24 Graduate Design Computing Teaching at the University of Sydney

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1.0 OBJECTIVES OF THE GRADUATE PROGRAMS IN DESIGN COMPUTING

Design Computing involves the effective application of computing technologies, digital media, formal methods and design theory to the study and practice of design. Computers are assuming a prominent role in design practice. This change has been partly brought about by economic pressures to improve the efficiency of design practice, but there has also been a desire to aid the design process in order to produce better designs. The introduction of new computer-based techniques and methods generally involves a re-structuring of practice and ways of designing. We are also seeing significant current developments that have far reaching implications for the future.

These innovations are occurring at a rapid rate and are imposing increasing pressures on design professionals. A re-orientation of skills is required in order to acquire and manage computer resources. Design

If designers are to lead rather than follow developments then they need to acquire specialist knowledge - a general Computing also demands technical competence, an awareness of advances in the field and an innovative spirit to harness the technology.understanding of computers and their impact, expertise in the selection and management of computer-aided design systems, and skill in the design and implementation of computer programs and systems.

The graduate design computing teaching at the Key Centre of Design Computing is targeted at architects, engineers and other design professionals as well as computer-aided design consultants, systems managers, researchers and educators.

1.1 The objectives of the graduate programs are:

- Provide education and training for design professionals who wish to gain specialist knowledge and skills in design computing in order to support their design activities.
- Provide education and training for design or computer professionals who intend to work as specialists supporting or managing design computing.
- Provide education and training for design or computer professionals who wish to be engaged in research and development in the area of design computing.

- Provide education and training for teachers of design who wish to specialise in the area of design computing.

2.0 THE CORE COURSES

There are 8 core courses in the graduate programs that provide the scope of the program. We defined these 8 courses as the basis for a broad and deep knowledge in design computing that go beyond the traditional view of design computing as CAD.

2.1 Currently, the 8 courses are:

- Theory and Practice of design Computing
- CAD in Design
- Multimedia in Design
- Database Management Systems in Design
- Artificial Intellgience in Design
- Computer Graphics Programming
- 3D Modelling and Photorealism
- Design Decision Support Systems

3.0 THEORY AND PRACTICE OF DESIGN COMPUTING

The objective of this course is to present two aspects of design computing: the current practice and technology of design computing, and the relevant theory of design computing. The first aspect is considered through an overview of the design computing applications, including computational methods, decision support, graphics and modelling applications, multimedia, artificial intelligence, CAD in practice, and networking and collaboration. The second aspect is considered through an introduction to design theory, methods and issues.

3.1 Specifically, the objectives are:

- To provide an overview of the scope of design computing applications and their use in practice.
- To describe the use of the computing applications and network available in the design computing laboratory.
- To present design computing as a network which provides an environment for collaboration.

- To present various theories of design and design computing.

3.2 Course content

Practice of design computing:

- Designers and computers
- Computers, networks, and software
- Computers in design practice
- Knowledge-based design systems
- Multimedia in design
- World Wide Web resources and electronic communication

Theory of design computing:

- Computational theories of design
- Large systems integration
- Research in design science
- Creativity and design

3.3 At the end of the course the student will:

- Have an understanding of the broad range of design computing in practice.
- Basic knowledge of Macintosh and UNIX computers, applications, and file management.
- Be able to find and place information on the World Wide Web, and establish a collaborative project using email.
- Have a general understanding of the range of design theories useful to design computing.
- Have a deep understanding of one aspect of design computing and its implications for design practice.

4.0 CAD IN DESIGN

The objective of this course is to provide a professional view of the use of CAD in design. CAD has become an increasingly important part of the skills a designer is expected to master. CAD systems present a way of visualising and communicating design that does not have an equivalent manual method. The role and uses of CAD in design practice have become a central issue in the way in which a designer

communicates and interacts with the changing community. This course develops skills in the use of a professional CAD system and presents the varied uses of CAD in professional practice.

4.1 Specifically, the objectives of this course are:

- To develop skills in the use of AutoCAD (or equivalent industry standard CAD system) for producing 2D drawings, 3D models, the use of layers, colours, libraries, and non-graphic data representation.
- To present the various issues in the use of CAD in the building and construction industry.

The specific course content will vary depending on the CAD system the student and lecturer choose to use.

4.2 The general knowledge portion of the course includes:

- Introduction to the representation of graphics in CAD systems.
- Introduction to the representation of non-graphic data in CAD systems.
- Presentations by visiting lecturers from professional practice on the use of CAD.

4.3 The content associated with the specific CAD system includes:

- Demonstration and tutorial exercises for the use of commands, blocks, and 3D models to generate production drawings.
- Instruction on the development of layers, colours, shadows, and animation of 3D models.
- Develop the documentation for a specific building using CAD.

