Digital Signal and Image Processing MSc

Location: City Campus, Leicester
Duration: 1 year full-time; 2–4 years part-time

This programme is organised by the Department of Mathematical Sciences and the Centre for Digital Signal and Image Processing at De Montfort University, Leicester.

Digital Signal Processing (DSP) and Digital Image Processing (DIP) are at the forefront of information technology. They are the basis for a broad range of applications including medical imaging, remote sensing, digital communications, geophysical prospecting, space exploration and robotics to name but a few. DSP and DIP are interdisciplinary subjects which utilize a wide range of mathematical and computational methods. There is currently a major shortage of specialists in the design, implementation and integration of software for DSPs and their component subsystems. This programme is designed to supply the necessary training for graduates to enter industry with programming and software engineering expertise for digital signal and image processing.

Who is the masters degree for?

The programme is an advanced modular programme for science and engineering graduates with a numerate academic background. It is concerned with training students in the art of professional software engineering for designing, building and executing individual signal and image processing modules (forming part of a developing software library) or integrating signal processing systems designed specifically for a well defined problem.

No former software engineering background is required, but the programme does assume a basic literacy in graduate mathematics and computing. Typically, graduates of this programme will find employment as programmers and software engineers, technical advisers and systems analysts in the software industry - in both the private and public sectors. Alternatively, their new skills may facilitate their development in existing professional careers.

Programme

As microprocessor CPUs become increasingly more powerful, there is less demand for designers of specialist DSP hardware units and greater need for software engineers to design modules and objects for execution on low- and high-level platforms. This programme provides a comprehensive coverage of those areas of mathematics, engineering and computing which are necessary for engineers to model, process and analyse digital signals and images.
By emphasising the practical application of the theoretical concepts and the central role of software engineering, the programme aims to equip students with knowledge and skills that will make them rapidly capable of useful employment without extensive further training. Whilst all necessary theory is covered, the emphasis throughout is on understanding and developing the ability to apply and adapt theory to real engineering problems. The modules have been designed to train students to design complex DSP and image processing systems and to provide knowledge on how these systems are constructed. Extensive use is made of MATLAB and in particular, the DSP and DIP Tool-boxes.

Programme modules

The modules delivered are summarised below.

Programming and Software Engineering
This module provides a ‘hands-on’ programming approach to software engineering. It covers structured and modular programming in C, object oriented design using C++, the definition and specification of a software system, development phases, testing techniques, reliability and maintenance.

Computational Methods
In designing algorithms to process digital signals and images, it is necessary to make provision for the numerical solution to various types of linear systems of equations. These systems arise from the analysis of digital signals and in particular, the design of digital filters. This module discusses the different classes of solution that are available and addresses the linear eigenvalue problem and singular value decomposition.

Signal Analysis
Covers the mathematical methods used for modelling digital signals and images and designing algorithms to process them. The syllabus includes a discussion of the classical and generalised Fourier transforms, the Hilbert transform and quadrature detection, convolution and correlation, the sampling theorem, statistical analysis of signals, optimisation methods, wavelets and fractal signals.

Digital Signal Processing
Introduces students to the operation, design and applications of various DSP techniques and to the design methodology’s for researching and developing DSP systems. This is based on the design of hardware and software modules and the use hierarchy. Object oriented design methods are also considered. Elements of the syllabus include the design of recursive and non-recursive digital filters, frequency domain data processing, time-frequency analysis, digital simulation, extraction of signals from noise, Bayesian estimation methods and non-linear filter design. Instruction is given on the design, programming and testing of various DSP algorithms in C/C++ to help students construct their own software library making use of the MATLAB DSP toolbox as a programming workbench and prototyping environment.

Digital Image Processing
This module extends the material covered in the DSP module and explores the algorithms available for image restoration and reconstruction, methods of image enhancement, segmentation techniques, transformation methods, noise reduction, image compression and the statistical analysis of images. In each case, real-life problems are explored covering a range of applications and instruction is given on the mathematical models that are used and the circumstances under which these models and the algorithms derived from them can be employed. As in the DSP module, students develop a library of software in C/C++ for image processing using the MATLAB toolbox as a prototyping environment to investigate different techniques for DIP.
Image Understanding
Covers the underlying physical principles and mathematical models which are common to imaging systems. It is shown how an understanding of the ‘physics’ of an imaging system can provide a suitable mathematical model for an image which leads to methods of processing and analysing an image. The module discusses techniques for simulating images derived from passive and active imaging systems, the principles and application of Fourier optics and the Abbe theory of imaging. It also includes a study of the applications of electromagnetic and acoustic imaging techniques.

Intelligent Systems
Considers the specification and construction of techniques of Artificial Intelligence (AI) for signal and image analysis. Emphasis is placed on the application of Fuzzy Logic and Artificial Neural Networks (ANNs) for adaptive control and computer vision respectively. The syllabus includes adaptive fuzzy inference systems, the application of ANNs for pattern recognition, AI in process engineering and knowledge-based systems.

