The challenge of integrating AI & smart technology in design education

THE CHALLENGE OF INTEGRATING 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 into the education of future designers. 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.

The paper describes the model used to introduce areas of Artificial Intelligence (AI) to undergraduate industrial design students. The successful interaction of research and education within a UK higher education establishment are discussed and project examples given. It is shown 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.

Introduction

If there is to be an 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 electrical/electronic engineering provide some of the information necessary to design and construct a wide variety of working prototypes. The knowledge gained in these subjects allows students to be more flexible in their approach to other areas of technology.

Industrial design education in the UK has been evolving steadily during the last two decades, with developments paralleled in other countries. One of the issues that is being more systematically addressed is the relationship between technology and designing. A report by Paul Ewing (1987) looked at this issue in relation to the undergraduate and postgraduate education of industrial designers.

> *These skills that are so urgently needed, are being taught, in the author's view, separately by two educational bodies. The Art Schools teach industrial design, and the science-based academies, in some cases, teach engineering design. However there has been little attempt to bring these two educational systems together. There is, though, a light at the end of the tunnel, because a number of universities, polytechnics and colleges of further education are beginning to realise the benefits of teaching design as a total activity encompassing industrial and engineering design.* (Ewing, 1987, p.2)

Ewing's report looked at the practice of twelve UK courses, four courses in the USA, one in Europe and one in Japan that were at the time (1984) teaching some combination of industrial and engineering design. This was followed by a more extensive survey of changing practices on industrial and product design courses by Jeremy Myerson in 1991. This survey classified the technologies taught on UK industrial design courses under ten headings: materials; processes; human factors; computing; workshop practice; manufacturing; information management; engineering science; mechanical engineering; and electrical/electronic engineering. A technological core was suggested (the first six of these categories), and recommendations were made concerning its delivery, assessment, links with industry, staff development, information and course titles. These were a valuable contribution, but the emerging nature of technological knowledge was only alluded to e.g.

> *Many course leaders at both degree and HND level admitted they had problems in defining a technological core of content. The following views were repeatedly expressed:*
>
> - *technology is fluid and ever-changing so there is no constant empirical body of technical knowledge that can be defined and communicated;*
> - *technology will continue to change long after students have graduated so the key strategy in the technological underpinning of course should be to imbue students with a spirit of technical enquiry and give them skills to go researching fresh technical information throughout their careers:*
> - *...* (Myerson, 1991, p.28)

This paper seeks to contribute to this debate through the analysis of emerging AI technology as taught to undergraduate industrial designers at Brunel University in the UK.

Many electronic consumer products are labelled 'intelligent' or 'smart' and the commercial implications of using such technology are 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 an attractive proposition for students to tackle within industrial 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. Due to the conflicting agendas of Intellectual Property Rights (IPR) and research dissemination, 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 area of industrial design 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.*).

Defining the Subject Area

The study of artificial intelligence requires attention to an eclectic body of knowledge. In a recent benchmarking document for the UK Quality Assurance Agency (QAA), Aaron Sloman considered AI to be a two-strand discipline of science and engineering, with science attempting to understand the mechanisms of intelligence and engineering attempting to apply the findings in the design of useful machines, (Sloman, 2000).

Defining ‘intelligence’ is a philosophically problematic area and one that has, to date, not received an acceptable consensus. Similarly, defining ‘artificial intelligence’ is equally troublesome but not only through philosophical interpretation but also by what products, methods and techniques qualify for the title.

In an earlier work, Sloman defines AI as,

> *The general study of self modifying information-driven control systems,*
> - *both natural (biological) and artificial,*
> - *both actual (evolved of manufactured) and possible (including what might have evolved but did not, or might be made at some future date)* (Sloman, 1995)

Thus catering for both the science and engineering aspects of the discipline.

A less philosophical text book definition, and one perhaps more biased to an engineering approach, is given by Elaine Rich & Kevin Knight,

> *Artificial Intelligence is the study of how to make computers do things which, at the moment, people do better.* (Rich & Knight, 1991, p.3)

There are many AI protagonists who will disagree with his statement simply because of its reference to computers. The literal use of the term 'computer' implies that the advance of AI is as much a function of Moore's Law (stating that computing processor power doubles every 18 months – although this itself is thought to be conservative) as it is a true understanding of the underpinnings of intelligence.

