The challenge of utilising new technology in design education

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Abstract

This paper examines some of the many problems and issues associated with integrating new and developing technologies in the design of products. As technology in general races ahead challenges arise for both commercial designers and educators on how best to keep track and utilise the advances. The challenge is particularly acute within tertiary education where the introduction of new cutting edge technology is often encouraged. Although this is generally achieved through the feedback of research activity, integrating new concepts at an appropriate level is a major task. Of particular concern is how focussed areas of applied technology can be made part of the multidisciplinary scope of design education.

This paper provides examples of the successful interaction of research and education within a UK higher education institution. It highlights that, through selective tuition of research topics and appropriate technical support, innovative design solutions can result. In addition, it shows that by introducing leading edge and, in some cases, underdeveloped technology, specific key skills of independent learning, communication and research methods can be encouraged. Furthermore, the paper examines both the successes and failures of the process and provides conclusions relating to curriculum development, effective learning, and assessment.

Keywords: Artificial intelligence, technology integration, technology transfer, research, tertiary education

Introduction

With the increasing emphasis on the design of functional products within education it is essential that design students gain a strong foundation in basic elements of technology. Specific areas of mechanics, materials science and electrics/electronics provide some of the information necessary to design and construct a wide variety of working prototypes. These well established disciplines are common to most successful design courses and the knowledge gained allows students to be more flexible in their approach to other areas of technology.

A technology that is advancing rapidly and becoming more commonplace within product design is that of artificial intelligence (AI). Many electronic consumer products are labelled ‘intelligent’ or ‘smart’ and the commercial implication of using such technology is readily appreciated. However, the success of this technology depends on the way in which it is designed into products for use in real-world human situations. The way people react to products is often a reflection on the ease with which they can interact with them, and applying AI can be seen as a step towards the development of user-friendly products. Presently AI can be used to make very limited human-like decisions and provide a form of interactive dialogue but, as a consequence, significant questions arise concerning the user acceptability and perception of such interactive technology. At present, important factors on how best to incorporate AI into products lack definition. Nevertheless its commercial use makes it an attractive proposition for students to tackle within design. Potentially it provides the opportunity to explore and experiment with state of the art technology and to develop innovative design solutions.

Providing suitable information and guidance for such rapidly developing and commercially competitive domains can, however, prove to be a major hurdle to educators. The technology transfer from industry to education and indeed from education into industry often lacks the dynamics required to support such an initiative. However, in the field of design and technology higher education, institutions are often at an advantage by being in a suitable position to exploit industrial collaborations as design solutions are often encouraged to incorporate more 'near market' attributes.

Some research groups in the area of AI believe that exposing students to cutting edge technology, its foundations, uses and development, can stimulate and yield innovative, technologically advanced design solutions to real problems (McCardle, 1998). In addition, it has been acknowledged by some research institutions that education plays a major role in defining and advancing certain technologies adopted within industry as students of today are potentially the end users and developers of tomorrow's technology. It is envisaged that accelerated developments can be achieved by introducing research-derived concepts at an early stage in a student's education (*ibid*).

AI and Design at Brunel University

The subject matter (AI and computational intelligence) is considered cutting edge technology, to which historically Brunel has made major contributions. [see Aleksander 1979, 1984 and Stonham, 2000]. It was noted, however, that the knowledge gained from this research was often retained within the UK research groups and not disseminated through to undergraduate students. As products began to appear on markets utilising smart computing, it became clear that the design degree courses could be supplemented and benefit from a module investigating how they were developed. Students could be made more aware of the possibilities of Smart computing, with additional support from the postgraduate researchers.

A common historical problem with most, if not all AI methodologies, has been the excessive claims made about their capabilities, which often led to beliefs that the technology was a panacea to all computing problems. Over the last ten years, as the number of AI applications increased, the limitation of the technology has become more evident. This has further resulted in increased scepticism from many industrial sectors about their use. The reality is that AI methodologies are enabling technologies which, in a design environment, can help to provide design improvements as well as complete solutions and stimulate innovation.

