Major Courses (PhD)

CS811 Computational Syntax and Discourse

(3 cr.hrs)

Objectives

At the end of this course, the students will be able to know about:

- The structure of phrases in a language
- The structure of sentences in a language
- The structure of phrases and sentence in local languages
- The processing of phrases and sentences by a computer
- To know discourse processing and segmentation of text

Language theory

Natural Languages, Regular languages, Formal languages

Grammar

Definition, elements, The Chomsky Hierarchy

Constituent Structure

Ambiguity, Constituency, Hierarchy, Syntactic categories, Tree diagrams,

Noun Phrases

Adjuncts, Complements and adjuncts of N, Determiners, Adjectives and Adjective Phrases (AF), Possession and recursion, English NP structure

Case and Agreement

Case, Agreement

Tense, Aspect and Modality

Tense, Aspect, Perfect vs. Perfective
Combinations of tense and aspect, Mood, Modality

Special sentence types

Direct vs. Indirect speech acts, basic word order, Commands, Questions, Negation

Subordinate clauses

Coordinate vs. subordinate clauses; complement clauses, Direct vs. Indirect speech, Adjunct clauses, and Relative clauses

Indirect object and Secondary objects

The use of Syntax in Corpus development
Word classes, Part-of-Speech tagging

Parsing
Parsing with Context-Free Grammars, Unification Parsing, Lexicalized and Probabilistic Parsing

Discourse analysis, Anaphora Resolution, Ellipses Resolution

Recommended Readings

1. Daniel Jurafsky and James H. Martin. (2000). "Speech and Language Processing". Pearson Education, Inc
2. Paul R. Kroeger. (2005). "Analyzing Grammar: An Introduction". Cambridge University Press.
3. Ruslan Mitkov (2002. "Anaphora Resolution" Longman Publishers

CS812 Corpus and Natural Language Engineering (3 cr.hrs)

Objectives
At the end of this course, the students will be able:

- To understand how a corpus can be developed and processed?
- To know what is in existing corpus?
- To know different types of corpora and their day to day applications

Corpus Linguistics basics
What is a corpus, Corpus-based vs. intuition-based approach, corpus-based vs. corpus-driven approaches

Corpus characteristics
Representativeness, Balancing, Sampling

Corpus Mark-up
Introduction, Rationale for corpus mark-up, corpus mark-up schemes, character encoding standards, Text Encoding Initiative

Corpus Annotation
Introduction, Corpus annotation, types of corpus annotations, embedded vs. standalone annotation, Part-of –Speech Annotation, Syntactic Annotation, Anaphoric Annotation

Multilingual corpora

Introduction, terminological issues, corpus alignment, parallel corpora

Using available corpora
Introduction, general corpora, specialized corpora, written corpora, spoken corpora, synchronic corpora, learner corpora, monitor corpora

Corpora and computational linguistics

How to Develop a Corpus?
Corpus development methodology, Collocation Studies, Concordancing

Practical
XML language

Recommended Readings

1. Tony McEnery, Richard Xiao and Yukio Tono. (2006). "Corpus-Based Language Studies: An advanced resource book". Routledge Applied Linguistics.
2. Tony McEnery and Andrew Wilson (2001). "Corpus Linguistics" Edinburgh University Press, 2nd Edition

CS813 Automatic Translation

(3 cr.hrs)

Objectives
At the end of this course, the students will be able to know about:

- The translation of natural languages by a computer
- The difficulties involved in machine translation
- The applications of machine translation

Linguistic aspects: (mainly different types of ambiguities)
Computational problems of machine translation

Paradigms of machine translation

1. Rule-Based: (direct, transfer, interlingua, knowledge-based and text-based architectures)

2. Empirical: (statistical and example-based architectures)

Evaluation of Machine translation

Examples of state-of-the-art Machine Translation Systems

Recommended Readings

1. Yorick Wilks (2008) "Machine translation : its scope and limits", New York : Springer
2. Philipp Koehn (Spring 2009) "Statistical Machine Translation", Cambridge University Press.

CS820 Advanced Wireless Sensor Networks

(3 cr.hrs)

Objectives

- To introduce history of WSNs, application domains, platforms, and the limitations of current platforms.
- To discuss network layers, standards, time synchronization, localization, and routing for WSNs.
- To explore software engineering, implementation, deployment, and testing issues for WSNs.
- To provide students with an in-depth understanding of systems and algorithmic issues in wireless sensor networks and networked embedded systems.
- To read a large number of research papers, writing critiques, class presentations.

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 in the near future.

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 a large number of research papers, writing critiques, class presentations.

Topics Covered

Overview of WSN - motivation, applications, sensors, platforms.
Sensor network applications - habitat monitoring, tracking, event localization, etc.
Programming the sensor nodes - TinyOS, NesC.
Wireless Networking - wireless transmissions, data dissemination, routing, MAC, coverage.
Middleware - time synchronization, localization, power management.

Pre-requisites

Proficiency in C, familiarity with networking and operating system concepts (undergraduate networking and OS courses)

Recommended Readings

1. Richard Zurawski, "Embedded systems handbook", 2006.
2. F. Zhao and L. Guibas "Wireless Sensor Networks: An Information Processing Approach", 2004.
3. Handouts will be distributed when necessary.

CS830 Computer Networking-II

(3 cr.hrs)

Objectives

This course has two objectives: one is to equip students with good knowledge on the selected advanced research topics in networking, and the other is to help students significantly improve research skills in terms of writing and presentation. Good knowledge will be obtained by attending and participating lectures. Readings will be provided. Students will experience a full cycle of typical research activities including literature survey, problem formulation, giving assumptions, providing a solution, providing a plan of evaluation of the solution, and finally presenting of the project results. After taking this course, students should be able to conduct research with a minimum level of guidance from their advisers. If desired, students will be able to extend the project toward their theses. Quality projects will be helped for a submission to conferences.

This PhD-level course is focused on understanding technical details in a number of areas of networking through reading and discussion of important research papers in the field. The topics which will be covered may include but are not limited to:

Internet Architecture, Transport Layer Protocols (IPv6)

Network Layer Protocols, Wireless Networking

Quality of Service, Network Security, Network Performance

Network Management, Network Applications

Design, specify implement and demonstrate a novel protocol. Perhaps the most exciting part of this course will be the research project. You will design, specify, implement, and demonstrate a protocol of your choice. It may be a performance-driven routing protocol that selects network paths based on measured delays or throughput.

Recommended readings

1. Network Algorithmic by George Varghese, Morgan Kaufmann, 2005.
   (In the second half of the semester we will mostly use research papers. We will also cover parts of the following books (you don't need to purchase them, but I highly recommend them if you are serious about networking):

2. M. Crovella and B. Krishnamurthy, Internet Measurement: Infrastructure, Traffic and Applications, 2006
3. Kumar, D. Manjunath and J. Kuri, Communication Networking, An Analytical Approach , 2004

(Additional good references:)

4. W. R. Stevens, TCP/IP Illustrated, Volume 1: The Protocols, 1994.
5. G. R. Wright and W. R. Stevens, TCP/IP Illustrated, Volume 2: The Implementation, 1995.
6. B. Krishnamurthy and J. Rexford, Web Protocols and Practice: HTTP/1.1, Networking Protocols, Caching, and Traffic Measurement, 2001

(The following books are excellent references for UNIX network programming, you may need them for the course project, and you will find them useful for years to come).

7. M. Donahoo and K. Calvert, TCP/IP Sockets in C (or Java): Practical Guide for Programmers, 2000
8. W. R. Stevens, UNIX Network Programming, Volume 1 (2nd edition): Networking APIs - Sockets and XTI, 2/e , 1998
9. W. R. Stevens, UNIX Network Programming, Volume 2 (2nd edition): Interprocess Communications, 1999

CS831 Advanced Network Security

(3 cr.hrs)

Objectives

- Understand the design and implementation of advanced cryptographic algorithms for wired and wireless computing environments including the design and implementation of RSA and ECC
- Achieve sound knowledge of network security components including the design, implementation, and configuration of Firewalls, Intrusion Detection Systems (static and dynamic checking of programs, anomaly detection, large-scale (Internet-wide) distributed intrusion detection, early sensing, complex attack scenario analysis, and automated response), Prevention Systems, Firewalls, IDSs, VPNs and prevention systems together
- Develop knowledge of advanced network security architectures to allow better network protection, load balancing and recovery from attacks
- Achieve sound knowledge of wireless network security

Students will be expected to read all of the papers assigned during the class or may be added based on class interest. Students will have to write at least two reviews of papers assigned. These will be submitted at the beginning of class. Students submitting reviews for a paper will be expected to be active in the discussion of that paper.

Major Topics

Security Concepts and Terminology, TCP/IP and OSI Network Security

Access Control Issues (Packet Filters, Firewalls), Communication Security (OSI Layer Security Protocols), Security Tools, Cryptography

System Security - Intruders and Viruses, E-mail and Web Security

Recommended Readings

1. Network Security Essentials, Prentice-Hall by William Stallings, 2000, ISBN: 0-13-016093-8.
2. Supplementary Materials
3. Maximum Security, 2nd Edition, SAMS Books by Anonymous, 1998, ISBN: 0-672-31341-3.
   Maximum Linux Security, SAMS Books by Anonymous, 2000, ISBN: 0-672-31670-6.
4. The Cuckoo's Egg : Tracking a Spy Through the Maze of Computer Espionage; by Clifford Stoll; Pocket Books; ISBN 0671726889
5. Material from the Internet
6. Software and manuals found in the lab and on the Internet.

CS840 Information & Web Semantics

(3 cr.hrs)

Course Description

The Semantic Web is concerned with how to characterize web content, web services and web agents to enable greater automation, integration and reuse across applications. This course introduces core topics of the Semantic Web, goes into depth on the technologies underlying it, and considers how the Semantic Web stands to affect everyday life. This course is aimed to give students a detailed understanding of the principles and practices underlying the Semantic Web and to equip them with knowledge engineering skills.