When searching for a definition of AI, the then chief scientist at Apple, Lawrence Tesler introduced Douglas Hofstadter to the dynamic nature of the field. His response to the question of defining AI has been named 'Tesler's Theorem' by Hofstadter and simply states,

> *AI is whatever hasn’t been done yet* (Hofstadter 2000, pp. 601)

There are various ways of interpreting this somewhat surprisingly succinct statement including claiming that the field of AI widens, as more appropriate tasks become apparent. But additionally, if we take this statement literally, it could also be interpreted that as specific tasks are accomplished then they cease to be considered a legitimate area of AI. Although this provides a very ephemeral definition, historically this can be seen to happen. Computers were once thought of as great electronic brains, and even the humble pocket calculator, perhaps the most ubiquitous of all computers, was once thought of as state of the art in electronic intelligence. Today we view such products with irreverence and they are universally accepted as common useful tools. They are certainly not seen as representing any form of intelligence.

Considering the transient and fragmented nature of the subject it is generally considered that,

> *AI is better defined by indicating its range.* (Oxford, 1997, p. 21)

To do so, however, yields a very subjective definition and one that necessitates the development of a taxonomy.

Towards Developing an AI Taxonomy for Designers

For designers working primarily in the area of applications, what is perhaps more important than an airtight definition of AI is the knowledge of the success or failures of particular existing techniques and the feasibility of their use within certain products.

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. However, 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.

Table 1 illustrates some of the major areas of AI, which are presently being researched. Within these areas, substantial and useful advances have been made, though it is acknowledged that most of these tasks are considered non-trivial and remain underdeveloped.

Research Domain	Example Tasks
Communication	Natural language production, Syntax, Multi-agents, Intelligent interfaces
Creativity and Cognition	Cognitive modelling, creating works of art
Game Playing	Tactics (e.g. Chess), Virtual Reality (VR), Simulators
Information Management	Knowledge based systems, Intelligent agents, Data mining
Learning Systems	Machine learning, Behavioural modelling
Perception	Vision, (optical character recognition, text readers), Spatial recognition, Hearing (voice recognition), smell and taste recognition
Symbolic Logic	Methods of abstraction, Modelling techniques
Understanding	Comprehension, Natural language, Reasoning systems

Table 1.

Current AI Research Areas

Within each research domain, various techniques in modelling, abstraction and computation have evolved and are often applied across the domains. The methods adopted can be dependent upon the application area, for instance schemes which do not provide causal relationships or cannot successfully model system functionality are rarely used for safety critical applications.

Table 2 divides AI approaches into what can be termed 'high' and 'low' levels. These levels refer to the approaches to specific problems, the nature of the abstraction necessary and the complexity of the required output. They do not refer to the complexity of the technique as every method, in the main, can be shown to be non-trivial.

Low-level approaches tend to focus on ‘raw data’ applications and in that respect they are fundamental in their approach. In general data can be pre-processed by a suitable algorithm and subjected to the technique to reveal patterns and relationships, highlight anomalies, predict temporal sequences, filter, optimise and learn patterns. The fundamental nature means that such techniques are portable from one problem to another i.e. techniques that predict stock market trends can also be used to recognise patterns in speech analysis.

High-level approaches use techniques that use models of the environment to solve a specific problem. The immediate difficulty with these approaches is setting the level of abstraction (often referred to as granularity) which will adequately satisfy the constraints of the problem domain. As a result such tasks are subjective and require a distinct and bespoke approach. The advantages are that holistic methods are possible and the functionality of complete systems can be analysed to reveal causal relationships under varying conditions.

The bespoke nature of high level approaches has, in general, made them specialist techniques requiring the complex skills of programmers and engineers. In terms of applying the technology, few development tools exist to enable the designer to construct and use model based techniques. This is, however, set to change as researchers acknowledge that active technology transfer plays a substantial part in advancing the field (see MONET 2000, for example).

In contrast, for the application of low-level approaches a plethora of commercially available software tools exist to aid applications developers and educators. Consequently these techniques have provided a far more accessible route to applying AI in product design.

High Level AI		**Low Level AI**	
Task Domain	**Typical Application**	**Task Domain**	**Typical Application**
Reasoning Systems, cognitive modelling,	Failure Modes Effects Analysis (FMEA), systems modelling, diagnostics	Pattern recognition, Prediction, Learning schemes	Speech recognition, image analysis, machine health monitoring, diagnostics, real time control
Generic Techniques	**Comments**	**Generic Techniques**	**Comments**
Modelling, Abstraction	Can provide causal relationships, subjective, non-trivial, time consuming, computationally intensive	Neural Networks, Fuzzy Logic, Genetic Algorithms	Portable, relatively short development times, can require large amounts of data, often difficult to analyse, non-formative approaches are apparent

Table 2.

