SOFTWARE ENGINEERING, HIGH PERFORMANCE COMPUTING – 3ème année cycle ingénieur Estia

Second diplôme : Master of science « Computational and Software Techniques in Engineering » de l'Université de Cranfield

Option in Software Engineering for Technical Computing (SETC)

Course details : MODULES

MODULE COMPUTATIONAL METHODS

Module Leader
Dr Irene Moulitsas

Aim
The module aims to provide an understanding of a variety of computational methods for integration, solution of differential equations and solution of linear systems of equations.

Syllabus
The module explores numerical integration methods; the numerical solution of differential equations using finite difference approximations including formulation, accuracy and stability; matrices and types of linear systems, direct elimination methods, conditioning and stability of solutions, iterative methods for the solution of linear systems.

MODULE C++ PROGRAMMING

Module Leader
Dr Irene Moulitsas

Aim
Object oriented programming (OOP) is the standard programming methodology used in nearly all fields of major software construction today, including engineering and science and C++ is one of the most heavily employed languages. This module aims to answer the question 'what is OOP' and to provide the student with the understanding and skills necessary to write well designed and robust OO programs in C++. Students will learn how to write C++ code that solves problems in the field of computational engineering, particularly focusing on techniques for constructing and solving linear systems and differential equations. Hands-on programming sessions and assignment series of exercises form an essential part of the course.
An introduction to the Python language is also provided.

Syllabus
The OOP methodology and method, Classes, abstraction and encapsulation;
Destructors and memory management, Function and operator overloading, Inheritance and aggregation, Polymorphism and virtual functions, Stream input and output;
Templates, Exception handling, The C++ Standard Library and STL.

MODULE COMPUTER GRAPHICS

Module Leader
Dr Karl Jenkins

Aim
Computer graphics is a key element in the effective presentation and manipulation of data in engineering software. The aim of this module is to provide an in depth overview of the mathematical and software principles behind 2D and 3D visualisation, the viewing pipeline, and practical implementation in the widely used OpenGL graphics library. Representative GUI based 2D and 3D OpenGL applications using the Windows environment are used. Reference is also made to the programming model employed in OpenGL-ES, the version of OpenGL created for embedded devices and the basis for Android and iPhone apps. Hands-on exercises and an assignment supplement the learning process.

Syllabus
- Mathematical principles behind 2D and 3D visualisation, Matrix transformations, The viewing pipeline, Modelling, viewing and projection, OpenGL graphics library, GLSL and shader programming.
- Development of CG applications using OpenGL, GLSL and Qt, UI
- WebGL, OpenGL-ES.

MODULE MANAGEMENT FOR TECHNOLOGY

Aim
The importance of technology leadership in driving the technical aspects of an organisations products, innovation, programmes, operations and strategy is paramount, especially in today's turbulent commercial environment with its unprecedented pace of technological development. Demand for ever more complex products and services has become the norm. The challenge for today's manager is to deal with uncertainty, to allow technological innovation and change to flourish but also to remain within planned parameters of performance. Many organisations engaged with technological innovation struggle to find engineers with the right skills. Specifically, engineers have extensive subject/discipline knowledge but do not understand management processes in organisational context. In addition, STEM graduates often lack interpersonal skills.
Syllabus
Engineers and Technologists in organisations : The role of organisations and the challenges facing engineers and technologies.
People management : Understanding you. Understanding other people. Working in teams. Dealing with conflicts.
The Business Environment: Understanding the business environment; identifying key trends and their implications for the organisation.
Strategy and Marketing : Developing effective strategies; Focusing on the customer; building competitive advantage; The role of strategic assets.
Finance : Profit and loss accounts. Balance sheets. Cash-flow forecasting.Project appraisal.
New product development: Commercialising technology. Market drivers. Time to market. Focusing technology. Concerns.
Business game: Working in teams (companies), students will set up and run a technology company and make decisions on investment, R&D funding, operations, marketing and sales strategy.
Negotiation: Preparation for Negotiations. Negotiation process. Win-Win solutions.
Presentation skills: Understanding your audience. Focusing your message. Successful presentations. Getting your message across.

MODULE SMALL-SCALE PARALLEL PROGRAMMING

Module Leader
Dr Salvatore Filippone

Aim
The advent of multi-core processors in the commodity desktop computer market has shifted the emphasis from traditional single threaded computing models to more advanced methods in order to take advantage of the additional processing power that is now available. This has implications for both the traditional high performance computing sector and the workstation market. This course aims to explore the different parallel processing techniques now available on small scale computer systems, such as multi-core desktop computers and GPU devices.

