COMPUTER AND MACHINE VISION – 3ème année cycle ingénieur Estia

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

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.

Intended learning outcomes On successful completion of this module a student should be able to:
1. Implement and use numerical integration methods.
2. Use appropriate techniques to formulate numerical solutions to differential equations.
3. Evaluate properties of numerical methods for the solution of differential equations.
4. Choose and implement appropriate methods for solving differential equations.
5. Evaluate properties of systems of linear equations.
6. Choose and implement appropriate methods for solving systems of linear equations.
7. Evaluate the behaviour of the numerical methods and the numerical solutions.

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.
Intended learning outcomes
On successful completion of this module a student should be able to:

1. Apply the principles of the object oriented programming methodology - abstraction, encapsulation, inheritance and aggregation - when writing C++ programs.
2. Create robust C++ programs of simple to moderate complexity given a suitable specification.
3. Use the Standard Template Library and other third party class libraries to assist in the development of C++ programs.
4. Solve a range of numerical problems in computational engineering using C++.
5. Use development environments and associated software engineering tools to assist in the construction of robust C++ programs.
6. Evaluate existing C++ programs and assess their adherence to good OOP principles and practice.

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.

Intended learning outcomes On successful completion of this module a student should be able to:
1. Apply the principles of the viewing pipeline to compute device coordinates from a suitable ‘world coordinate system’ model.
2. Use the mathematical basis behind 2D/3D modelling and viewing to solve visualisation problems in OpenGL.
3. Understand, write and use basic shader programs using GLSL
4. Create simple interactive computer graphics based applications using OpenGL, GLSL (the shading language) and Qt.
5. Evaluate the major differences between the different version of OpenGL.

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 MANAGEMENT FOR TECHNOLOGY

Signal Analysis
Module Leader
Dr Zeeshan Rana
Aim
The aim of this module is to provide students with the necessary mathematical basis and skills for the study of Computer and Machine Vision.

Syllabus

- Revision of complex algebra
- Important generalised functions
- Series representation of period signals
- Fourier analysis and the Fourier transforms
- Convolution and correlation
- The Sampling theorem
- The Z transform
- Probability and statistics: discrete, continuous and special distributions, sampling and estimation, significant tests.

MODULE DIGITAL SIGNAL PROCESSING

Module Leader
Dr Yifan Zhao
Aim
Digital signal processing, a major technology in almost all modern hi-tech applications and products, is at the heart of mobile phones, communications and vibro-acoustical condition Monitoring. The aim of this course is to provide an industry oriented course covering not only the theoretical aspects of classical and advanced time-frequency DSP but also the solid implementation aspects of the subject for students wishing to pursue a career in such areas as communications, speech recognition, bio-medical engineering, acoustics, vibrations, radar and sonar systems and multimedia.

Syllabus

- Discrete-time signals and systems
- The correlation of discrete-time signals
- The discrete Fourier transform
- The power spectral density
- The short time Fourier transform
- The wavelet transform
- Classical and adaptive digital filtering

MODULE MACHINE LEARNING

Module Leader

Dr Irene Moulitsas

Aim

The aim of this module is to provide students with the necessary knowledge and understanding for the application of machine learning techniques to real world industrial problems within the domain of digital signal and image processing and beyond.

Syllabus

- Machine Learning Theory & Methodology
- Decision Tree Classifiers
- Instance Based Learning
- Bayesian Classification
- Genetic Algorithms
- Ant Colony Optimisation
- Neural Networks
- Support Vector Machines

MODULE ADVANCED GRAPHICS

Module Leader

Dr Karl Jenkins

Aim

High performance computer graphics are used in many areas of software application development, and are fundamental to games, entertainment, CAD and scientific visualisation. The aim of this module is to introduce students to the advanced techniques used in the generation of computer graphics. Building on the basic methods of the Introductory course, students will learn how to generate more realistic effects, such as the use of lighting and surface details to create realistic representations of computer generated graphical objects and display them to the screen.

Syllabus

Surfaces and Tessellation, Geometric and Raster Algorithms, Light, Illumination and Shading, Texture Mapping, Bump Mapping, Displacement Mapping, Environment Mapping, Introduction to Virtual Reality.