Course Objectives

- Understand the limitations of the current web in different scenarios
- Know about the enabling technologies of the Semantic Web
- In-depth knowledge of the application of these technologies
- Understand and use the tools developed in the field of web semantics
- Understand how more automation is achieved by adding semantics to web services

Course Contents

Introduction to Semantic Web

The Syntactic Web, The Semantic Web, Working of the Semantic Web, Scope and Boundaries of the Semantic Web, Effects of the Semantic Web on Person, Business, Education and Government

Semantic Web Concepts

Ontologies, Taxonomy, Thesauri and Ontologies, Ontology Classification, Ontology Evolution, Merging, Alignment, Ontology Description Languages, Knowledge

Representation in Description Logic, RDF and RDF Schema, OWL, Rule Languages, Semantic Web Services

Semantic Web Technologies

Methods for Ontology Development, Ontology Sources: Dublin Core, vCard, FOAF, Wordnet, CYC, SUMO, Other Ontologies, Ontology Libraries, Semantic Web Software Tools: Ontology Editors, Triple Storage Systems, Reasoners, SW Development Toolkits, Other Tools, SW Projects

Semantic Web Applications

Semantic Desktop: Metadata, Ontologies, Related Applications

Software Agents: Forms, Architecture, Communication in Semantic Web

Other Applications: Art, Geospatial Semantic Web etc

Recommended Readings

1. Karin K. Breitman, Morco A. Casanova, and Walter Truszkowski, Semantic Web: Concepts, Technologies, and Applications, Springer-Verlag, 2007.
2. Grigoris Antoniou and Frank van Harmelen, A Semantic Web Primer, MIT Press, 2004.
3. John Davies, Rudi Studer and Paul Warren, Semantic Web Technologies: Trends and Research in Ontology-based Systems, John Wiley & Sons, 2006.
4. Raj Sharman, Rajiv Kishore and Ram Ramesh, ONTOLOGIES: A Handbook of Principles, Concepts and Applications in Information Systems, Springer, 2007.

CS841 Advanced Ontology Engineering

(3 cr.hrs)

Course Description

In the Computer Science perspective, ontology refers to the specification of knowledge about entities, and their relationships and interactions in a bounded universe of discourse only. As a result, a number of such ontologies have been created in several different areas. This course focuses on Foundations of Ontology-Driven Information Systems (ODIS), Ontology Engineering, ODIS Architectures, and ODIS Applications.

Course Objectives

- The ability to think about ontologies and information systems in conjunction with each other
- To cover both the structural and temporal dimensions of Information systems
- Know about the principles and techniques of ontology engineering
- Understand ODIS architectures in a variety of contexts including knowledge intensive business process, object models, ontology metaphors,

- Understanding the need of ontologies in Service Oriented Architecture (SOA)

Course Contents

Foundations of Ontology-Driven Information Systems: The road towards ontologies, Use of ontologies in Knowledge Management Systems, Ontologies in Buisness Model reengineering, Using Ontologies in Semantic Web

Ontological Engineering**:** Ontological approach to develop knowledge intensive systems, Standards for ontology development, Ontology Specification and Integration, Ontology Revision, Ontology Population

Ontology-Driven Information Systems Architectures: Ontology of Hypermedia Systems, Ontology-enables DBMSs, Ontology-based User Modeling, Ontology-based Personalized Search, Ontology in automating knowledge intensive business processes

Ontology-Driven Information Systems Applications**:** ODIS for Supply chain management, Ontology in News domain, Ontology in Mobile Domain, Ontology in Manufacturing Domain, Ontology in Medical domain, Ontology based smart card system

Recommended Readings

1. Raj Sharman, Rajiv Kishore and Ram Ramesh, Ontologies: A Handbook of Principles, Concepts and Applications in Information Systems, Integrated Series in Information Systems, Springer Science, 2007.
2. Asuncion Gomez-Perez, Oscar Corcho and Mariano Fernandez-Lopez, Ontology Engineering: with examples from the areas of Knowledge Management, e-Commerce and the Semantic Web, Advanced Information and Knowledge Processing Series, Springer 2004.
3. LG Dietz, Enterprise Ontology: Theory and Methodology, Springer 2006.

CS843 Information Visualization (3 cr.hrs)

Course Description

The goal of information visualization is the unveiling of the underlying structure of large or abstract data sets using visual representations that utilize the powerful processing capabilities of the human visual perceptual system. This course will take a critical stance towards the field of information visualization. It surveys the existing approaches to information visualization and also analyzes the factors that contribute to success or lack thereof, as a means to determine how to devise future successful visualizations. Criteria for success in this analysis are either positive results from usability studies or wide adoption by the target user population. This course will also have a focus on how to present information clearly and effectively.

Course Objectives

- Provide a sound foundation in human visual perception and how it relates to creating effective information visualizations
- Understand the key design principles for creating information visualizations
- Study the major existing techniques and systems in information visualization
- Evaluate information visualizations tools
- Design new, innovative visualizations
-

Course Contents

Introduction and overview, Multivariate Data & Table/Graph Design, Case Studies, Visual Perception, Cognitive Issues, Multivariate Visual Representations, Parallel Coordinates and more, Visualizing Big Data, InfoVis Systems & Toolkits, Commercial Systems Demos, Learning Tableau, Tufte's Visual Design Principles, Time Series Data, Interaction, Overview and Detail (Focus & Context), Zooming and Panning, Visual Analytics, Hierarchies and Trees - Node-link and Space-filling, Graphs and Networks, Text and Documents, Evaluation, Animation, Geovisualization, Social and Casual Information Visualization

Recommended Readings

1. Stuart K. Card, Jock D. Mackinlay, and Ben Shneiderman, Readings in Information Visualization: Using Vision to Think, Morgan Kaufmann Publishers, 1999.
2. S. K. Card, Information Visualization. In The Human-Computer Interaction Handbook, Lawrence Erlbaum Associates; 2003.
3. S. Few, Effectively Communicating Numbers - Selecting the Best Means and Manner of Display, ProClarity Corporation, 2006.

CS844 Web Information Retrieval and Mining

(3 cr.hrs)

Course Description

The explosive growth of the Web has dramatically changed the way in which information is managed and accessed. Information Retrieval (IR) is finding unstructured information, usually documents, that satisfy an information need from within large collections, usually on servers or on the internet. As the World Wide Web is considered to be the most common and huge collection of such documents, the primary focus of our course will be the Web. This course aims to provide an in-depth coverage of the pre- and post-web IR techniques and tools. Web mining and knowledge discovery techniques on the web are also discussed.

Course Objectives

- Understand the difference in data retrieval and information retrieval
- Knowing how to make an efficient index of a huge dataset
- Utilizing more effective ranking techniques
- Extract useful patterns from the web

- Personalize the web experience

Course Contents

Information Retrieval and Information Extraction (IR & IE)

Traditional Vs. Web IR, Text Retrieval, Multimedia IR: Image Retrieval, Video Retrieval, Audio Retrieval, Page ranking algorithms, Search engine architecture, Crawling Techniques, Crawler algorithms

Modeling

Retrieval Evaluation: Models, Languages, Indexing, Searching, Query Languages and Operations, Indexing and Searching, Parallel and Distributed IR, User Interface Visualization, Libraries and Bibliographical Systems, Digital Libraries

Web Mining

Web Usage Mining, Web Content Mining, Web Structure Mining, Web Personalization, Recommender Systems

Recommended Readings

1. Zdravko Markov and Daniel T. Larose, Data Mining the Web: Uncovering Patterns in Web Content, Structure, and Usage, Wiley-Interscience, 2007.
2. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, Data-Centric Systems and Applications Series, Springer, 2009.
3. Mark Levene, An Introduction to Search Engines and Web Navigation, Pearson Education, 2005.
4. Anthony Scime, Web Mining:Applications and Techniques, Idea Group Publishing, 2004.
5. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008.
6. G. G. Chowdhury, Introduction to Modern Information Retrieval, Neal-Schuman Publishers, 2003.

CS845 State-of-the-art in Software Technology (3 cr.hrs)

Description

The objective of this course is to introduce students to the broad range of web-based services, computer languages, APIs, and other software tools that are developed in both commercial and open-source domains. This course specifically explores collaborative, project oriented and open source tools and services that prove useful in software projects and research. After completion of this course a student will be able to select/recommend the most appropriate tool for a service/application. This will also enable a student to monitor developments in the field of software technology.

Objectives

- Understand trends, tools and techniques used in open source software development
- Application of these tools for locally setting up a prototypical research project
- Know about web-based services and their suitability for different applications
- Knowledge of APIs and tools used in different research areas of Computer Science

Course Contents

Programming Languages and Software Development Tools
Introduction, Evolution, Procedural, OO, Declarative, State-of-the-art, APIs, Compilers, Cross-Compilers, Build Tools, IDEs, Version Control, Object Oriented, CASE Tools, UML, Application Servers, Testing, Virtual Machines
Commercial and Open Source Software Development
Licensing, Desktop Vs. Web-based OS development, Development Tools and Services, Open Source API
Communication
Chat, Conferencing, Email, Email clients (MUA), Filters, File Sharing, Internet Phone, VoIP, RSS Feed Readers, Streaming
Databases
Database Engines/servers, DB Frontends, ETL Tools, Database Design Tools, Distributed and OO DBMSs, Data Mining Tools, Encrption Technology in Databases, Data Quality Tools
OS and Desktop Environments
Windows family of OS, Unixes, Gnome, KDE, Window Managers
Data Formats and Data Ptotocols
DocBook, HTML/XHTML, JSON, SGML,TeX/LaTeX, XML, XML-RPC, AJAX, SOAP, RSS, NNTP, Web Services
Internet
FTP, Log Analysis, DNS, WWW/HTTP: Browsers, Http Servers, Indexing, Search, Site Management, Dynamic Content: Blogging, Message Boards, Wiki, Ticketing Systems, CMS Systems, CGI Tools/Libraries
Security
Antivirus, Anti-Spyware, Firewalls, Encryption Software, Privacy Software
Browsers
Web Browsers, RSS and News Readers, Plug-ins and extensions for browsers
Educational Software
E-book software, Reference Software, Teaching Tools, E-learning Software tools
Business Software
Accounting, Billing, Auction Software, Collaboration Software, Database Management Software, Document Management, Ecommerce, Office Suits, Project Management, Presentation Software
Plagiarism Software Tools and Services
Other Tools
Mobile Tools/APIs/OS, Cluster and Grid Computing Software, Multimedia Codecs and APIs

Recommended Readings

1. Karl Fogel, Producing Open Source Software: How to Run a Successful Free Software Project, O'Reilly Media, Inc., 2005.
2. Heather J. Meeker, The Open Source Alternative: Understanding Risks and Leveraging Opportunities, Wiley Illustrated Edition, 2008.
3. Open Source Initiative, http://www.opensource.org
4. Open Source Software, http://sourceforge.net
5. Eclipse IDE, http://www.eclipse.org
6. Free Software Downloads, http://www.download.com
7. World Wide Web Consortium, http://www.w3.org
8. Wikipedia, http://www.wikipedia.org/

CS850 Topics in Databases

(3 cr.hrs)

Objectives

The main objective of this course includes an overview of the selected advanced topics in databases. A student should have studied databases at master's level that provides foundation for this course. A student should study recent research work going on in the area of databases.

