Version 1.3 24 May 2018

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 from Canvas 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 Canvas, please check regularly.

Course Schedule

Date, Time		Description	Reading	Teacher
Monday 19 March 15 – 17 **Q11**	L1	Course Introduction • Power System Information • Data Analysis *Development Environment Setup*		LN FG
Tuesday 20 March 13 – 15 **Q11**	L2	Java Programming I • Syntax and datatypes • Expressions and method *Java Programming Hands-on I*		LN FG
Thursday 22 March 13 – 15 **Q11**	L3	Java Programming II • Classes and inheritance *Java Programming Hands-on II*		LN FG
Monday 26 March 15 – 17 **Q11**	L4	Java Programming III • Execution flow, loops • Arrays *Java Programming Hands-on III*		LN FG
Tuesday 27 March 13 – 15 **Q11**	L5	Java Programming IV • Exceptions • Input & output *Java Programming Hands-on IV*		LN FG
Wednesday 29 March 13 – 15 **B21**	Ex1	Java Programming Exercise • Recap of Java III and Java IV		LN FG
Monday 9 April 15 -17 **Q11**	L6	Java Programming V • XML files *Java Programming Hands-on V*		LN
Tuesday 10 April 13 -15 **Q11**	L7	Power System Data Models I • Common Information Model CIM-RDF schema		LN
Thursday 12 April 13 – 15 **B21**	Ex2	Java programming Exercise • Recap of Java V		LN FG
Monday 16 April 15-17 **Q11**	L8	Power System Data Models II • Relational Databases • SQL		LN
Tuesday 17 April 13-15 **Q11**	Ex3a	Cim2MatPower Hands-On **N.B.** Pick one of these sessions		FG

Thursday 19 April 15 -17 **Q11**	Ex3b	Cim2MatPower Hands-On **N.B.** Pick one of these sessions		FG
Monday 23 April 15 – 17 **Q11**	L9	Power System Data Models III *Guest lecture by Mr Lars-Ola Österlund from ENTSO-E*		L-O Ö
Tuesday 24 April 13 – 15 **Q13**	L10	Power System Data Models IV • Java and SQL – JDBC		LN FG
Thursday 26 April 13-15 **Q11**	Ex4	Java programming exercise • Work on assignment. • Teachers available in classroom		LN FG
Friday 27 April 10 - 12 **Q11**	L11	Machine Learning I • Introduction and notation		LN KP
Thursday 3 May 10 – 12 **Q13**	L12	Machine Learning II • Decision trees		LN KP FG
Friday 4 May 15 – 17 **Q13**	L13	Machine Learning III • kNN algorithm		KP LN FG
Monday 7 May 15 – 17 **????????**	L14	Machine Learning IV • k-means clustering		KP LN FG
Tuesday 8 May 13 – 15 **Q13**	L15	Machine Learning V • Artificial Neural Networks • Concept & structure		KP LN FG
Monday 14 May	Project 1	Hand-in project #1		
Monday 14 May 15 – 17 **Q11**	L16	Machine Learning VI • Artificial Neural Networks • Back & forward propagation		KP LN FG
Tuesday 15 May 13 – 15 **Q13**	L17	Machine Learning VII • Q&A • Work with exercises		KP FG
Thursday 17 May 13.00 – 15.00 **TR 33**	Test	Voluntary Test **N.B.** Starting time 13.00 sharp. **Rooms:** Velander & Herlitz		LN

Monday 11 June	Project 2	Hand-in project #2		

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 information modelling and machine learning. The test provides a potential additional 10 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 in the course pages in Canvas.

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

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

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
Francisco José Gomez	Course Assistant Assignment 1	fragom@kth.se
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