Version 1.0 20 March 2017

EH2745
Computer Applications in Power Systems

Introductory course

Course Memo

4,5 ECTS credits

Overview

Efficient planning, operation and control of electric power systems is completely dependent on well-functioning computer systems. A key function in these systems is the ability to analyse large amounts of data. Such analysis needs to be done both in off-line situations to optimize dispatch of generation, forecast production of RES, plan grid expansions and understand customer behaviour, but also in real-time to identify faults and risks of instability as well as decision support for automatic grid reconfiguration. For all these applications, the analysis of large amounts of high quality data – popularly known as Big Data – is critical for providing necessary support for decision-making or automated control actions.

Course Objectives

The aim of the course is to train the students in developing computer systems for advanced planning, operation and control of electric power systems. On completion of the course, the student will be able to:

- Develop a Java application
- Analyze the need for information exchange and suggest appropriate information models and protocols.
- Create consistent information models for power systems control.
- Develop a database to store essential information about power system.
- Describe a group of machine learning algorithms applicable in power systems
- Define and implement a suitable machine learning algorithm for identification of power system states.

Prerequisites

EH2741 Communication & Control in Electric Power Systems (recommended)

Course Structure

The course consists of three blocks: Software development in Java, power system data modelling and machine learning. The software development block runs throughout the course and forms the basis for the two other blocks.

Software Development in Java starts from the basics of Java programming and introduces the student to software development in Java including aspects such as file input/put, XML parsing, and integration with databases.

Power System Data modelling is focused on modelling of power system data according to the Common Information model making it amenable for analysis in computer applications.

Machine learning finally, provides an introduction to simple techniques and algorithms focused on analysing large amounts of data such as for example measurements from power systems.

Lectures and Exercise sessions

The course consists of a total of an introductory lecture, 17 combined lecture and exercise sessions and one final voluntary test. Since the course is applied, there is a need to mix theory and practice (programming) to facilitate learning and provide the hands-on experiences needed to learn software development. Most of the scheduled 2 hours sessions are therefore split between lecture time and exercise time in the classroom.

In addition to the combined lecture and exercise sessions, there are voluntary project hours are arranged. These are not scheduled, but during these hours the course lab is open for use and course assistants are present to assist in the work.

Course examination & Project Assignment

The course examination consists of two project assignments involving development of two small power system applications. Passing both assignments is necessary to pass the course. Passing the assignments provides the student with the grade of E. For higher grades, it is necessary to sit the final voluntary test.

In Project Assignment 1 the students will develop a small power system model, export it as a CIM-XML file and finally import it into a Relational database where it will be stored for later analysis.

Project Assignment 2 involves developing a Machine learning algorithm to analyse stored power system data in order to identify power system states.

Both of the assignments are to be developed in Java, and are to be done in groups of one or two students.

Finally, the voluntary test covers the theoretical concepts covered in the course. The test is individual.

Course Administration

All course materials can be downloaded at KTH social and project assignments must be submitted to preliminary specified storage before 21.00 the corresponding due dates. Course updates, schedule changes etc. will continually be posted on the KTH social, please check regularly.

Course Schedule

Date, Time		Description	Reading	Teacher
Monday 20 March 15.00 – 17.00 **OV10**	L1	Course Introduction • Power System Information • Data Analysis *Development Environment Setup*		LN T &W
Tuesday 21 March 13.00 – 15.00 **OV10**	L2	Java Programming I • Syntax and datatypes • Expressions and method *Java Programming Hands-on I*		LN T &W
Thursday 23 March 13.00 – 15.00 **OV10**	L3	Java Programming II • Classes and inheritance *Java Programming Hands-on II*		LN T &W
Monday 27 March 15.00 – 17.00 **OV10**	L4	Java Programming III • Execution flow, loops • Arrays *Java Programming Hands-on III*		LN T &W
Tuesday 28 March 13.00 – 15.00 **OV10**	L5	Java Programming IV • Exceptions • Input & output *Java Programming Hands-on IV*		LN T &W
Thursday 30 March 13.00 – 15.00 **OV10**	L6	Java Programming V • XML files *Java Programming Hands-on V*		LN T &W
Monday 3 April 15.00 -17.00 **OV10**	L7	Power System Data Models I • Common Information Model • CIM-RDF schema		LN
Tuesday 4 April 13.00 – 15.00 **OV10**	L8	Power System Data Models II (guest lecture) CGMES		Lars-Ola
Thursday 6 April 13.00 -15.00 **OV10**	L9	Hands on Session • Java CIM • SQL		T &W
Tuesday 18 April 08.00 -10.00 **OV10**	Ex1.1	Cim2MatPower Hands-On		T &W
Thursday 20 April 15.00 -17.00	Ex1.2	Cim2MatPower Hands-On		T &W