A specific research group within the department stimulated the focus on artificial neural network (ANN) applications. At that time the Neural Applications Group aimed its research at hardware and software solutions to automated weld control, pattern recognition and machine health monitoring. ANNs are essentially a low-level AI technique in that they can be used to learn and generalise on raw data. The technique is therefore more adaptable for use in a wide variety of applications. An increasing awareness of these techniques within academia as well as industry resulted in a plethora of software demonstration packages emerging. With the increasing availability and quality of practical development tools, it became clear that it was possible to develop a course based upon application and the technology's role in design, rather than to emphasise pure theoretical understanding, the depth of which was considered too detailed for a multidisciplinary design degree.

The "Smart Computing Applications in Design" final year module at Brunel University's Design Department is derived from a module focused solely on Neural Computing in the early 1990s. The original course objective was to reflect the general developmental and theoretical solution methodologies practised within the field of AI at that time. However, computing and IT is advancing at an unprecedented rate (for example, Moore's law states that computing processor power doubles every 18 months – although this itself is thought to be conservative). It was therefore a necessary requirement that the overall course structure and contents be periodically assessed with consultation from leading researchers within the department. As a consequence the existing course has expanded to encompass more commonly encountered AI techniques such as fuzzy logic, genetic algorithms, knowledge based systems and cased-based reasoning.

Course Structure

The present course is offered as two final year optional modules over two semesters of 13 weeks duration. Contact time is restricted to 3 hours per week including lectures and tutorials. The first module aims to provide students with an overall foundation in the subject areas that lead into the second module, which is focussed on practical based applications.

In the first semester, the foundation module introduces students to the important enabling technologies of Smart Computing techniques, and to understand how to incorporate such techniques into systems and product design. The module places the techniques in context within the fields of computing, data analysis, and design, covering the acknowledged best practice guidelines, ultimately encouraging the students to develop analytical approaches to data analysis. By the end of this module the student has a basic understanding of the history and impact of AI and Smart techniques in design and appreciates their strengths and weaknesses. An important element within the module is to enable the student to become familiar with data visualisation and manipulation with spreadsheet software, and to engage with AI developmental software tools.

In the second semester, the applications module aims to develop the student's knowledge of implementing Smart software solutions and take into account hardware practicalities by undertaking a real world project. The project enables the student to identify the suitable technology for specific application problems and be familiar with the design and application guidelines. In addition, having undertaken a design implementation of Smart computing to a specific application problem, the student is aware of the technical limitations and lead times for developing solutions.

The resources required are minimal, consisting of NT workstations with WWW access, suitable AI software development tools such as 'Neuralworks Pro II', Neusciences' 'Neuframe' and data analysis software such as MS Office (Excel) and SPSS (statistical package for social sciences). In addition postgraduate researchers provide appropriate support for tutorials and consultancy during the main project of semester two.

What was always important with respect to preparing such a course, was determining appropriate goals for the assessments, ensuring that the course supplements the student's design degree, and that the students can put their knowledge into practice in the real and commercial world.

Pre-requisites

The Industrial Design courses at Brunel University contain a relatively high level of engineering disciplines including computing (programming), computer interfacing and mechatronics. Although this generally attracts students of above average numerical skills, apart from modules such as mathematics studied as part of the degree, no further pre-requisites are required. Apart from general computer literacy, no previous experiences of software or AI subject areas are expected.

Assessment

The assessment procedure is a complicated mechanism, and relies upon feedback from students, industry, the department, and arbitrary measures against personal goals. This is especially pertinent with a course containing cutting edge and often underdeveloped subject matter. It is also easy to be over expectant of the student attainment levels, and the non-contact study time they attribute to their study of a module.

Throughout the whole course, students are encouraged to learn through their experimentation and mistakes, and to realise their analytical abilities to problem solving. The ability to identify a suitable methodology to solve a given problem and the technology's role in product design development and innovation is considered an important part of the learning process. Given these criteria, credit is gained for the process of deriving a solution together with the evaluation of results, and not based purely the success of the final outcome.

In terms of assessment, both modules have a 30% weighted examination with the remainder consisting of coursework assignments in semester one and the main project with viva voce in semester two. Due to the relative low numbers within the option groups, averaging twelve students, all projects and assignments are individual, and are based on problems provided by the lecturer – the reasons are discussed below.

