanics, Dynamics, Aesthetics (MDA) model, Core Game Dynamics, Objectives and Motivation, Game Elements and Atoms, Rule Design, Game Complexity and Difficulty, Game Narrative, Basic principles of non-linear narratives, Interactive narrative and the narrative paradox, Common forms of game narrative and the Heros Journey, Narrative structures for games, Research and Digital Entertainment, Innovative forms of interaction and control, Location aware narrative, Adaptive games, Games development Engines, e.g. Unity. Serious Games Research, Designing Games for Social Change.

Reference Material

1 Whitton, N. (2014). *Digital Games and Learning: Research and Theory* (Latest ed.). Routledge.

2 Chou,Y. (2015). *Actionable Gamification - Beyond Points, Badges, and Leaderboards* (Latest ed.). Octalysis Media

3 Kapp, K.M. (2012). *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education* (Latest ed.). Pfeiffer.

4 Whitton, N. (2010). *Learning with digital game: A practical guide to engaging students in higher education* (Latest ed.). London, Routledge.

5 Zemliansky,P. (2010). *Design and Implementation of Educational Games: Theoretical and Practical Perspectives* (Latest ed.). Information Science Reference.