Contents

Data Warehousing: Warehouse Architecture, Dimensional data model, STAR and Snow Flake Schemas, Aggregations, ETL Process, Data Marts, ROLAP vs MOLAP, Data cleaning, Materialized views,
Data Mining: A View of the KDD Process; Problems and Techniques; Data Mining Applications; Prospects for the Technology, Data Mining Inputs and Outputs, Data Mining Algorithms, Evaluating Data Mining Results
Database Security: Data protection: basic concepts, Access control policies, Administration policies, Advanced access control models, Fine Grained Security Techniques, Data Encryption
Distributed and Object Oriented Databases: Distributed DBMS Architecture, Design, Semantic Data Control, Distributed Query Processing and Concurrency Control

Recommended Readings

1. Witten and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufman, 1999.
2. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufman, 2000.
3. D. Hand, H. Mannila and P. Smyth. Principles of Data Mining, MIT Press, 2001.
4. M. H. Dunham. Data Mining: Introductory and Advanced Topic. Prentice Hall, 2003.
5. M. Jarke, M. Lenzerini, Y. Vassiliou, P. Vassiliadis (ed.), Fundamentals of Data Warehouses, Springer-Verlag, 1999.

6. Ralph Kimball, The Data Warehouse Toolkit, Wiley 1996.
7. Database Security By Silvana Castano Published 1995 Addison - Wesley

CS851 Advanced Object-oriented Methods

(3 cr.hrs)

Objectives

- Each student should know the basis for object-oriented analysis and design.
- Each student either prepares a research paper on some aspect of object orientation or builds and analyzes a non-trivial object oriented model.
- Each student reviews one other student's research paper as for a refereed journal or conference.

Description

The course investigates the object-oriented approach to system analysis and design.

Contents

UML: Introduction, UML Views, Use cases, Class, State, Sequence, Collaboration, Activity, Component, Deployment diagrams, Relationship, Generation / Specialization, UML and extensions, Design Patterns, Object-oriented languages Smalltalk, Ada, Eiffel, Java, C++, Python, Concurrency in Java, Concurrent object oriented languages, Concurrent Smalltalk, Eiffel, Inheritance anomaly

Recommended Readings

1. M. Fowler, UML distilled, 2nd Ed., Addison-Wesley 2000
2. S. W. Ambler, What's missing from the UML? Object Magazine 7:8, October 1997, 28-36
3. S. Caddel, Software architecture and the use of patterns: How Christopher Alexander's The timeless way of building can be applied to software design, Tech. Report CTU-CS-2001-06
4. D. Caromel. Toward a method for object-oriented concurrent programming. CACM Sept. 1993, 90 - 102
5. Cockburn, The interaction of social issues and software architecture, CACM 39:10 (October 1997) 40-46
6. Henderson-Sellers and F. Barbier, Black and white diamonds, Proc. <<UML>>'99. LNCS 1723, Springer 1999, 550-565
7. N. L. Kerth and W. Cunningham. *Using patterns to improve our architectural vision*, IEEE Software, January 1997, 53-59
8. Kristensen, Complex Associations: Abstractions in object-oriented modeling, Proc. OOPSLA '94, 272-286
9. P. Löhr. Concurrency annotations for reusable software, CACM 36:9 (Sept 1993) 81-89
10. Programming languages. In G. Agha, P. Wegner, and A. Yonezawa, editors, Research directions in concurrent object-oriented programming, pages 107 - 150. MIT Press, 1993. http://web.yl.is.s.u-tokyo.ac.jp/papers/

B. Meyer. Systematic concurrent object-oriented programming. CACM 36:9 (Sept 1993) 56 - 80.
11. J. J. Odell, Six different kinds of aggregation, JOOP January 1994, 10-15.
12. J. J. Odell, Power types, JOOP May 1994, 8-12

CS852 Advanced Software Engineering and Design (3 cr.hrs)

Objectives

This course describes the software development process in detail, including the software life cycle and models of software development; requirements analysis and software design techniques, such as SADT and Jackson Design Methodology; techniques for software quality assurance, including design reviews, testing, metrics, and an introduction to program verification; and software project planning, organization, and management. A student should study recent research work in the area of software engineering during this course.

Learning Outcomes

By the end of the course, students will be able to:

- Collect software requirements and develop use cases
- Develop analysis and design models
- Critique analysis and design models to suggest possible improvements
- Use analysis/design models to guide implementation
- Assess and ensure software quality using unit tests, system tests, metrics, and static analysis
- Understand the software lifecycle
- Understand the issues involved in planning and estimation for a software project

Course Contents:

Introduction, Development Process, Requirements Gathering Handling Changing Requirements, Object-Oriented Analysis, Object-Oriented Design, Software Architecture, Team project implementation, Version control, Design principles, Iterating and Testing, Software Lifecycle, Extreme Programming (XP), Users Stories, Pair Programming, Refactoring, Unit Testing, Extreme Programming Project Management

Recommended Readings

1. Kent Beck and Cynthia Andres, Extreme Programming Explained, 2nd ed. Aug 2006
2. Martin Fowler, UML Distilled, 3rd ed. 2003
3. The Unified Modeling Language User Guide, Grady Booch, et. al., Addison Wesley, 1999, ISBN: 0201571684
4. Refactoring: Improving the Design of Existing Code, Martin Fowler, et. al., Addison Wesley, 1999, ISBN: 0201485672
5. Design Patterns, Gamma, et. al., Addison Wesley, 1995, ISBN: 0201633612
6. AntiPatterns: Refactoring Software, Architectures, and Projects in Crisis, Brown, et. al., Wiley, 1998, ISBN: 0471197130

7. Object-Oriented Software Construction, Second Edition, Bertrand Meyer, Prentice Hall, 1997, ISBN: 0136291554

CS860 Advanced Computer Graphics

(3 cr.hrs)

Objectives

- To learn the state of the art computer graphics techniques
- Development and implementation of graphics algorithms
- Graphics programming skills for 2D and 3D
- Learning at least one standard graphics library and its use (OpenGL)

Introduction

Computer graphics is the first course in this area , and assumes no prior background of students in this area. This course will emphasize on principles needed to design, use and understand computer graphics systems. This course covers fundamental topics from two dimensional computer graphics such as scan conversion , filling , 2D-Viewing , Clipping , 2D Projections , 3D concepts , Graphical User Interfaces(GUI) and Modeling Concepts. The course will also put emphasis on practical aspect with use of OpenGL to illustrate various concepts.

Introduction to Computer Graphics

Overview of Computer Graphics(Ch1,Hill), Elements of Pictures(Polylines, Text, Filled Regions, Raster Images etc), Graphics Display devices, Graphics Input Primitives, Image Representation (Ch1, Schaum Series), RGB Color Model, Direct Coding, Lookup Tables, Image Files

Drawing Figures (Ch2,Hill)

Device Independent Programming and OpenGL, Window based programming, Drawing basic primitives, Line Drawing, Simple Interaction with the Mouse and Keyboard

Scan Conversion (Ch3, Hearn, Baker)

Scan Conversion, Scan Converting a Point, Scan Converting a Line, DDA Algorithm, Bresenham's Line Algorithm, Scan Converting a Circle, Properties of Circles, Midpoint Circle Algorithm, Scan Converting an Ellipse, Properties of Ellipses, Midpoint Ellipse Algorithm

Filling Algorithms (Ch3,Hearn,Baker)

Filling Areas, ScanLine Polygon Fill Algorithm, Boundary Fill Algorithm, Flood Fill Algorithm

Two Dimensional Geometric Transformations (Ch5,Hearn,Baker)

Basic Transformations, Translation, Rotation, Scaling, Matrix Representations and Homogeneous Coordinates, Composite Transformations

2D Viewing(Ch6,Hearn,Baker)

World windows and Viewports, Clipping Points, Clipping Lines, Cohen Sutherland Line Clipping, Liang-Barsky Line Clipping, Clipping Polygons, Sutherland-Hodgeman, Polygon Clipping, Weiler-Atherton Polygon Clipping, Text Clipping, Exterior Clipping

3D Concepts(Ch9,Hearn,Baker)
Three Dimensional Display Methods, Parallel Projection, Perspective Projection, Depth Cueing, Visible Line and Surface Identification, Surface rendering, Exploded and, Cutaway Views, Three Dimensional and Stereoscopic Views

Illumination and Shading (Ch14, Hearn, Baker)
Illumination Models, Light Sources(Point Light, Directional Light, Spot light), Reflections, Ambient Light, Diffuse Reflection, Specular Reflection and Phong Model, Flat, Gouraud and Phong Shading methods, Texture Mapping

Image Manipulation and Storage (Ch17, Foley et al)
What is an Image, Filtering, Image Processing, Geometric Transformations of Images, Multipass Transformations, Image Compositing, Mechanism for Image Storage, Special effects with images

Recommended Readings

1. Computer Graphics, 2nd Edition , Hearn, Baker, Addison Wesley, 1994
2. Computer Graphics using Open GL, 2nd Edition, F.S Hill, Jr. Prentice-Hall, 2001
3. Computer Graphics principles and practice,2nd Edition, Foley, Van Dam,Feiner Hughes, Addison-Wesley 1996.
4. Computer Graphics(Schaum's outlines series),2nd Edition,Zhigang Xiang, Roy Plastock , McGraw-Hill, 2000.

CS861 Pattern Recognition

(3 cr.hrs)

Objectives
The objective of this course is to provide an introduction to a variety of techniques used in the statistical, neural and machine learning domains. These methods are applicable to a vast array of problems in the speech recognition, image analysis/computer vision, signal processing, biometrics and document image analysis. The students will be introduced to research through case studies and discussion of research papers. The students will develop research skills by doing research project involving literature review, EEE style semester research paper and practical implementation with relevant results.