'High' and 'Low' Level Tasks and Techniques

IT and Smart Technology

Within education curricula, Information Technology has made a great impact expedited by the advent of the World-Wide-Web and the consequent cultural information explosion. IT is a generic expression that can include any form of technology (equipment and/or technique) used by people to collect, store, control and communicate information. The field of AI encompasses all these areas and could therefore be considered a part of the IT revolution.

'Smart Technology' is an unfortunate term that has been used in a somewhat cavalier manner, mainly due to media hype and commercial exploitation. In the mid-eighties the development of shape memory alloys led to the tag 'Smart Materials'. This was followed by 'Smart Cards' a simple memory device on a piece of plastic the size of a credit card which contained user profiles to operate user dependent machinery such as bank teller machines. Since then a whole manner of devices and products have been designed and marketed bearing the label 'smart', or even more misleading, 'intelligent'. There are examples where IT has been merged with common domestic products, for instance by allowing Internet access via an LCD screen in the door of a microwave, or by installing a barcode reader and Internet access in a fridge, whereupon these humble kitchen appliances are apparently rendered 'intelligent'.

A common misconception is that AI and Smart technology are one and the same thing. The understanding and appreciation of AI as a philosophical science and an engineering discipline should, however, refute this. The proposed model illustrated in Figure 1 aims to create a more usable definition for distinguishing AI and Smart Technologies from an application based engineering perspective. If we consider Tesler's theorem then legitimate AI areas, in both high and low level techniques, are shown as future research goals. Advances in AI research are disseminated through to applications research. Finally, proven techniques are integrated into commercially viable designs at the product development stage. Referring back to Tesler's Theorem, at the point of accomplishing the technique it can no longer be considered legitimate AI. What remains are tried, but possibly not thoroughly tested, techniques that could be considered to be within the realm of Smart Technologies.

It is acknowledged that this model does not take into account so called 'Smart Materials'. However, it is debatable if the purely reactive physical properties of materials qualify as being smart. As a leading proponent in this area, J. S. Sirkis of the Smart Materials and Structures Research Centre, University of Maryland, states,

> *'…"The materials themselves are not smart…..they just provide a certain function by converting energy from one form into another"…'* (Wayt Gibbs, 1996)

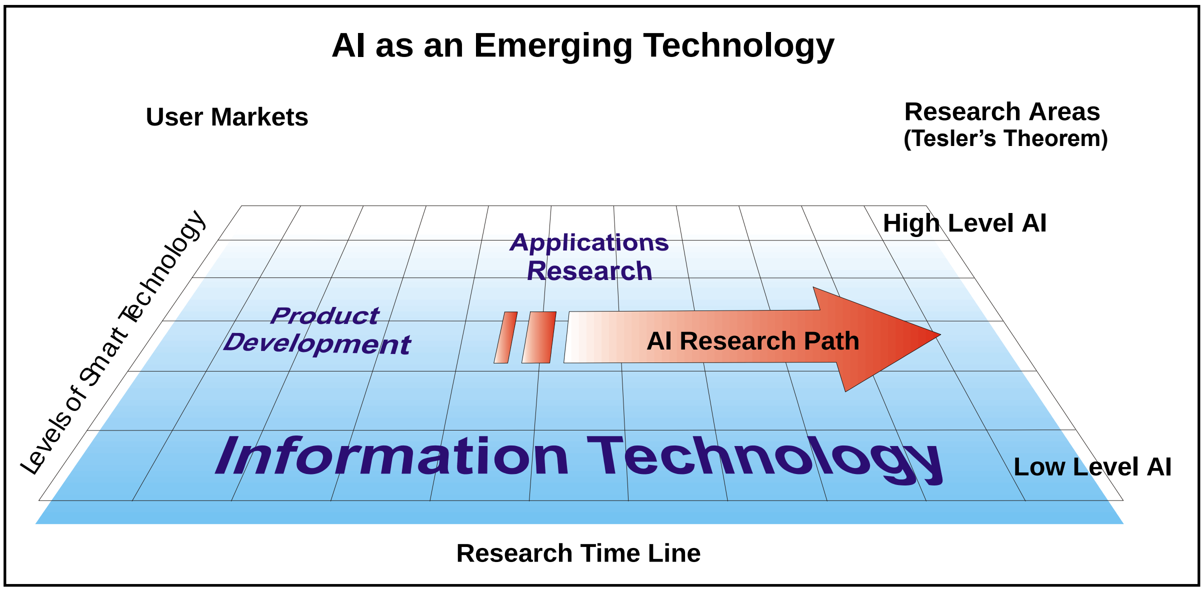

Figure 1.