4.4 At the end of the course the student will have:

- Skills in using a broad range of CAD system commands for generating complex drawings.
- Skills for the layout and printing of production drawings.
- Skills in the development of 3D CAD models.
- Basic understanding of how CAD systems represent graphic and non-graphic data.
- A portfolio of designs documented using a CAD system.

5.0 DATABASE MANAGEMENT SYSTEMS FOR DESIGN

Database management systems provide the designer with a software system that can manage the storage, retrieval, and integrity of the non-graphic data associated with a project. In order to make use of database management systems, the professional needs to understand how these software packages represent and store data. The objective of this course is to introduce the basics of database management and then to introduce their practical use in design.

5.1 Specific objectives of the course include:

- To introduce the concept of database management through the development of a hypertext database.
- To introduce basic programming techniques through the development of scripts in a hypertext environment.
- To introduce the theoretical basis for database management systems.
- To provide methods and guidelines on the design of a database schema for design application.
- To develop skills in implementing and maintaining a database using a standard query language.

5.2 Course content

This course provides an introduction to the management of design data and writing simple programs to manipulate design data. The content of the course includes both a theoretical and practical perspective of database management in design. The theoretical perspective includes the object-oriented view of managing data, data models, database design, and scripting and query languages. The practical perspective considers the applications of database management in the construction industry, facilities management, and multimedia data management.

5.3 The topics presented include:

- Hypercard databases and scripting languages.
- Relational, extended relational, and object-oriented data models.
- Database design and normalisation techniques.
- Query languages and SQL.
- Multimedia data management.

5.4 The students will be able to:

- Implement a database in Hypercard.
- Write simple scripts to search and navigate through the data.

- Design and develop a database using a relational database management system (RDBMS).
- Write SQL statements to manipulate the data in the RDBMS.
- Extend the RDBMS to include multimedia data.
- Select an appropriate software tool for implementing a professional design database.

6.0 MULTIMEDIA IN DESIGN

This course focuses on the use of computer graphics and multimedia in design. Multimedia computer systems involve the dissemination and manipulation of information by integrating a range of media—text, moving and still images, video, computer models, and sound—in ways that are highly interactive and responsive. Multimedia is a recognition of the increasingly amorphous nature of computers and information technology. A computer can assume a range of roles within a vast media matrix. Design is a vital component within this matrix. Multimedia systems have to be designed well. Multimedia systems also have an important role to play in the information intensive task of design.

6.1 Specifically, the objectives of this course are:

- To present students with the range of current technologies pertaining to the design of interactive, networked multimedia computer systems.
- To present these systems in the context of design.

6.2 Course Content

This course introduces the broad range of graphics technology that makes up multimedia systems and their integration. The terminology of *multimedia* is a recognition of the increasing role of the computer as medium. Like the components of the mass media of radio, television and newspapers, computers now constitute links within global communications networks.

The course takes students through a series of staged exercises to build up to a state-of-the-art multimedia presentation involving graphics, sound and video. The material covered is as follows:

- 3D modelling.
- Paint systems.
- Image processing.
- Video processing.
- Computer animation.

- Integrated multimedia systems.
- The role of multimedia in design.
- Multimedia authoring and programming.

6.3 Students will be equipped with the following:

- Broad understanding of the capabilities of computer systems in the area of graphics and multimedia.
- Skills in using simple computer graphics and multimedia systems.
- Skills in comparing and evaluating different graphics systems and their suitability for different practical situations.
- Critical appreciation of the role of the computer as a mass media technology.
- Material for a folio of work and sample systems demonstrating design and technical competence in the various areas of computer graphics and multimedia covered in the course.

7.0 ARTIFICIAL INTELLIGENCE IN DESIGN

The application of artificial intelligence techniques in design is becoming a common approach to computer aids for designers that complements the mathematical and graphical support systems. The aim of this course is to explore issues in and develop an understanding of artificial intelligence concepts in the development of knowledge-based design systems. The course focuses on the symbolic representation of design knowledge in a form that is understandable to designers and able to be reasoned about in a computer. This is developed in parallel with the notions of expert systems.

7.1 Specifically, the objectives are:

- To provide an overview of artificial intelligence in design.
- To provide the basis for symbolic reasoning in design.
- To provide the theory and implementations of expert systems in design.
- To introduce reasoning paradigms in design.

7.2 Course content

The course covers different ways to represent and reason about knowledge inside computers with an emphasis on their applicability and use in design. In particular, rule-based systems and frame-based systems are explored.

The course content includes the following topics:

- Artificial intelligence and design.
- Symbolic modelling in design.
- Knowledge representation in design.
- Logic programming.
- Expert systems in design.
- Reasoning with knowledge in design.

Students, upon completion of the course, will have an understanding of the representations and processes involved in the use of artificial intelligence concepts in the design domain, be able to program in a symbolic programming language and be able to use expert system shells.