Course Outline
Introduction to Pattern Recognition, Machine Perception, Pattern Recognition Systems, Design Cycle, Learning and Adaptation, Pre-Processing, Feature Extraction, Image Compression, Edge Detection, Skeletonization, Segmentation, Geometric features, (Loops, Intersections and Endpoints), Bayes Decision Theory, Dimensionality Reduction:

Principal Component Analysis, Linear Discriminant Analysis, Problems of Dimensionality, Neural Networks: Kn-Nearest Neighbor Estimation, Unsupervised learning, clustering, vector quantization, K-means, Multilayer Neural Networks
Support Vector Machines, Hidden Markov Model, Comparing Classifiers using Cross-Validation

Relevant Research Papers

- Mathew A. Turk, and Alex P. Pentland, "Face Recognition Using Eigenfaces", IEEE ,1991.
- Michael J. Lyons, Julien Budynek, and Shigeru Akamatsu, "Automatic Classification of Single Facial Images", in IEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 21, No. 12, December 1999.
- Zhao,W., Chellappa, R., and Krishnaswamy, A, "Discriminant analysis of principal components for face recognition", In Proceedings, International Conference on Automatic Face and Gesture Recognition. Page 336–341, 1998.
- Daniel L. Swets and John (Juyang) Weng, "Using Discriminant Eigenfeatures for Image Retrieval", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 18, No. 8, August 1996.
- Anil K. Jain, Robert P.W. Duin, Jianchang Mao, "Statistical Pattern Recognition: A Review," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 22, no. 1, pp. 4-37, January, 2000.

Recommended Readings

1. Richard O. Duda, Peter E. Hart and David G. Stork, "Pattern Classification", 2nd Edition. John Willey and Sons Inc. 2001
2. Abhijit S. Pandya, Robert B. Macy, "Pattern Recognition with Neural Networks in C++" CRC-Press, 1995
3. Andrew Webb, "Statistical Pattern Recognition", 2nd Ed, Wiley 2002
4. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications" Prentice-Hall, Inc., 1994

CS862 Computer Vision

(3 cr.hrs)

Objectives

At the end of this course, the students will be able:

- To understand how images are processed by a computer?
- To differentiate between just recording images and understanding them just like human beings
- To grasp the concept of the capability of a computer or a robot to see things with understanding and making appropriate decisions

Course Description

Introduction to the basic concepts in computer vision.
An introduction to low-level image analysis methods, image formation, edge detection,

feature detection, image segmentation. Image transformations (e.g., warping, morphing, and mosaics) for image synthesis. Methods for reconstructing three-dimensional scene information using techniques such as depth from stereo, structure from motion, and shape from shading. Motion and video analysis. Two-dimensional object recognition.

Recommended Readings

1. Computer Vision: A Modern Approach by D. A. Forsyth and J. Ponce, Prentice Hall, Upper Saddle River, N.J., 2003

CS863 Special Topics in Computer Science

(3 cr.hrs)

CS864 Computational Morphology

(3 cr.hrs)

Objectives

After the completion of this course a student will be able to have a strong understanding of the following:

- Morphology and its types
- Different phenomena involved in morphology
- Analyzing inflections and derivations
- Computational models for morphological analyzers and synthesizers
- Xerox tool for the implementation of morphological analyzers and synthesizers
- Implementation of morphological analyzers and synthesizers

Introduction to Morphology and Computational Morphology

What is morphology, morphemes, introduction to morphological analysis.

Words and Lexemes

What is word, types of words, inflection Vs derivation, Item-and-arrangement, Item-and-process, the lexicon.

Morphology and Phonology

Allomorphs, prosodic morphology, Morpho-phonology

Derivation

Derivation and lexicon, derivation and semantics

Inflection

What is inflection, inventory of Inflectional morphology types, Typology

Morphological productivity
Introduction, Productivity and structure, degrees of productivity

Practical

Regular expressions
Finite automata
FST
The XFST interface
The LEXC language
Planning and managing finite state projects

Recommended Readings

1. Daniel Jurafsky and James H. Martin. (2000). "Speech and Language Processing". Pearson Education, Inc.
2. Mark Ronoff and Kirsten Fudeman. (2005). "What is Morphology?". Blackwell Publishing.

CS865 Topics in Data Warehousing and Business Intelligence

(3 cr.hrs)

Course Description
This course provides an insight into data warehousing, its design and architecture, and issues involved in using data warehouse in business organizations. The course also discusses warehouse DBMS, data marts and other advanced techniques including ETL processes.

Course Objectives

- To discuss issues involved in Data Warehousing.
- To understand the concepts and details of warehouse architecure.
- To understand the working of different data warehouse models and OLAP Operations.

Course Contents
Some Issues in Data Warehouse Design: monitoring; wrappers; integration; data cleaning; data loading; materialised views; warehouse maintenance; OLAP servers; metadata. Heterogeneous information; the integration problem; the Warehouse Architecture; Data Warehousing; Warehouse DBMS. Aggregations: SQL and aggregations; aggregation functions; grouping. Data Warehouse Models and OLAP Operations: Decision support; Data Marts; OLAP vs OLTP; the Multi-Dimensional data model; Dimensional Modelling; ROLAP vs MOLAP; Star and snowflake

schemas; the MOLAP cube; roll-up, slicing, and pivoting. Research topics in Business Intelligence, What is Information Systems and Business Intelligence, Advance Techniques in ETL Process, Introduction to the Unified Dimensional Model (UDM), Dimensions, Cubes and their features, The MDX Language and KPIs.

Recommended Readings

1. Fundamentals of Data Warehouses, M. Jarke, M. Lenzerini, Y. Vassiliou, P. Vassiliadis (ed.), Springer-Verlag, 1999.
2. Elizabeth Vitt, Michael Luckevich, Stacia Misner "Business Intelligence: Making Better Decisions Faster" Publisher: Microsoft Press, Publication Date: May 17, 2002, ISBN 0-7356-1627-2
3. Cindi Howson "Successful Business Intelligence: Secrets to Making BI a Killer App" Publisher: The McGraw Hill Companies, Publication Date: November 26, 2007 Edition: 1, ISBN: 978-0-07-149851-7
4. Thomas H. Davenport, Jeanne G. Harris, Robert Morison "Analytics at Work: Smarter Decisions, Better Results" Publisher: Harvard Business School Publishing Corporation Publication Date: February 8, 2010, ISBN 978-1-4221-7769-3
5. Swain Scheps "Business Intelligence for Dummies" Publisher: Wiley Publishing, Inc. Publication Date: January 10, 2008, ISBN 978-0-470-12723-0

CS866 Text Mining

(3 cr.hrs)

Course Description

This course introduces the techniques used for information retrieval using text mining. It discusses the types of text from which the information is to be retrieved and the design of the queries to get the required information.

Course Objectives

- To introduce the basics of information retrieval.
- To discuss the design of queries and use of different optimization techniques.
- To discuss information retrieval performance.

Course Contents

Introduction to Information Retrieval. Inverted indices and boolean queries. Query optimization. The nature of unstructured and semi-structured text. Query expansion: spelling correction and synonyms. Wild-card queries, permuterm indices, n-gram indices. Edit distance, soundex, language detection. Index construction. Postings size estimation, merge sort, dynamic indexing, positional indexes, n-gram indexes, real-world issues. Parametric or fielded search. Document zones. The vector space retrieval model. Scoring documents. Vector space scoring. The cosine measure. Efficiency considerations. Nearest neighbor techniques, reduced dimensionality approximations, random projection. Relevance feedback. Pseudo relevance feedback. Query

expansion. Automatic thesaurus generation. Sense-based retrieval. Experimental results of performance effectiveness. Improving Retrieval Performance by Relevance Feedback. Vector space classification using hyperplanes; centroids; k Nearest Neighbors. Text classification. Exploiting text-specific features. Feature selection. Evaluation of classification. Micro- and macro-averaging. Comparative results.

Recommended Readings

1. Managing Gigabytes, I. Witten, A. Moffat, and T. Bell. Managing Gigabytes: Compressing and Indexing Documents and Images , Weily, 1996
2. Modern Information Retrieval, R. Baeza-Yates and B. Ribeiro-Neto Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA 1999
3. Foundations of Statistical Natural Language Processing, C. Manning and H. Schütze, MIT Press. Cambridge, MA: May 1999.
4. Information Retrieval: Algorithms and Heuristics, D. Grossman and O. Frieder, Springer, 2004

CS867 Topics in Data Mining

(3 cr.hrs)

Course Description

This course is designed in a way to discuss latest issues involved in data mining. The main concept of the course is to discuss latest research dimensions in the field of data mining using latest research papers and literature. The will make an extensive use of online resources.

Course Objectives

- To review latest research papers in the field of data mining.
- To discover the latest advancements in data mining applications.
- To discuss data mining algorithms**.**

Course Contents

Review of research papers, A View of the KDD Process; Problems and Techniques; Data Mining Applications; Data Mining Inputs and Outputs: Concepts, Instances, Attributes; Kinds of Learning; Providing Examples; Kinds of Attributes; Preparing Inputs. Knowledge Representations; Decision Tables and Decision Trees; Classification Rules; Association Rules; Regression Trees and Model Trees; Instance-Level Representations. Data Mining Algorithms: One-R; Naïve Bayes Classifier; Decision Trees; Decision Rules; Association Rules; Regression; K-Nearest Neighbor Classifiers. Evaluating Data Mining Results: Issues in Evaluation; Training and Testing Principles; Error Measures, Holdout, Cross Validation; Comparing Algorithms; Taking Costs into Account; Trade-Offs in the Confusion Matrix

Recommended Readings

1. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufman, 2000.
2. D. Hand, H. Mannila and P. Smyth. Principles of Data Mining, MIT Press, 2001.
3. M. H. Dunham. Data Mining: Introductory and Advanced Topic. Prentice Hall, 2003.

4. Larry Wasserman, All of Statistics: A Concise Course in Statistical Inference. Springer, 2003.
5. The Elements of Statistical Learning, Hastie, Tibshirani, Springer, 01-Dec-2008
6. Pattern Recognition and Machine Learning, Bishop, Springer; 1st ed. 2006

CS868 Advanced Topics in Wireless Networks (3 cr. hrs)

Course Description

Wireless networks are a fast changing field, new technologies and strategies are being introduced rapidly. This course will introduce advanced topics in wireless networks. A detailed description of cellular mobile infrastructure and network architecture will be provided.