AI and Smart Technology

For the purposes of the model in Figure 1, only those products resulting from the direct consequence of AI research and its applications are considered. The model, however, is considered valid for such areas as wearable technology where IT and programmability is integrated into textiles and garments.

Why do designers need to know about AI and Smart Technology?

The commercial implications of using AI technology to create a unique selling feature is a familiar theme in product design, but, important factors on how best to include AI techniques in products to improve *usability*, are ill-defined. Factors including the potential users' perception and understanding of the technology alongside their confidence in depending upon such products are presently rarely considered. Gaining the confidence of users needs to be a principle task in ensuring successful design of interactive products.

It can be seen within present consumer products that simply automating functions can cause the user frustration and annoyance. Auto-focussing cameras, auto text formatting within software packages, voice-activated controls and speech generating alarms are examples of where the intended added functionality can ultimately result in user aggravation. Works by Jordan and Stanton (Jordan, 1998 and Stanton, 1998) cite many examples of the failures in the design of usable products. Unfortunately there is a track record of getting it wrong!

In terms of usability, AI can be viewed as a method for supporting a working dialogue with a product. Establishing the dialogue need not, therefore, be just an ergonomic relationship, effective interface design and degrees of controlled automation, it can also encompass the complex manipulation of information and the interaction with embedded knowledge. There is no inherent intelligence within a machine and it is left to the designer, of both hardware and software, to artificially create the functionality. It is, however, extremely rare for product designers to become involved with this level of technical engineering detail. But the combination of hardware, software and AI techniques is what endows smart products with functionality. Knowledge of the capabilities and limitations of the technology will enable product designers to be more creative and innovative and ensure the design of more successful interactive products.

AI researchers have acknowledged that there is a noticeable lack in communication between AI developers and designers wishing to apply the technology. At a recent international workshop to discuss the acceptability of specific state of the art AI techniques in industry, it was noted that the development of usable systems was significantly hindered by failures in recognising the importance of human interaction issues, (McCardle, 1998). The interaction issues are not the sole responsibility of ergonomists and designers, it is also a necessary consideration for computer scientists and AI developers. Furthermore, to ensure the success of smart products, it will be an ever-increasing responsibility of designers to be able to find common ground with software engineers, computer scientists and electronics engineers.

AI and Design at Brunel University, UK

AI and computational intelligence is considered cutting edge technology, to which historically Brunel University in the UK has made major contributions to the field (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 specific research group within the department stimulated the focus on Artificial Neural Network (ANN) applications. At that time, 1991, the Neural Applications Group aimed its research at hardware and software solutions to automated weld control, pattern recognition and machine health monitoring. ANN's 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 applications 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 1990's. The original course objective was to reflect the general developmental and theoretical solution methodologies practised within the field of AI at that time. However, it is generally acknowledged that computing and IT is advancing at an unprecedented rate (for example, Moore's law). 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 practise their analytical abilities through 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 on 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 standalone 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 2 and 3). Through the use of infrared 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.

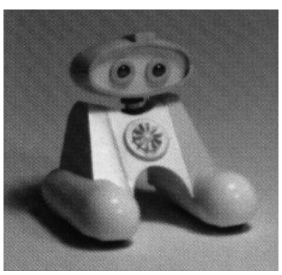

Figure 2.
The ’timid’ autonomous mobile robot

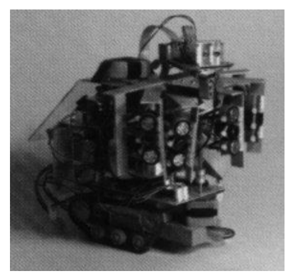

Figure 3.
The prototype.
PIC based neural network guidance system and pattern recognition.
“You try to shoot it. It tries to hide”

Robotics has been a continuing theme throughout the course, and with the knowledge to program a 'virtual personality', interesting adaptations have been evident. For instance, the 'Tomodachi' (Figure 4), bringing the attraction of Tamagotchi toys into three dimensions. Voice recognition technology has also proven popular where familiar controls are discarded in favour of voice commands as in the 'VCCD' compact disc player (Figure 5).