Projects

The students are always encouraged to apply their learning experiences within other modules, including their own final year major design project. But for the main project in the AI module, they are also encouraged to identify a separate real-world application. However, experience in the early years of the course has shown that difficulties in obtaining the necessary information and data for this assignment often resulted in the student having very little time dedicated to completing the project. More recently, pre-determined ideas have been supplied from which a student must choose (each of which has its own intricate and individual problems to overcome) and personal projects can only be undertaken if the supervisor is satisfied that the proposal is feasible given the imposed constraints of time and resources. Although considered a key skill, time management and in particular estimating lead times for information surveys proved to be the major problems for students. Failures of modules were nearly always associated with late submissions due to data collection times. Failure due to a misplaced AI technique was very rare.

Design Realisation

The most recent development is the ability to realise AI solutions in hardware. PC based development tools are used to generate independent ‘C’ source code which can be compiled and run as stand alone executable files. Alternatively, the source code can be translated to PIC assembly language and embedded within micro-controllers. Examples include a smart vacuum, which saves energy by controlling the motor speed depending upon the amount of dirt detected in the carpet and a smart toy that identifies ‘hiding places’ in a room (see Figures 1 and 2). Through the use of infra-red sensors and pattern recognition the embedded algorithm controls and directs the mobile robot autonomously, away from any pre-programmed ‘danger areas’. In this particular case the hardware sensor processing was developed separately to the main project for the module.

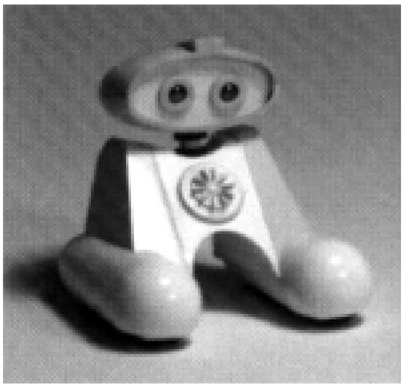

Figure 1 The ‘timid’ autonomous robot

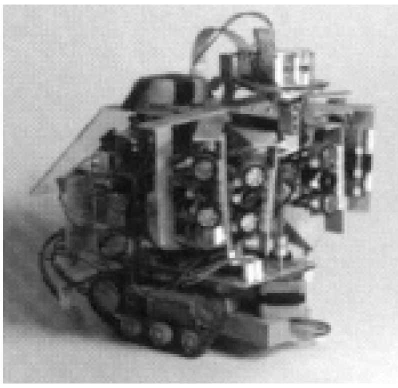

Figure 2 The prototype. PIC based neural network guidance system and pattern recognition. “You try to shoot it. It tries to hide”

Cardionetics, from undergraduate design idea to company

Graduates of the course have gone on to postgraduate studies in smart computing within the department, and also within the research department of companies applying the technologies. In particular, Cardionetics Ltd (Cardionetics, 2000), a neural medical products developer, was founded upon a final year design project which implemented techniques taught within the AI modules. The original concept was to use ANNs to analyse heart ECG signals and detect specific abnormalities. The product was developed from monitoring infant conditions utilising PC based software, to a portable product with the AI algorithms embedded in a 32 bit ASIC hardware platform which can monitor a patient for 24hrs and identify problematic heart conditions. Its success has been acknowledged by being selected as a UK Millennium Product (Figure 3 and 4).

Figure 3 The heart monitor during development

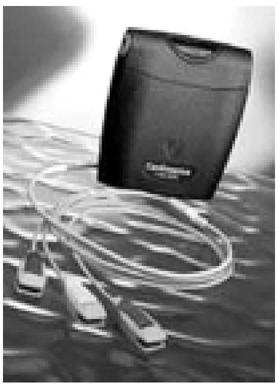

Figure 4 The CNET 2000 Millennium product (Courtesy of Dr T J Harris, CardioneticsLtd, UK)

Conclusions

The rapid advancement of technology means the dissemination of research to undergraduate students should be a natural and valuable part of the design education process. In addition, involving the student in active research activities can further enhance key skills and increase self-efficacy.

Artificial intelligence is a subject area that offers the possibility for undergraduate design students to become active in research and apply cutting edge technology. Applied AI can provide innovative and exciting opportunities for the design of smart and interactive products.

Instigating an AI course suitable for design students need not be resource intensive. The commercial availability of educational and demonstration software for specific areas of 'low level' AI techniques has enabled a worthwhile and rewarding course for students.

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Acknowledgements

- Centre for Neural Computing Applications (CNCA), Brunel University

- Cardionetics Ltd