Course Objectives

To provide a solid foundation of cellular mobile technologies and practical systems.

- n of cellular mobile technologies and practical systems.
- To introduce different cellular mobile technologies and practical systems.
- To provide a detailed description of cellular mobile infrastructure and network architecture.

Course Contents

Wireless radio channel, large-scale fading models, small-scale fading models, Cellular wireless networks, Power Consumption, Location and Mobility Management, Wireless Broadband Networks, LMDS, MMDS, Free Space Optics, Wireless wireline interworking, Mobile IP, Wireless personal area networks (Bluetooth, UWB, ZigBee), 802.11 (a, b, g, n) networks, Mobility management and radio resource management, Traffic models and mobility models, High-Speed Downlink Packet Access, TCP/SCTP over Wireless System, Next Generation and New Generation Networks, Security, Handoff and mobility management in NGN, Mobile IPv6, Satellite Systems, Broadcast system, digital audio video broadcasting, convergence of broadcasting and mobile computing, Evolution of GSM andCDMAone System to 3G and beRond, Cognitive radio 802.22 networks, spectrum handoff and other research issues, 802.21 Media Independent Handover, Mobile Broadband Wireless Access (MBWA) 802.20 networks. Simulations of wireless networks (OPNET, NS2).

Recommended readings

1. Gary J. Mullet, Wireless Telecommunications Systems and Networks, Springer; 1 edition (May 19, 2004)
2. F. Adelstein, S.K.S. Gupta, G.G. Richard III and L. Schwiebert, Fundamentals of Mobile and Pervasive Computing, McGraw Hill, 2005, ISBN: 0-07-141237-9.
3. Garg, Wireless Communications and Networks, Morgan Kaufmann 2007, ISBN 978-0-12-373580-5.
4. Kumar, Danjunath and Jury, Wireless Networking, Morgan Kaufmann 2008, ISBN 978-0-12-374254-4.

5. Schwartz, Mobile Wireless Communications, Cambridge University Press, 2005, ISBN 0-521-84347-2.
6. Mark and Zhuang, Wireless Communications and Networking, Prentice Hall 2003, ISBN 0-13-040905-8.
7. Pahlavan and Levesque,Wireless Information Networks, Wiley 2005, ISBN: 978-0-471-72542-8.

CS869 Cloud Computing

(3 cr.hrs)

Course Description

Cloud computing represents a major paradigm shift in computing from the era of personal computers to the era of computing as a utility. Most major Internet services are already deployed in the “the cloud”. In the near future, we may store all our data in "the cloud" and execute most applications from “the cloud.” The primary objective of the course is to provide introduction to the current practices of cloud computing, mainly focusing on cloud computing models, techniques, and architectures.

Course Objectives

When students complete this course, they will:

- Understand the reasons for the paradigm shift
- Have the knowledge of designing and implementing cloud-based software systems
- Be able to understand and work with services of the leading cloud computing providers like Amazon and Google
- Know the current challenges facing cloud computing.
- Be able to pursue research in cloud computing

Course Contents

Cloud Computing Fundamentals, Evolution, Objectives, Characteristics, Components, Delivery Models, Service Layers, Opportunities, Risks, Benefits, Vendor Survey

Cloud Computing Services: Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), System Architectures & Operational Models, Vendor Selection Challenges.

Cloud Computing Deployment: Infrastructure & Connectivity, Virtualization Types & Techniques, Security & Privacy, Reliability & Resilience, Usability & Performance, Real World Case Studies Service Oriented Architecture: Web Applications and Web APIs, Web Services, SOA and Cloud Computing, Designing and Developing a Cloud-based application.

Overview of Virtualization: Basic Concepts and Architecture of Virtualization, Benefits and Dangers of virtualizing applications and servers, Hardware considerations, software & Licensing considerations, Enterprise Server Virtualization Platforms, Virtualization Best Practices, Secure Deployment of Virtualized Server Environments

Recommended readings

1. Cloud Computing, A Practical Approach, Toby Velte, Anthony Velte, Robert Elsenpeter, McGraw-Hill Osborne Media; 1st edition, 2009.
2. Cloud Application Architectures: Building Applications and Infrastructure in the Cloud, George Reese, O'Reilly Media; 1st edition, 2009.
3. Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, Recursive Press, 2009
4. Cloud Computing Bible, Barrie Sosinsky, Wiley; 1 edition, 2011.
5. The Cloud at Your Service, Jothy Rosenberg, Arthur Mateos. Manning Publications; 2010.
6. Cloud Computing For Dummies, Judith Hurwitz, Robin Bloor, Marcia Kaufman, Fern Halper, For Dummies, 2009.
7. Cloud Application Architectures: Building Applications and Infrastructure in the Cloud, George Reese O'Reilly Media; 1 edition, 2009.
8. Virtualization - The Complete Cornerstone Guide to Virtualization Best Practices Ivanka Menken, Emereo Pty Ltd; 2nd edition, 2010

CS870 Agile Methodologies and Applications

(3 cr.hrs)

Course Description

This course describes the software development process in detail, including the software life cycle and models of software development. Emphasis is on agile software development processes. The course will take a detailed overview of different agile methodologies which are being used extensively in the software development industry. Also, different techniques for software quality assurance, including design reviews, testing, metrics, and issues involved in planning and estimation for a software project will be reviewed.

Course Objectives

- To understand the concept behind agile development methodology.
- To study different models designed on top of Agile Manifesto.
- To take an overview of the application areas where agile methodologies can be used.

Course Contents

Introduction, Development Process, Agile Concepts, The Agile Life-Cycle and Artifacts, Agile Technologies: Detailed process of Scrum, XP and Crystal. Feature Driven Development, DSDM, Adaptive Software Development. Team Dynamics, Agile Engineering, Agile Testing Strategies, Test Automation. Planning, Estimation, Iterating Agile Project Management, Retrospectives. balancing agility and discipline. Application areas of agile development processes. Literature review, Case studies and experience reports.

Recommended readings

1. Kent Beck and Cynthia Andres, Extreme Programming Explained, 2nd edition. Addison-Wesley Professional, 2006

2. Martin Fowler, UML Distilled, Addison-Wesley Professional, 2004
3. Extensive use of latest online resource

CS871 Software Measurement and Metrics

(3 cr.hrs)

Course Description

This course will provide a comprehensive insight into setting up the metric program and managing software measurement information step-by-step. Therefore, the students will be able to implement the measurement program and use of this information in managing projects and processes.

Course Objectives

- To understand the concept of software measurement.
- To clarify what to measure and why to measure during a software development activity.
- To study different techniques of measurement.

Course Contents

Concept of software measurement, What and why to measure?, Project Level and Organization Level Measurement, Software measurement process and activities, Setting up a metrics program, Prerequisites to measurement, Measurement categories and basic measurements, Standards, Models and Initiatives, Establishing organizational measurement database, Meeting business objectives and goals, Goal Question Metric Technique (GQM), Plan measurement, Identify and prioritize information needs, Select and specify measurement, types of metric (product, process, resource), Establish baseline performance measurement plan, Implementation of a measurement program, Reporting, analyzing, and evaluating measurement, evaluating measures and measurement process, using metrics to evaluate software process models, Identify and Implement Improvements, Measurement and analysis in CMMI, Case Study, Literature review, Measurement tools.

Recommended readings

1. Applied software measurement: global analysis of productivity and quality, Capers Jones McGraw-Hill Professional, 2008
2. Software Process Improvement: Metrics, Measurements, and Process Mod-Elling, Michael Haug, Eric W. Springer, 2001
3. Software Metrics: A Rigorous and Practical Approach, Norman E. Fenton Shari Lawrence Peeger, Course Technology; 2 edition, 1998

CS872 Software Architecture

(3 cr.hrs)

Course Description
To give the students an understanding of the concept of software architecture, and of how this phase in the development between requirement speciation and detailed design plays a central role for the success of a software system. The students will get knowledge of some well-known architecture patterns, and will be able to evaluate architectures for software systems. In addition, the students should get some understanding of how the developers' experiences and the technical and organizational environment will influence on the choice of architecture.

Course Objectives:

- To understand the basics of software architecture.
- To study different types of architectures used in software development industry.

Course Contents
Software architecture terminology, architecture in the system development life cycle, architecture dimensions; physical versus logical architectures, Architectural styles and patterns, methods for constructing and evaluating architectures, and component-based development. Object-oriented frameworks. Web-based architectures, Centralized versus distributed architectures. Literature review.

Recommended readings

1. P. Clements, F. Bachmann, L. Bass, D. Garlan, J. Ivers, R. Little, R. Nord, and J. Staord, Documenting Software Architectures: Views and Beyond, Addison Wesley, 2003, ISBN 0-201-70372-6.
2. Taylor, Medvidovic, and Dashofy, Software Architecture: Foundations, Theory, and Practice, 2009
3. Anthony J. Lattanze, Architecting Software Intensive Systems: A Practitioners Guide, 2008, Auerbach Publications
4. Bass, Clements, and Kazman, Software Architecture in Practice (2nd Edition), 2003, Addison-Wesley Professional

CS873 Software Engineering Ontologies

(3 cr.hrs)

Course Description
The objective of this course is to study in detail the Ontologies available for software development and highlights their strengths and 9weaknesses in achieving the goals for which the Ontologies have been developed. The course starts from the introduction to Ontologies and latest languages used to describe / document Ontologies. Use of Ontologies and its significance in development of software systems will be covered with the help of some real life examples. Then a detailed study and comparison of different Ontologies available for each phase in the software engineering development life cycle will be done.

Course Objectives

- To understand principles, methods and tools of ontology engineering.
- To discuss the use of ontologies in software engineering.
- To study different ontologies used in various stages of software development.

Course Contents

Ontology Engineering: Principles, Methods, Tools, and Languages. Using Ontologies in Software Engineering. Development of Ontologies for SWEBOK (Software Engineering Body of Knowledge): Issues and Techniques. Some Ontologies for Software development: Ontologies for Requirements, Design, Maintenance, Measurements, Use of Ontologies in Domain Oriented Software Development Environments. Comparative Study of Semantics Coverage in Ontologies as per SWEBOK. Alignment of Different Available Ontologies.

