Design of a Flexible and Project Based Postgraduate Module on Applied Computational Intelligence: A Case Study

Jenny Carter
Centre for Computational Intelligence
Faculty of Technology
De Montfort University
The Gateway
Leicester LE1 9BH
Great Britain
jennyc@dmu.ac.uk

Samad Ahmadi
Centre for Computational Intelligence
Faculty of Technology
De Montfort University
The Gateway
Leicester LE1 9BH
Great Britain
sahmadi@dmu.ac.uk

***Abstract*—The MSc Intelligent Systems (IS) and the MSc Intelligent Systems and Robotics (ISR) programmes at De Montfort University are Masters level courses that are delivered both on-site and by distance learning. The courses have been running successfully on-site for 8 years and are now in the fifth year with a distance learning mode. The Applied Computational Intelligence module gives students the chance to apply knowledge gained in other modules on an application area of their choice. A substantial number of these involve robotics work though not all. Over the years there have many excellent pieces of work submitted by students for this module and number have gone on to be published. This paper presents the background to the module, ideas for flexible design of such modules, some examples of the students' assignment work and a discussion of the perceived value of the module.**

***Index Terms*—Case studies, post-graduate, project based learning, distance learning, flexible design.**

I. Introduction

The MSc Intelligent Systems (IS) and the MSc Intelligent Systems and Robotics (ISR) programmes at De Montfort University are Masters level courses that are delivered both on-site and by distance learning. The courses are delivered mainly by the members of the Centre for Computational Intelligence (CCI) at De Montfort University. Their development enabled us to capitalise on the research taking place within the CCI and therefore on the strengths of the staff delivering the modules.

Each MSc consists of 8 taught modules and an independent project which is equivalent to 4 modules. Each module is worth 15 credits (7.5 ECTS). The MSc ISR includes two mobile robots modules whilst MSc IS replaces one of these with a Data Mining module as an alternative application area for those less interested in pursuing mobile robotics work. A Research Methods module is delivered in semester 1 to ensure that students are equipped with the necessary skills to carry out literature searches, write project proposals and so on; and a module titled 'Applied Computational Intelligence (CI)' enables students to pursue an appropriate area of their own interest in greater depth. An overview of the course content is shown in figure 1. In this paper we discuss the approach taken in design of the Applied CI module to create a flexible, dynamic and project based module.

The remainder of the paper is structured as follows: Section 2 gives some background information about the module, its learning outcomes and how they are assessed; Section 3 describes some of the work submitted by students for assessment in this module with particular focus on those that are robotics based; Section 4 provides some discussions and Section 5 draws conclusions from this work.

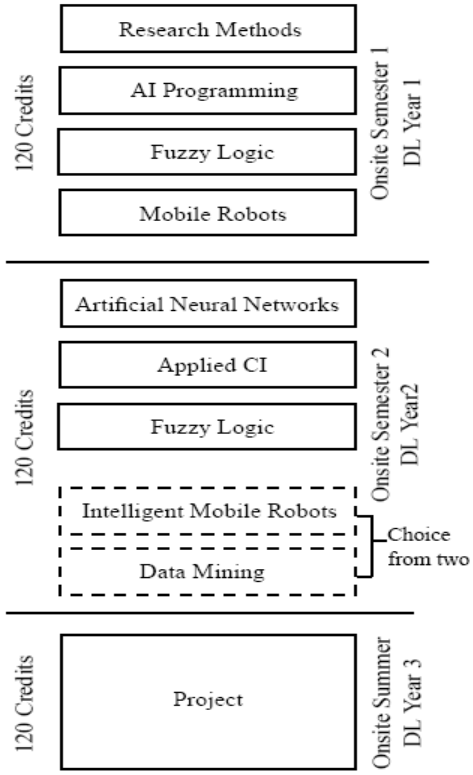

Figure 1. The course structure

II. The Applied Computational Intelligence Module

This section gives an overview of the content of the Applied CI module. There are two tutors associated with the module. The module aims to introduce new application areas of CI while bringing together the ideas and techniques covered in the other modules thus giving the students the opportunity to begin to develop their special interests. The learning outcomes (LOs) have been devised with this in mind and are as follows:

- LO1 - Apply AI techniques to given practical problems
- LO2 - Recognise the multi-disciplinary nature of AI and its potential application areas.
- LO3 - Critically appraise relevant literature in order to formulate a plan for their own practical/experimental work
- LO4 - Synthesise a solution to a problem (planned in LO3) and evaluate the solution.

In order to achieve these LOs the modules is organised into a series of lectures, lab sessions, tutorials and seminars. Also to achieve flexibility in bringing new application areas the module is designed as a set of different blocks of lectures each focusing on one application area and some gest lectures. This enables us to include new and exciting application areas based on our new interests without major changes to the structure of the module. Examples of such blocks are knowledge based systems, AI for video games, music and AI, web log mining and philosophy of AI.

This module is delivered both to on-site students and to distance learning students.The basic teaching strategy is to provide students with presentations, research papers and reading associated with fundamental issues and enable learning through reading, discussions (using the e-learning facilities &/or seminars), practical implementations and/or experimental work. Students are also given application papers to support the fundamental topics in the syllabus and have access to current research material much of which results from the work of the CCI. Each year there are guest speakers.