Graphical User Interfaces
Introduces the methods of design required in the development of Graphical User Interfaces (GUIs) for ‘driving’ complex signal and image processing systems and libraries. Both X-windows and NT-windows systems are used and students are introduced to a range of state-of-the-art Computer Aided Software Engineering Tools for developing GUIs on both high- and low-level platforms. The syllabus covers the following areas: X-windows, Motif programming, top-down design, graphics standards, X-designer, visual C++ development systems, Java and J++ development tool-kits.

Research Project
The project can be taken either at De Montfort University or on location in industry, typically in a software company. The research project provides the opportunity to develop, to demonstrate and to appraise the knowledge and skills acquired from the programme in the solution of real practical problems subject to typical commercial constraints. All research projects are concerned with the pursuit of practical knowledge and its application to real-life problems.

How is the Programme organised
The programme is composed of three Semesters each of which is 4 months in duration. The taught part of the programme is confined to the first two semesters, starting in September and students are initially assessed by a combination of examinations, coursework and/or minor project work. A crash course in technical English is available prior to the start of the programme in August and September together with short courses in basic computing as required. Each module consists of a 30 hour lecture course with computing laboratory sessions. Programme notes and other supplementary material is issued for each module together with appropriate software. Examinations are held at the end of each semester. In addition to formal lectures, students are encouraged to attend a series of seminars run by the Department of Mathematical Sciences and the Centre for Digital Signal and Imaging Processing at De Montfort University, in which personnel from both academic and industrial organisations present research papers and provide information on software products and their applications to signal and image processing. A number of short courses are held throughout the year on emerging areas of importance in DSP which are not covered in the masters programme but are open to all students. A block diagram illustrating the basic organisation of the programme is given in Table 1 on the back of this brochure.

Financial support
A number of studentships provided by a variety of manufacturing industries and software houses are available. In addition, a limited number of scholarships are available which are awarded on a competitive basis.

Flexible part-time study
Flexible arrangements are possible for students wishing to take the programme on a part-time basis. The usual scheme is to take the programme over two years, attending four modules each year. The assigned practical work for each module and the associated deadlines can be arranged to suit students other commitments. Those proceeding to project work are allowed 12 months from the last written examination before handing in their dissertations.
The programme has been designed to be suitable for the in-service training of existing scientists and engineers as well as those seeking a change of career. Such applicants are invited to discuss their particular circumstances with the programme director Professor J M Blackledge
tel: +44 (0) 116 257 7473,
e-mail: jmb@dmu.ac.uk.

Case Study: Ursula Augsdorfer

Ursula Augsdorfer studied Mathematics at the Berlin Technical University from 1990 to 1996 specialising in the area of mathematics for information technology. She studied for her masters degree in Digital Signal and Image Processing in order to further her education in the area of information and communications technology. Her research project was on the simulation of medical ultrasound images. 'The MSc provided me with a broad range of the theoretical and practical aspects of signal and image processing with particular emphasis on the necessary programming skills and software engineering techniques. The programme has significantly helped me to develop my career prospects for an academic and/or industrial research career.' Ursula is currently studying for a PhD working in the Institute of Simulation Sciences at De Montfort University. She is researching a technique for simulating the non-linear dynamical behaviour of an imploding shock wave which is believed to be associated with the phenomenon of sonoluminescence. The simulation involves developing numerical solutions to the Reyleigh-Plesset equations and a fully 3D visualisation system for analysing the behaviour of this non-linear effect in real time.

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Table 1: Nominal class hours

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<thead>
<tr>
<th>Semester</th>
<th>Course</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1st Semester</td>
<td>Programming and Software Engineering</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Computational Methods</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Signal Analysis</td>
<td>30</td>
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<td></td>
<td>Digital Signal Processing</td>
<td>30</td>
</tr>
<tr>
<td>Total lecture hours:</td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>2nd Semester</td>
<td>Digital Image Processing</td>
<td>30</td>
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<td></td>
<td>Image Understanding</td>
<td>30</td>
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<td></td>
<td>Graphical User Interfaces</td>
<td>30</td>
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<td>30</td>
</tr>
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<td></td>
<td>120</td>
</tr>
</tbody>
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| 3rd Semester   | Research project working with a research group at De Montfort University Leicester or in industry. The research groups available include the Centre for Digital Signal and Image Processing based in the Institute of Simulation Sciences and the Centre for Modern Optics based in the Science and Engineering Research Centre. Descriptions of available projects with expected deliverables are issued to students early in the second semester.

Further information

Application forms and further details are available from the Postgraduate Admissions Tutor:
Tel: Leicester +44 116 257 7699
Fax: Leicester +44 116 254 1891
Email: cms@dmu.ac.uk
www: http://www.cms.dmu.ac.uk/
Courses/course-list.html