Recommended readings

1. Ontologies for Software Engineering and Software Technology, Coral Calero, Francisco Ruiz, Mario Piattini, Springer; 1 edition, 2006, ISBN-10: 3540345175
2. Extensive Use of Online Available Latest Resources

CS874 Software Process Improvement

(3 cr.hrs)

Course Description

To explain the principles of software process improvement and to explain how software process factors influence software quality and productivity. To demonstrate how SPI is performed and how the results are analyzed. To define change management and to explain how the improved performance is measured. To demonstrate how SPI works in agile environments and how agile environments benefit from organized process improvement.

Course Objectives

- To understand the basic idea behind process improvement.
- To discuss and understand the issues involved in software process improvement.
- To study latest approaches to software process improvement including agile methodologies.

Course Contents

Overview, Concepts, Choosing an Improvement Goal, Assessment of Existing Processes, Analysis of the Results, Legacy Process Artifacts, The Process Improvement Plan, Process Definition/Refinement, Process Implementation, Change Management, The Impact of Improved Processes, Measuring Improved Performance, Issues, Benefits. Agile Approach to SPI, Literature Review.

Recommended readings

1. Process Improvement Essentials CMMI, Six Sigma, and ISO 9001, James R. Persse, O'Reilly Media 2006
2. Reducing Risk with Software Process Improvement, Louis Poulin, Auerbatch Publications 2005
3. Software Process Improvement for Small and Medium Enterprises: Techniques and Case Studies, Hanna Oktaba, Mario Piattini, IGI Global 2008
4. Extensive use of latest available online resources.

CS875 Advanced User Interface Design and Development

(3 cr.hrs)

Course Description

To learn how to design, prototype, and evaluate user interfaces using a variety of methods. To understand how to study the tasks that a prospective user will need to accomplish with a software system, the cognitive constraints that affect UI design, and to learn some basic techniques for evaluating a user interface design and the importance of iterative design in producing usable software, prototyping, low fidelity design, and implementation of initial versions of user interfaces.

Course Objectives

- To understand the importance user interface of a software .
- To discuss various principles of user interface design and development.
- To understand the concept and approach of Web 2.0
- To learn the techniques of usability testing.

Course Contents

Introduction and Overview, Principles of HCI, User interface Design, Personas, Goals, and Task Analysis, Scenarios, Comparative Analysis, Survey/Interview/and questionnaire's fundamentals, Cognitive Considerations, Affordances, Mappings, Mental Models, Metaphor, Locus of Attention. Errors, Modes, Design guidelines, Heuristic Evaluation, Low- fi Prototyping and Test, Wireframing, Formal Usability Testing, Graphic Design, introduction to Web 2.0, Keystroke-Level Model, GOMS (Goals, Operators, Methods, and Selection rules), Fitts Law, Alternative Interfaces, Pilot Usability Study, Case studies, Literature review.

Recommended readings

1. RichardW. Pew, Evolution of Human-tomputer Interacÿion: From Memex to Bluetooth and Beyond, Introduction in The Human-Computer Interaction Handbook, Jacko and Sears (Ed.), Lawrence Erlbaum Associates, 2003.

2. MarkW. Newman and James A Landay. Sitemaps, Storyboards, and Specifications: A Sketch of Web Site Design Practice. In the Proceedings of Designing Interactive Systems, DIS 2000, New York City, 2000.
3. Michel Beaudouin-Lafon and Wendy Mackay, Prototyping Tools and Techniques, Chapter 52 in The Human-Computer Interaction Handbook, Jacko and Sears (Ed.), Lawrence Erlbaum Associates, 2003.

CS876 Software CASE Tools and Applications

(3 cr.hrs)

Course Description

Computer-Aided Software Engineering tools, in the field of Software Engineering, is the scientific application of a set of tools and methods to a software system which is meant to result in high-quality, defect-free, and maintainable software products. CASE tools assisst software engineers and refer to methods for the development of information systems together with automated tools that can be used in the software development process.

Course Objectives

- To understand the concept and use of CASE tools.
- To discuss various emerging CASE methodologies.

Course Contents

CASE tools and techniques, CASE in software development process, Traditional CASE methodologies, Emerging CASE methodologies, specialized design tools, e.g., MDA - Model Driven Architecture CASE Tools, MDD - Model Driven Development CASE Tools, Database Modeling CASE Tools, UML - Unifed Modeling Language CASE Tools, Reverse engineering CASE Tools, Agile Modeling CASE Tools, Business Process Management CASE Tools, Software Architecture CASE Tools, Design CASE Tools, Requirements Management CASE Tools, Web Engineering Tools,Workbenches CASE Tools..

Recommended readings

1. Selected software CASE tool documentation.
2. Extensive use of latest available online resources.

CS877 Special Topics in Software Engineering

(3 cr.hrs)

Course Description

The course provides an overview of the latest developments and research in the field of software engineering. The main objective of this course is to keep the students up to date with the new ideas being presented in flagship software engineering conferences and journals. The entire course will be based upon the literature review of topics from the research papers presented in Software Engineering conferences and published in journals in the recent years.

Course Objectives

- To keep the students up to date with the latest advancements in the field of software engineering.
- To be able to discuss current issues in software engineering research.

Course Contents

Following are some of the proposed topics; the instructor may select any other topic(s) of interest from the latest technologies and may cover two or more of the topics in detail:

Advances in Security Engineering, Advances in Service oriented software engineering, Advances in Aspect oriented software development, Knowledge management issues in software engineering, Agile Knowledge Management, Cloud computing, Software testing, End user software engineering, Patterns and frameworks, Knowledge Based Software Engineering, Semantic Web Enabled Software Engineering, etc., Literature review and support tools (if apply).

Recommended readings

1. Current research publications and literature.
2. Extensive use of online available latest resources

CS878 Mobile Based Augmented Reality

(3 cr.hrs)

Course Description

Augmented Reality (AR) is a new technology that involves the overlay of computer graphics on the real world. It has many possible applications in a wide variety of fields including entertainment, education, medicine and manufacturing. In this course students will be introduced to the field of Augmented Reality and taught how to build their own AR applications using freely available open source tools. Instead of the traditional AR, the focus of this course is on the emerging field of Mobile based AR. They will be thoroughly introduced to the Smartphone AR browsers and Toolkits.

Course Objectives

By the end of the course students will have:

- an understanding of the field and its applications in several different fields
- the skills necessary to develop their own mobile AR applications
- knowledge of sensors in mobile phones and their use in AR
- an understanding of the current areas of research in the field.

Course Outline

Augmented Reality: Introduction, history, state of the art Traditional Augmented Reality: Principles, Techniques, Tracking and Authoring Tools Mobile based AR Smartphones and AR Embedded Sensors and AR Mobile Operating Systems and AR Mobile AR Browsers Mobile AR Toolkits Creating Content for mobile AR applications

Mobile Phone Based AR Applications Collaborative Augmented Reality Research Directions in Augmented Reality

Recommended readings

1. Professional Augmented Reality Browsers for Smartphones: Programming for junaio, Layar and Wikitude, Lester Madden, Wiley; 1 edition, 2011.
2. Pro Android Augmented Reality, Kyle Roche, Chris Chiappone, Frank LoVecchio. Apress; 1 edition, 2011.
3. iOS Sensor Programming: Augmented Reality and Location Enabled iPhone and iPad Apps, Alasdair Allan, O'Reilly Media; 1 edition, 2011.
4. Augmented Reality: A Practical Guide, Stephen Cawood and Mark Fiala, Pragmatic Bookshelf, O'Reilly Media, 2008.
5. Interactive Environments with Open-Source Software: 3D Walkthroughs and Augmented Reality for Architects with Blender 2.43, DART 3.0 and ARToolKit 2.72. Wolfgang Höhl, Springer Vienna Architecture; 1 edition, 2008.
6. Emerging Technologies of Augmented Reality: Interfaces and Design. By Michael Haller, Michael Haller, Bruce Thomas, Mark Billinghurst, IGI Global, 2006.
7. The End of Hardware, 3rd Edition: Augmented Reality and Beyond, Rolf R. Hainich, BookSurge Publishing; 3 edition, 2009.
8. Always On: How the iPhone Unlocked the Anything-Anytime-Anywhere Future--and Locked Us In. Brian X. Chen. Da Capo Press, 2011.

CS879 Context Aware Computing

(3 cr.hrs)

Course Description

Modern computers are considered away from reality as they are unaware of who, where, and what is around them. This leads to a mismatch between the requirements of an information seeker and the results provided by a computer system. Computers have extremely limited input and are aware of explicit input only. The field of Context-Aware Computing makes computers more aware of the physical and social worlds we live in. Context-awareness is an enabling technology that combines a broad scope of topics in computer science. This course deviates a bit from ubiquitous and pervasive computing and focuses more on context awareness on the web and on mobile platforms which is the current hot area of the field.

Course Objectives

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

- Understand the importance and application of context awareness
- Get an insight into context-aware applications
- Know the methods required in the design of context-aware applications

Course Contents

Context and Context-aware Computing, Context Types, Why Context-aware Computing? Context-aware Applications, Challenges in Implementing a Context-aware Application
Sensing Context, Modeling Context, Context Specification, Context Interpretation, Quality of Context, Context Aware Programming, Programming Models Automatic Adaptivity, Social Information Filtering Web Recommendations, Personalization, User Modeling Location Awareness, GPS, RFIDs and Other Sensors Smartphone and Context Awareness Context-aware Web Services Metadata, Semantics and Context-awareness

Recommended readings

1. Enabling Context-Aware Web Services: Methods, Architectures, and Technologies. Michael Sheng, Jian Yu and Schahram Dustdar. Chapman and Hall/CRC; 1 edition, 2010.
2. Context-aware Semantics-based Information Retrieval, C. Kessler. IOS Press, 2010.
3. Context-Aware Pervasive Systems: Architectures for a New Breed of Applications , Seng Loke. Auerbach Publications; 1 edition, 2006.
4. Context-Aware Mobile and Ubiquitous Computing for Enhanced Usability: Adaptive Technologies and Applications, Dragan Stojanovic. Information Science Reference; 1 edition, 2009.
5. Quality of Context: First International Workshop, QuaCon 2009, Stuttgart, Germany, June 25-26, 2009. Revised Papers (LNCS), Kurt Rothermel, Dieter Fritsch, Wolfgang Blochinger, Frank Dürr. Springer, 2009.
6. Location- and Context-Awareness: First International Workshop, LoCA 2005, Oberpfaffenhofen, Germany, May 12-13, 2005, Proceedings (LNCS), Thomas Strang, Claudia Linnhoff-Popien. Springer, 2005.