MODULE APPLICATIONS OF COMPUTER VISION FOR ROBOTICS (GROUP PROJECT)

Aim

The low-level and mid-level visual understanding achievable using various digital image processing techniques allow us to tackle the Artificial Intelligence problem of artificial visual sensing – computer vision (also termed 'robot vision'). By developing these techniques further we can apply image processing to a number of different visual inspection and understanding tasks within the realm of science and engineering. Here we investigate applied digital image processing in the form of computer vision – the automated interpretation and understanding of visual information. The digital signal application area focuses on the use of vibroacoustics for condition monitoring.

Syllabus

- Geometric Object Recognition (industrial)
- Principle Component Analysis Based Object Recognition (industrial and faces)
- 3D object recognition and sensing – range data and stereo vision
- Object motion detection, scene change detection and object tracking approaches

MODULE IMAGE PROCESSING AND ANALYSIS

Module Leader

Dr Yifan Zhao

Aim

The most powerful method of sensing available to humans is vision. In computing visual information is represented as a digital image. In order to process visual information in computer systems we need to know about processing digital images. Here we focus upon the task of low-level visual processing.

Syllabus

- Image Applications
- Image Representation
- Image Capture Hardware
- Image Sampling & Noise
- Image Geometry & Locality, Processing Operations Upon Images
- Camera Projection / Convolution Model
- Image Transformation
- Image Enhancement

MODULE COMPUTER VISION

Module Leader
Dr Zeeshan Rana
Aim
Digital Image Processing allows us to process visual information in computer systems. By processing visual information we can develop automated visual interpretation and understanding – artificial vision, itself a large part of wider field of the Artificial Intelligence. In order to achieve this we must be able to extract high-level visual information such as edges and regions from images and additionally allow for the efficient storage of large amounts of visual data. Here we concentrate on mid-level visual interpretation and image compression.

Syllabus
- Image Restoration
- Image Compression
- Image Feature Extraction and Processing
- Image Segmentation
- Basic Feature-based Classification Approaches
- Stereo Vision and Object Tracking

MODULE DÉVELOPPEMENT RAPIDE D'APPLICATIONS

Responsable : Sébastien BOTTECCHIA
Intervenants :

Pré Requis
- Modélisation orientée objet.
- Programmation orientée objet,
- Méthodes d'analyse et de conception.

Learning Outcomes
- Être capable de mettre en application différentes connaissances liées à la programmation.
- Être capable de développer une application métier en utilisant des outils professionnels

Contenu
À partir d'un cahier des charges métier (en lien avec l'option), il s'agit de mettre en œuvre les phases suivantes:
- Analyse s'appuyant sur des méthodologies connues
- Conception à l'aide d'une démarche basée sur UML
- Réalisation du programme (programmation-objet de la solution avec Visual Studio)

Un outil professionnel utilisé par de nombreuses SSII tel que Visual Studio dispose de fonctionnalités permettant de faciliter le développement. Seront notamment abordés :
- Conception UML de manière graphique
- Génération de code (squelette) à partir d'un diagramme UML
- Utilisation des assistants de génération d'IHM.

MODULE DÉMARCHE DE RÉSOLUTION DE PROBLÈMES

Responsable : Véronique PILNIERE
Intervenants : V.Pilnière, E.Villeneuve, J.Lartigau, S.Bottecchia, G.Terrasson, C.Merlo, J.Chatenoud

Pré Requis
Expériences professionnelles

Learning Outcomes
- Approfondir les démarches de résolution de problèmes
- Appliquer une démarche et méthodologie rigoureuses

Contenu
Ce module se décline sur des thématiques particulières en fonction du parcours de l'étudiant (option choisie).
Démarche de résolution de problème : de l'identification du problème (besoin) à sa résolution.

MODULE : PROJETS 3A

Pré Requis
- Outils et méthodes de gestion de projet.
- Connaissances techniques liées au sujet du projet (mécanique, conception, électronique, informatique…)

Learning Outcomes
- Être capable de satisfaire la demande des parties prenantes d'un projet, en particulier d'un client, en faisant preuve de responsabilité, d'engagement, d'organisation.
- Être capable de choisir les outils et méthodes adéquats en faisant preuve d'autonomie.
- Être capable de réaliser un projet technique pluridisciplinaire, en équipe, en respectant les normes/réglementations et les principes de propriété intellectuelle.