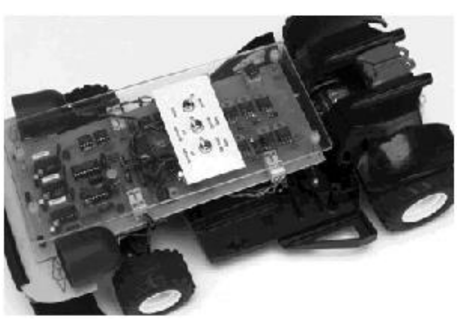

Figure 4.
The Tomodachi Robot Toy

Figure 5.
Voice activated CD player

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 Artificial Neural Networks to analyse heart ECG signals and detect specific abnormalities. The undergraduate project culminated in a wearable product, called Minilink (Figure.6), able to monitor the users heart activity during exercise. The project was later developed for monitoring infant conditions utilising PC based software, and finally to a portable product with the AI algorithms embedded in 32 bit ASIC hardware. The system can monitor a patient for 24hrs and identify problematic heart conditions. Its success has been acknowledged through its selection as a UK Millennium Product (Figure 7).

Figure 6.
The original MiniLink Wearable Heart Monitor

Figure 7.
The CNET 2000 Millennium Product
(Courtesy of Dr. T.J. Harris, Cardionetics Ltd)

Future goals of AI, Smart Technology and the role of the designer
In June 1999 Sony launched the AIBO™ (Sony, 2000), an 'entertainment' robot that takes the form of a small dog. AIBO (the name means 'companion' in Japanese) is described as,

> *'an autonomous robot that acts in response to external stimulation and its own judgement. It displays various emotional expressions and learns by communicating and interacting with human beings', (Ibid.).*

Although some of these comments may be debatable in terms of philosophical issues, the AIBO certainly demonstrates that present technology is capable of providing products that exhibit a persona, a feature expedited not only by sympathetic packaging but also by including its own idiosyncratic agenda. Although designed specifically for the purpose of entertainment, future adaptations could yield more serious applications. With 3,000 units being sold within the first 20 minutes of the launch, the popularity of the AIBO illustrates the willingness of people to interact with 'mechatronic personalities'.

One of the major thrusts in AI research is *machine learning*, of which the AIBO is a commercial example. In this area, software programmes are developed that can change the operating characteristics of a machine depending on its environment and will respond to new situations with a sort of 'educated guess' based on its previous experience. The entertainment factor of the AIBO is embodied in not knowing, or the surprise at, the reactions of the product when stimulated with novel situations.

If such functions are to be utilised within more serious consumer products, the designer is faced with the problem of how such adaptability can be related to the user. In the majority of design scenarios utilising conventional HCI methods, machine interfaces are constant and therefore behave in a consistent and perceivably reliable manner. However, by introducing adaptability the consistent behaviour would, by definition, be lost. Unless such devices possess a form of explanatory interface that relates the concept and level of adaptability, the user would be faced with a seemingly inconsistent machine and one that could consequently be perceived as unreliable.

In describing hurdles to the design of intelligent products, John Bonner (Bonner, 1999) raises pertinent questions that need to be addressed. Such issues as adaptive interfaces that communicate to users 'how intelligent' the product is under particular circumstances are cited. Further problems associated with the levels and types of feedback in dynamic situations are also highlighted, indicating that present conventional HCI methods do not adequately cater for such scenarios.

The future role of the designer will necessitate not only understanding such criteria as effective usability, functionality and product semantics, which are seemingly obvious requirements but, in addition, understanding the user's capabilities, confidence and perceptions of products. This is especially pertinent when designing products with adaptable interfaces.

Conclusions

The rapid advancement of technology means that 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 and Smart Technologies are subject areas that offer 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.

Understanding the fragmented and transient nature of the field of AI, and the development of a basic taxonomy has been an invaluable exercise and a major necessity in designing a suitable AI course for industrial design students.

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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Student Reading List

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Biography

John McCardle B.Sc. Ph.D. AMIEE, is a lecturer in the Department of Design & Technology, Loughborough University. He was formerly trained as a control engineer with the Ministry of Defence in the UK before turning his interests towards industrial design. As a founding member of the Neural Applications Group in the Department of Design, Brunel University he gained a Ph.D. in applied neural nets. He has also researched applied AI within the Centre for Intelligent Systems at the University of Wales, Aberystwyth where he was network manager for MONET - the European network of Excellence in model based systems and qualitative reasoning. His current research interests include Artificial Intelligence; Cognitive modelling; Human Computer Interaction (HCI); Cybernetics; Smart technologies; Design support tools; Embedded intelligence & product semantics.

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