CS880 Digital Forensics

(3 cr.hrs)

Course Description

The vast majority of modern criminal investigations involve some element of digital evidence, from mobile phones, computers, CCTV and other devices. This course will cover fundamentals of computer forensics and investigations. It will focus on the technological aspect of digital forensics with less regard to its legal aspect. This course provides a thorough explanation of how computers & networks function, how they can be involved in crimes, and how they can be used as evidence. It covers how to conduct digital investigations and how to locate and utilize digital evidence on computers, networks, and mobile systems. Topics include a systematic approach to computer investigations, email and image file analysis; and guidelines for investigation reporting and development of a computer forensics laboratory. Various forensic tools will be used, preferably open source.

Course Objectives

Upon completion of this course, a student will be able to

- Utilize a systematic approach to computer investigations
- Utilize various forensic tools to collect digital evidence
- Perform digital forensics analysis upon Windows, MAC and LINUX operating systems
- Perform digital forensics analysis upon Mobile systems and Smart phones
- Perform email investigations
- Analyze file systems
- Understand anti-forensic methods and tools

Course Contents

Computer Investigations Case examination and assessment, Evidence gathering, Systematic approaches to computer investigations, Conducting an investigation

Operating Systems and File Systems Review of file structures, boot processes, and data structures of popular operating systems, NTFS, Macintosh, Linux Preparing Media to Accept an Image Create a partition, Wipe partition using DOD standard, Verify wipe of partition Digital Forensics Evidence Restoring a Hard Disk Image, Verifying restore was successful, Boot to the evidence Operating System Data Acquisition Identify methods, Utilization of various data acquisition tools Computer Forensic Analysis Concepts, Utilization of various analysis tools, Recognizing, locating, recovering and analyzing images, Processing evidence with FTK, Data Carving, Searching the Registry Linux Forensics Linux Distributions Boot block, superblock, inode block and data block, Understanding inodes, Linux Loader & GRUB, Linux drives and partition schemes, Sleuth Kit, Autopsy, HELIX and, KNoppix MAC Forensics HFS, HFS+, Finder, File Manager, Macintosh acquisition methods using MacQuisition, Using Black Bag Tools

Computer Forensic Investigation Reporting Reporting guidelines, Witness Requirements

Anti Forensics.

Recommended readings

1. Digital Forensics with Open Source Tools, Cory Altheide, Harlan Carvey, Syngress Elsevier USA, 2011.
2. Computer Forensics For Dummies, Linda Volonino, Reynaldo Anzaldua, For Dummies, 2008.
3. Guide to Computer Forensics and Investigations, (3rd edition), Nelson, Phillips, Enfinger Steuart, Thomson, 2004, ISBN 0-619-21706-5
4. Introduction to Security and Network Forensics, William Buchanan, Auerbach Publications, 2011
5. Principles and Practice of Information Security, Volonino Robinson, Prentice Hall, 2003, ISBN 0-13-184027-4
6. Handbook of Digital Forensics and Investigation, Eoghan Casey, Academic Press, 2009.
7. Digital Evidence and Computer Crime, Third Edition: Forensic Science, Computers, and the Internet, Eoghan Casey BS MA, Academic Press, 2011.

CS881 Social Web

(3 cr.hrs)

Course Description

The Social Web has captured the attention of millions of users as well as billions of dollars in investment and acquisition. Social web applications evolve around the connections between people and their objects of interest. This course elaborates on the evolution and current state of the art of the Social Web and focuses on concepts, tools and techniques for building social web application that attracts and retains regular visitors, and gets them to interact.

Course Objectives

After completion of this course, a student will be able to:

- Get a straightforward synopsis of the social web landscape
- Use and modify open source scripts to harvest data from social network APIs such as Twitter, Face book, and LinkedIn
- Explore and analyze social connections
- Understand the value of integrating semantic technologies with social web applications

Course Contents

Social Web Evolution and state of the art, Building a Social Applications, Analyzing, Creating, and Managing Community Relationships, Relationships, Responsibilities, and Privacy, Community Structures, Software, and Behavior, Social Media, Social Network Patterns, Modeling Data and Relationships, Making Connections and Managing Communities, Building APIs, Integration, and the Rest of the Web, Launching, Marketing, and Evolving Social Applications, Extracting and Analyzing Data from Facebook, Twitter, and Other Social Media Sites, Integration of Social Web with Semantic Web/

Recommended readings

1. Building Social Web Applications: Establishing Community at the Heart of Your Site, Gavin Bell. O'Reilly Media, 2009.
2. Designing for the Social Web. Joshua Porter, New Riders Press, 2009.
3. Mining the Social Web: Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites, Matthew A. Russell, O'Reilly Media; 1 edition, 2011.
4. Social Web Evolution: Integrating Semantic Applications and Web 2.0 Technologies , Miltiadis D. Lytras, Patricia Ordóñez de Pablos. IGI Global, 2009.
5. The Social Sÿmantic Web, eohn G. Breslin, Alexandre Passant, Stefan Decker. Springer, 2009.

CS882 Special Topics in Wireless Sensor Networks (3 cr.hrs)

Course Description

This course aims introducing concepts and research topics in Wireless Sensor Network. It will cover topics ranging from Introduction to Sensor networks and its applications, Security issues in WSN, MAC protocols in WSN, Sensor Database System, Localization and Topology management and the methods that are used in Localization.

Further new research topics may also be included in the course depending on new research made in the field of Wireless Sensor Networks. Each discussion-oriented lecture will be preceded by the reading of 1-2 papers, resulting in a rich collection of papers by the end of the semester.

Course Objectives

- To introduce current research topics otherwise not covered in other courses.
- To introduce new areas of research related to Wireless Sensor Network.

Course Contents

Introduction will include Wireless Sensor Networks, Typical Architecture, Characteristics of WSN, Applications of WSN, and Challenges in WSN. New issues related to Security, Sensor Database System, Localization and Management. In addition any other current topic deemed necessary by the instructor may also be included.

Recommended readings

1. Wireless Sensor Networks, Ian F. Akilliz and Mehmet Can Vuran, Wiley; 1 edition, 2010
2. Wireless Sensor Networks, 1945-3078, www.scrip.org/journal/wsn.
3. Ad Hoc Networks ISSN: 1570-8705, Elsevier

CS883 Embedded Systems (3 cr.hrs)

Course Description

The course will span a variety of topics ranging from Microprocessor, Micro-Controllers, Communication interfaces, Memory used in embedded systems, radio communications, Systems infrastructure including QoS support and energy management and example applications. Each discussion-oriented lecture will be preceded by the reading of 1-2 papers, resulting in a rich collection of papers by the end of the semester.

Course Objectives

- To obtain a broad understanding of the technologies and applications for the emerging and exciting domain of embedded system.
- To focus especially on Wireless Sensor Network.

Course Contents

Introduction, Overview of Embedded Systems, Embedded System Design, Typical Architecture, Characteristics of Embedded Systems, Common Standard Components, Applications of Embedded Systems, Microprocessors and Microcontrollers, Communication Interfaces, Serial Communication, Controller Area Network interface in Embedded System, Inter-Integrated Circuit (I^2C) Bus Interface, Memory, Indicators, Radio Frequency Spectrum.

Recommended readings

1. Embedded Systems Design: An Introduction to Processes, Tools and Techniques, CMP Books; 1st, 2001
2. Extensive use of latest online resource.

CS884 Localization techniques in Wireless Sensor Networks

(3 cr.hrs)

Course Description

The course will address signal processing techniques for WSN. Fundamentals, algorithms, and numerical results will be provided for the two topics. With regards to localization techniques, a measurement campaign set to test cooperative localization algorithms under a common setting is also described and experimental results are given.

Course Objectives

- To study signal processing techniques for localization.
- To study spatio-temporal process estimation techniques for environmental monitoring.

Course Contents

Introduction to short-range Localization, Motivations, Localization basics, Distance , estimation (ranging), Basic concepts on estimation theory, Performance limits in Time-of-Arrival (TOA) estimation, Ranging with UWB signals, Main sources of error in TOA estimation, Practical TOA estimators, Ranging in the IEEE 802.15.4a standard, Advanced issues, Motivations and ingredients for localization, Localization requirements Classification of localization techniques, Bayesian and non-Bayesian localization, Single hop localization algorithms (range-based, AoA, ML and hierarchical ML, LS), Multi hop localization (N-hop, DV-hop), Iterative distributed localization, Range-free localization Position tracking (Bayesian filtering), Inference through factor graphs, Beacons planning and

accuracy, Fundamental limits: position error bound, Model for range estimation errors, Algorithms with knowledge of the environment, Cooperative algorithms (iterative LS, CDAP), Experimental results, How to design experiments, Case study 1 (UWB ranging and localization), Case study 2 (VICom platform with mote sensors/or Mote2/3 or any available platform.

Recommended readings

1. Localization Algorithms and Strategies for Wireless Sensor Network: Monitoring and Surveillance Techniques for Target Tracking , Ferit Ozan Akgul, Mohammad Heidari, Nayef, and Kaveh Pahlavan, IGI Global, 2009
2. Extensive use of latest online resource.

CS885 Middleware- II

(3 cr.hrs)

Course Description

Mobile Middleware course provides a comprehensive overview of mobile middleware technology. The focus is on understanding the key design and architectural patterns, middleware layering, data presentation, specific technological solutions, and standardization.

Course Objectives

- To study middleware technologies with special focus on Wireless Sensor Network.
- To focus on mobile middleware technologies.

Course Contents

Introduction, Architectures and Platforms, Support Technologies, Principles and Patterns, Interoperability and Standards, Mobile Messaging, Publish/Subscribe, Data Synchronization, Security.

Recommended readings

1. Mobile Middleware: Supporting Applications and Services Sasu Tarkoma, Jaakko Kangasharju,Wiley, 2009, ISBN: 978-0-470-74073-6

CS886 Special Topics in Information Security (3 cr.hrs)

Course Description

This course covers both computational and information-theoretic security approaches, as well as their combined use in cryptography. The course also covers the application of information security technology to real life problems, including selected computer and network security topics. Critical information society services, such as electronic voting, secure identification and privacy protection, will be used as case studies.