Syllabus

Introduction to Parallel and Multi-Threaded Programming, Safety and Liveness: Synchronisation Techniques, OpenMP – concepts, structures and usage.Using CUDA to solve general purpose problems on the GPU, Software Tools (debugging and optimisation).

MODULE HIGH PERFORMANCE TECHNICAL COMPUTING

Module Leader
Dr Irene Moulitsas

Aim
The aim of this module is to teach the student the modern computational skills on a key grid platform. Many interesting scientific problems require analysis of large datasets. For such problems, harnessing distributed computing and storage resources is clearly of great value. Furthermore, the natural parallelism inherent in many data analysis procedures makes it feasible to use distributed resources efficiently.

Syllabus
- The focus of this module is on parallel algorithms and domain decomposition techniques which are suitable for simulation on High Performance Distributed Computing systems. Emphasis is on algorithms for execution on loosely coupled distributed systems, like grid-systems.
- Data-intensive computing algorithms like distributed data mining and data warehousing.
- Parallel numerical algorithms to solve model applications will be discussed and studied through implementation in the hands-on part of the course.
- Load-balancing methods and domain decomposition techniques will be introduced.

MODULE REQUIREMENTS ANALYSIS AND SYSTEM DESIGN

Module Leader
Dr Salvatore Filippone

Aim
This course aims to provide a more in-depth look at the software life-cycle phases, requirements engineering and design of applications.

Syllabus
- Software Development Life Cycles
- Requirements Analysis (user requirements, systems requirement specification, functional & non-functional requirement, software requirements specification, modelling and prototyping, structured analysis, formal specification)
- System modelling: UML diagrams, behavioural models, structural models, introduction to model checking and formal specifications
- Design & Implementation: design fundamentals, design architecture, architectural styles, design patterns, data design, objected oriented design, distributed systems design, component based design, data flow oriented design, data oriented design, real time design ;

MODULE CLOUD COMPUTING

Module Leader
Dr Salvatore Filippone

Aim
The aim of this module is to provide students with the necessary knowledge and understanding of virtualisation technologies and their application to the provision of on-demand computational resources, as well as a wider understanding of how those resources are consumed through Cloud Computing services.

Syllabus
- Virtualisation
- Related Internet technologies (tbc)
- Introduction to Cloud Computing
- Topics in Cloud Computing

- Cloud Environments and Technologies
- Introduction to data stream processing
- Applications of Cloud Computing

MODULE SOFTWARE TESTING AND QUALITY ASSURANCE

Aim

This course aims to address issues concerned with related to the quality of software, validation and verification, and softwares standards.

Syllabus

- Verification & Validation (verification and validation planning, software testing techniques & strategies, preparing test cases and test environments, unit testing and mocks/fakes/stubs, integration testing, validation testing, system testing, regression testing, customer acceptance testing, advanced debugging, automated static analysis, test documentation, Test Driven Development)
- Test Management.
- Software Quality (Introduction to Software Quality, Quality Management (Assurance, Planning and Control), Product quality and process quality, Quality Metrics and Standards, Process Improvement, Reliability).
- Evolution & Software Maintenance (version & change control, maintainability & maintenance, re-engineering, refactoring, reverse engineering).
- Software Engineering Standards (ISO, IEEE).

MODULE ADVANCED JAVA

Module Leader

Dr Irene Moulitsas

Aim

The Java language has become an essential tool for developers of web-based, network centric and mobile device based applications. This module aims to provide the student with the necessary skills to develop robust software using the Java language. The principle elements of the language, associated class libraries and good design principles are covered. Comparisons are made along the way with C++. Hands-on programming exercises using a leading development environment and culminating in the construction of a fully functional three-tier application forms an important part of the course.

Syllabus

Elements of the Java Standard Edition, Basic and advanced language constructs, Comparisons with C++, Java libraries for I/O, Collections and GUI development, Design principles and patterns ,The Netbeans and development environment, Documentation tools.

MODULE APPLICATIONS IN PRACTICAL HIGH-END COMPUTING - GROUP PROJECT

Aim

This module aims to provide the student with skills in the areas of: the software quality and project management, technical/engineering applications and cluster computing so that they can undertake a group project.

Syllabus

Project Management (risk analysis, estimation models, project planning and scope definition, communication and team working)

Software Metrics & Quality Assurance (definition, collection, quality metrics, productivity metrics, the review process, software reliability, using software quality metrics)

Automation Using Software Tools (overview of CASE, project management tools, documentation tools, quality assurance tools, analysis and design tools, integration and testing tools, maintenance tools)

Methods for coding and validating technical and engineering applications –f round-off and ill-conditioning Algorithmic stability and performance

Specification and performance of computing clusters
Validation and tuning of applications on medium-scale distributed architectures.