7.3 Specifically, at the end of the course the student will:

- Have a broad understanding of the range of artificial intelligence in design.
- Be able to formulate problems for solution as logic programs.
- Be able to construct the knowledge base of an expert system
- Have basic skills in Prolog and a rule-based programming language.
- Be able to identify potential applications of AI for a professional design firm.

8.0 COMPUTER GRAPHICS PROGRAMMING

The objective of this course is to present the principles of structured programming, the design of software in the context of graphics applications, and the development of web resources such as cgi applications and applets.

8.1 Specifically, the objectives are:

- To introduce the principles of software design.
- To expose students to a structured programming environment.
- To explore the capabilities of interface design using the X11 widget library interface.
- To introduce the principles of interface design using the Motif widget library.

8.2 Specific instruction in the following topics will be given:

- Data structures including arrays, records and pointers.
- Databases and files.
- Use of a graphics libraries, menus, dialogue boxes, etc.
- The use of compilers.
- Interface design.

Experience in ANSI C and use of X11 graphics is provided. Instruction in graphic interface design using a Widget library and object-oriented programming techniques will also be included.

8.3 At the end of the course the student will be able to:

- Develop and implement graphics applications using a structured programming language.
- Access and use a graphics library and widget tool set.
- Design and implement a customised graphics interface.
- Use compilers to build application software.
- Advise on the implications and development of programming customised applications in a professional design firm.

9.0 3D MODELLING AND PHOTOREALISM

The objective of this course is to explore advanced systems of computer graphics in the context of design. A broad range of graphics technologies are considered, with emphasis on 3D modelling and photorealism. In particular the aim is to demonstrate the practical application of these techniques, using commercial modelling and rendering packages.

9.1 Specifically, the objectives are:

- To introduce advanced systems of photo-realistic computer rendering in the context of design.
- To instruct students in the use of a ray tracing package using high-end computer technology.
- To demonstrate the potential and limitations of current rendering technologies.
- To expose students to advanced graphics and modelling techniques such as affine transformations, constructive solid geometry, image processing and data exchange protocols.
- To consider future development opportunities for graphics and modelling in design.

9.2 Course content

- Introduction to graphics technologies and photorealism.
- The specification of 3D geometric entities within a sophisticated modelling package.
- Assigning colour and texture information to the geometric entities.
- Generating complex photorealistic images.
- Image processing and future developments of the technology.

9.3 At the end of the course the student will:

- Be able to specify and generate advanced photorealistic images using ray tracing.
- Describe complex 3D geometries using constructive solid geometry.
- Describe affine transformations in a CAD system.
- Interpret various CAD data structures.
- Interpret and translate CAD models between different CAD packages using dxf and other standards.

- Specify digital colour definitions and be equipped to recognise problems of colour calibration and colour perception.
- Import graphic images and undertake texture mapping of complex objects.
- Process digital images using graphics tools.
- Generate stereo and animated sequences of photorealistic images.
- Be able to identify and select features of 3D modelling systems that match the needs of a professional designer.

10.0 DESIGN DECISION SUPPORT SYSTEMS

The aim of this course is to explore issues in and develop an understanding of the computational processes which support design decision making. The course focuses on the use of computers as design decision support systems which can be used to aid designers. It introduces the idea of information represented by symbols with processes which operate on that information in order to support decisions. The course draws its material from mathematically-based models of simulation and optimization.

10.1 The specific objectives of this course are:

- To provide an understanding of mathematically modelled design decision support systems.
- To provide the theory of and to operationalise simulation as a design decision support system.
- To provide the theory of and to operationalise optimization as a design decision support system.

10.2 Course content

The course content focuses on mathematical models of design decision making. The broad topics of mathematical modelling, simulation, search, optimization, and dynamic programming as applied to design decision making are presented.

10.3 Specific topics include:

- Identifying and modelling the relationship between performance and structure variables for computer simulation.
- Formulating an objective function and constraints for design optimization.
- Search methods for solving mathematically-based design problems.
- Design decision variables for formulating linear and dynamic programming approaches to decision making.

- Identifying and modelling Pareto optimal decision making.

10.4 At the end of the course the student will:

- Have a broad understanding of mathematically-based design decision support systems.
- Be able to formulate problems for solution with a range of software packages, including Stella and ALPAL.
- Be able to interpret and use the results from such systems.
- Be able to implement a design decision support concept as a computer program.

SUMMARY

The content of the courses offered in the Key Centre of Design Computing are revised almost annually to accommodate developments in computer applications. The overall structure of the courses varies every three to four years. The development of content is based on both changes in the computer industry and in research developments in design computing. Another important factor in developing the graduate program is the undegraduate teaching done by the Key Centre. The Architecture Faculty has approximately 300 undergraduate students. The computing component of the undergraduate degrees is developed and taught within the Key Centre, drawing from the material offered at the graduate level to present a range of design computing applications. The combination of graduate and undergraduate teaching, and research provides a rich source of ideas for curriculum development.