Course Objectives

- Familiarity with scientific challenges in information security.
- Ability to extract information from scientific papers in the area.
- Comfortability with security proofs and ability to think abstractly about information security problems.
- Increased sensibility to privacy issues, anonymity requirements and related protection/anonymisation techniques.

Course Contents

Foundations of cryptography, Applications of computational number theory to cryptography, Information theoretic security and quantum cryptography, Privacy and anonymity concerns and solutions etc.

Recommended readings

1. Information Security Management Handbook, Fifth Edition
   Harold F. Tipton , Micki Krause , Auerbach Publications; 5 edition, 2003
2. Extensive use of latest online resource.

CS887 Special Topics in Computer Networks

(3 cr.hrs)

Course Description

This course has two objectives: one is to equip students with good knowledge on the selected advanced research topics in networking design, Security, QoS, and Internet Architectures. To help students significantly improve research skills in terms of writing and presentation. Good knowledge will be obtained by attending and participating lectures. Readings will be provided. Students will experience a full cycle of typical research activities including literature survey, problem formulation, giving assumptions, providing a solution, providing a plan of evaluation of the solution, and finally presenting of the project results. After taking this course, students should be able to conduct research with a minimum level of guidance from their advisers. If desired,

students will be able to extend the project toward their theses. Quality paper will be submitted to the conference.

This PhD-level course is focused on understanding technical details in a number of areas of networking through reading and discussion of important research papers in the field. The topics which will be covered may include but are not limited to:

Course Contents

Internet Architecture, Transport Layer Protocols IPv4 and IPv6
Current Internet architecture new study new QoS architectures such as

Integrated services and Differential services. and need for IPv6 protocols.

Network Layer Protocols, Wireless Networking
Quality of Service, Network Security, Network Performance
Network Management, Network Applications
Security Concepts and Terminology, TCP/IP and OSI Network Security
Access Control Issues (Packet Filters, Firewalls),
Communication Security (OSI Layer Security Protocols), Security Tools,
Cryptography, System Security - Intruders and Viruses, E-mail and Web Security
Advance topics in computer networks

Design, specify implement and demonstrate a novel protocol. Perhaps the most exciting part of this course will be the research project. You will design, specify, implement, and demonstrate a protocol of your choice. It may be a performance-driven routing protocol that selects network paths based on measured delays or throughput.

Recommended readings

1. Network Algorithmic by George Varghese, Morgan Kaufmann, 2009
2. Network Security Essentials, Prentice-Hall by William Stallings, 2010, ISBN: 0-13-016093-8.
3. M. Crovella and B. Krishnamurthy, Internet Measurement: Infrastructure, Traffic and Applications, 2006
4. Kumar, D. Manjunath and J. Kuri, Communication Networking, An Analytical Approach , 2004
5. Additional good references:
6. M. Donahoo and K. Calvert, TCP/IP Sockets in C (or Java): Practical Guide for Programmers, 2009
7. W. R. Stevens, UNIX Network Programming, Volume 1 (2nd edition): Networking APIs - Sockets and XTI, 2/e , 2010
8. W. R. Stevens, UNIX Network Programming, Volume 2 (2nd edition): Interprocess Communications, 2011

CS888 Special Topics in Human Language Technology

(3 cr.hrs)

Course Contents

Basic Concepts, Morphology: Introduction, Derivation, Inflection, productivity
Syntax: Introduction, Three aspects of syntactic structure, Identifying constituents and categories, Reflexives, Control
Corpus Linguistics: Introduction, Characteristics, Encoding and annotation, Multi-lingual Corpora
Text Simplification: Discourse boundaries and discourse units, Anaphora Resolution, Splitting long sentences into short sentences, Text Simplification versus Controlled Languages
Machine Translation: History, Strategies
Advanced Topics in Human Language Technology

Recommended readings

1. Analyzing Syntax: A Lexical-Functional Approach by Paul R. Kroeger, Cambridge University Press, 2004
2. An Introduction to English Morphology by Andrew Carstairs-McCarthy, Edinburgh University Press, 2002
3. Corpus Linguistics: An Introduction by Tony McEnery and Andrew Wilson, Edinburgh University Press, 2001
4. Machine translation: past, present, future By J. W. Hutchins, Ellis Ellis Horwood, 1986
5. Text-Based Machine Translation By M. A. Khan, 1995
6. Latest topics in more recent journals

CS889 Advanced Topics in Real-Time Systems

(3 cr.hrs)

Course Description

The course discusses the advanced topics and issues in Real-Time systems which will help students understand the problems and issues with Real-Time Systems.

Course Objectives

The objective of this course is to give a detailed account of all the issues in Real Time Systems. After the course students should:

- Understand the different concepts of real-time systems

- Be able to identify problems and conduct research in the area of real-time systems.

Pre-Requisites

Operating Systems with understanding of the Unix/Linux Operating System.

Course Contents

The following topics will be covered in the course:

- Review of the basics of Real Time Systems
- Concurrency in Real-Time Systems
- Scheduling on single processors and multiprocessors: Fixed and dynamic priority systems.
- Shared Resources: on single and multiprocessors
- Schedulability Analysis
- Reliability and Fault Tolerance
- Support for Real Time in different Operating Systems

Recommended readings

1. Burns, A. & Wellings, A. J. (2009). Real-Time Systems and Programming Languages: ADA 95, Real-Time Java, and Real-Time POSIX. 4th edition, Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA
2. Buttazzo, G., Lipari, G., Abeni, L. & Caccamo, M. (2005). Soft Real-Time Systems: Predictability vs. Efficiency (Series in Computer Science). Plenum Publishing Co
3. Buttazzo, G. (2011). Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications. Springer

CS890 Advanced Topics in Parallel Programming (3 cr.hrs)

Course Description

Over the past few years, every major microprocessor manufacturer has introduced processor chips with multiple cores, with dual and quad core processors for desktop and laptops, and over a hundred cores available in some Graphics Processing Units. The expectation is that the numbers of cores per chip will roughly double every two years while processor clock speeds will remain relatively flat. This makes parallel programming a concern for the entire computing industry.

Course Objectives

This course will provide detailed study on different parallel programming models. The course will center on concepts of parallelism, locality and synchronization. The course will emphasize on the techniques that are most appropriate for multicore architectures.

Prerequisites
Computer architecture, Operating Systems, C programming language or equivalent.

Course Contents

The following topics will be covered in the course:

- A review of basic parallel computing
- The multi-core revolution
- Parallel programming architectures, paradigms and issues
- Data parallelism
- task parallelism
- Synchronization techniques
- Shared data structures
- Load balancing: static load balancing, allocation, dynamic load balancing, migration

Recommended readings

1. Rauber, T. & Runger, G. (2010). Parallel Programming: for Multicore and Cluster Systems. Springer.
2. Pacheco, P. (2011). An Introduction to Parallel Programming. Morgan Kaufmann
3. Asanovic, K., Bodik, R., Catanzaro, B. C., Gebis, J. J., Husbands, P., Keutzer, K., Patterson, D. A., Plishker, W. L., Shalf, J., Williams, S. W. & Yelick, K. A. (2006). Technical Report UCB/EECS-2006-183 EECS Department, University of California, Berkeley

CS891 Distributed Real-Time Java Systems

(3 cr.hrs)

Course Description

Java is a high level language which relieves real-time programmer of working on a very low level programming platform. Since multiprocessors and distributed systems are the new architecture of choice, an active research area is how real-time Java applications can be executed across a parallel and distributed system.

Course Objectives

This course provides in-depth information on current research trends in real-time Java and how it is being extended to execute on modern architectures. After the course students should be able to

understand problems and issues of executing real-time Java applications on multiprocessors and on distributed systems.

Pre-Requisites

Operating Systems, Computer Architecture and Concurrent Programming in Java or equivalent.

Course Contents

The following topics will be covered in the course:

- An overview of Real Time Specification for Java (RTSJ)
- Supporting RTSJ on Multiprocessors
- Schedulable Objects on Multiprocessors: allocation, scheduling and migration.
- Memory management: locality, memory allocation, access times
- Component based Real-Time Java Development
- Dealing with Non-Standard Memory Architectures

Recommended readings

1. Higuera-Toledano, M. T. & Wellings, A. J. (2012). Distributed, Embedded and Real-time Java Systems. Springer
2. Wellings, A. (2004). Concurrent and Real-Time Programming in Java. John Wiley & Sons
3. Dibble, P. C. (2008). Real-Time Programming with the Java Platform. Prentice Hall PTR, Upper Saddle River, NJ, USA
4. Bollella, G. & Gosling, J. (2000). Computer 33, 47–54
5. Malik, A. H., Wellings, A. & Chang, Y. (2010). In Proceedings of the 8th International Workshop on Java Technologies for Real- Time and Embedded Systems JTRES '10 pp. 36–45, ACM, New York, NY, USA

CS892 Real-Time Scheduling Theory

(3 cr.hrs)

Course Description

Scheduling theory is an important topic in real-time systems.

Course Objectives

In this course, scheduling theories will be studied to provide formal design and verification of real-time systems. The main objectives are to introduce the basic concepts of real-time scheduling, illustrate the most significant and state-of-the-art results in the field, and provides the basic methodologies for designing predictable computing systems which can be used to support critical control applications.

Prerequisites

Operating Systems.

Course Contents

The following major topics will be covered in the course:

- Introduction to Task Models and Scheduling
- Uniprocessor Scheduling for Periodic/Sporadic Tasks
- Resource Sharing and Priority Inversion
- Resource Reservation Servers
- Worst-Case Execution Time Analysis
- Multiprocessor Scheduling
- Schedulability with Resource-Sharing for Multiprocessor

Recommended readings

1. Burns, A. & Wellings, A. J. (2009). Real-Time Systems and Programming Languages: ADA 95, Real-Time Java, and Real-Time POSIX. 4th edition, Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA.
2. Buttazzo, G., Lipari, G., Abeni, L. & Caccamo, M. (2005). Soft Real-Time Systems: Predictability vs. Efficiency (Series in Computer Science). Plenum Publishing Co.
3. Buttazzo, G. (2011). Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications. Springer.
4. Davis, R. I. & Burns, A. (2011). A Survey of Hard Real-Time Scheduling for Multiprocessor Systems. ACM Computing. 43, 35:1–35:44.