OV10				
Friday 21 April 15.00 -17.00 **OV10**	Ex1.3	Cim2MatPower Hands-On		T &W
Monday 24 April 15.00 – 17.00 **OV10**	L10	Power System Data Models III • E-R models • E-R exercise session		LN
Tuesday 25 April 13.00 – 15.00 **OV10**	L11	Power System Data Models IV • SQL • JDBC Java – SQL hands on		LN T &W
Thursday 27 April 13.00-15.00 **OV10**	L12	Machine Learning I • Notation and logic Concept learning		LN KP T&W
Thursday 4 May 13.00 – 15.00 **OV10**	L13	Machine Learning II • Statistical methods		LN KP T&W
Monday 8 May 15.00 – 17.00 **OV10**	L14	Machine Learning III • Decision trees		LN KP T&W
Tuesday 9 May 13.00 – 15.00 **OV10**	L15	Machine Learning IV • k-means clustering • kNN algorithm		LN KP T&W
Thursday 11 May 13.00 – 15.00 **OV10**	L16	Machine Learning V • Artificial neural networks Course Wrap-up and recap		LN KP T&W
Monday 15 May	Project 1	• Hand-in project #1		
Monday 15 May 15.00 – 17.00 **OV10**	L17	Exercise Session Neural Networks Hands on		KP T &W
Tuesday 16 May 13.00 – 15.00 **OV10**	L18	Exercise Session		KP T &W
Thursday 18 May 13.00 – 15.00	Test	Voluntary Test		LN
Monday 12 June	Project 2	Hand-in project #2		

NOTE: **Choose one of the slots for CIM2MatPower Hands-On session.**

Assessment & Grades

The grading of the course is based on the student achievements in the assignments and on the individual test.

- To pass the course, a student needs to successfully pass both project assignments. The projects are graded as *Fail, Pass* or *Pass with distinction*
- Passing each project gains the student 5 course points , for a total of 10 points for the projects. Students that pass the project with distinction, can gain up to 10 course points per project passed with distinction, for a maximum of 20 points total for both projects
- The voluntary test at the end of the course covers all parts covered in the course, including Java programming, information modelling and machine learning. The test provides an potential additional 20 course points.

Grades are awarded depending on the sum of course points achieved according to the table below:

Grade	Course points
A	30
B	25
C	20
D	15
E	10

Course Literature

The course literature mainly consists of hand-outs provided during the course. A significant part of the course material is already available on-line, other parts will be provided on the course page in Social.

Java Programming:

Please see course page MIT Open Courseware Introduction to Programming in Java, where you can find a wealth of programming reference material.

Information modelling.

"CIM for dummies", Alan McMorran, University of Strathclyde (Available on KTH Social)

"Common Grid Model Exchange Standard (CGMES)" ENTSO-E (available online)

Relational Databases

Excerpts from "Fundamentals of Relational Database Management Systems" by S. Sumathi, S. Esakkirajan (selected sections)

Machine Learning

Excerpts from "Automatic Learning techniques in Power Systems" by Louis Wehenkel (selected sections)

Course Staff

The following persons are active during the course

Lars Nordström	Course Responsible Course Examiner	larsno@kth.se
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