To accommodate the distance learning students some of the sessions are pre-recorded using video, some are in the form of presentations with added sound using Articulate Presenter, and there are various electronic resources including e-books that are available with multi-user licenses from the univeristy library.

The assignment is divided up into 3 components though 2 of these relate to the same activity. Initial laboratory work on some new topics as assessed as a portfolio of lab exercises and this is worth 20% of the module mark. The remainder is for the main project style piece of work. Assessment of this is divided up as 20% of the module mark for a conference style presentation and 60% for a report detailing the project work carried out. An extract from the assignment is given in below:

*"**Select an area of study** based on your interests and possible directions for your MSc project in consultation with your tutors (some example areas of applications are provided in Appendix 1). Write a short 'terms of reference' (TOR) document. This should be approved by one of the tutors before you begin work on this project."*

***Carry out investigative work** into the chosen area, this should include the following activities:*

- *critical review of associated literature*
- *Either a practical implementation to illustrate some feature of the application area **or** appropriate experimental work to support the investigation.*

So this part could take the form of practical work if for example you base your study in the area of Robotics or Expert Systems etc. or it may be experimental (something with music or data classification etc. might require this);

***Prepare a presentation** +/- demo that facilitates discussion of your subject area. This should last no longer than 20 minutes and should include 5 minutes for questions. For distance students we will arrange a time that fits with your work schedules and will use Skype (unless you want to come in to do it here in Leicester). "*

The students are required to submit the report in the form of a conference paper using one of the IEEE templates found in [1]. One advantage of doing this is that those that do work that is of publishable quality and are interested to do so can prepare the document for publication with the minimum of additional time. Tutors provide feedback for those cases to make the report into a publishable paper. In section 3 we consider some examples of the students' work.

III. Examples of projects from past students

This section looks at examples of work submitted by students on this module in the past. We will briefly mention some of the non-robotics focused examples but will give greater emphasis to those that do feature applications in the area of robotics.

Projects chosen by students cover a wide range and many of them then take the work further for their main MSc project. Some have then continued with the work to PhD level. A number of students have completed good project work in the application area of AI and computer games, notably, Martin Rhodes [2, 3] and Matthias Brandstetter [10, 11] developed their work further for the MSc project and subsequently for a PhD in a related area. The subject of [2] and [3] was on using evolutionary computation to the optimisation of simulated free kick situations in Football and the resulting project won the BCS machine intelligence prize in 2008. In [10] a novel genetic programming was proposed to solve Ms. Pacman competition problem and in [11] a new approach and interface for learning from user experience in games was developed. William Lawrence [4], 5] developed a Mathematics teaching game using neural network.

Over the years quite a few students have used this assignment to develop entris for the Robot Challenge that takes place annually in Vienna [6]. Three of these are described below.

A. Autonomous robotics helicopter

Ben Passow started working on an autonomously controlled robotics heicopter for his assignment in this module (Fig. 2). He developed this for his Masters project and further work led to him being awarded a PhD. The helicopter has featured at the robot challenge on more than one occasion where he won prizes. He also won the BCS machine intelligence prize at the SGAI conference in Cambridge. The focus of this work was the development of a fuzzy inferencing system to control the heading of a small indoor helicopter and a section from the abstract is given here: "The work addresses the problem of system identification when implementing a Takagi-Sugeno-Kang type fuzzy logic controller. Instead of identifying the system formally beforehand, the fuzzy controllers consequent parameters are learned using a Neuro-Fuzzy Inference System with data collected from an existing, previously implemented proportional controller. The controllers are implemented on an embedded microcontroller driven system attached to the helicopter" [6, p1]

Figure 2. Autonomous robotic helicopter

B. Puck collect robot challenge entry

Another student, now also doing a PhD with us developed a robot for entry to the 'puck collect' stream. This is where the robot has to be able to wander around at the same time as an opponent and collect coloured pucks (the colour is either blue or red and is allocated at the beginning of the match). Pucks of the correct colour then have to be deposited on a 'home' square of the same colour. See Fig 3.

David Croft's robot, Puckman, (fig. 4) used a vision system that meant it was possible to use only a small mouth for puck collection and the design was such that it aimed to collect only the correct colour of puck. A camera was mounted on the front of the robot as part of the vision system. If a puck of the wrong colour was collected a secondary system took over to identify and reject it. The edge detection technique implemented here was a FIRE operator with a Mamdani fuzzy inferencing system. David was able to apply this to a colour vision system by processing each RGB colour channel as separate grey scale and then combining them again. This was an excellent design and although the reasons were usually down to some other lesser fault rather than a problem with the idea and implementation of the vision system.

C. Sumo robot challenge entry

A current full time student of the course developed an entry for the sumo stream of the competition (Fig. 5).

For this development the student used the Lego NXT programmable brick. The computational design included the use of a colour sensor and a vision system (an ultrasound sensor). The vision sensor enabled the robot to find its opponent and then the use of the engineering features, namely the weapon, would set in. Again this was a good design with good ideas.

Figure 3. The puck collect entry [8]

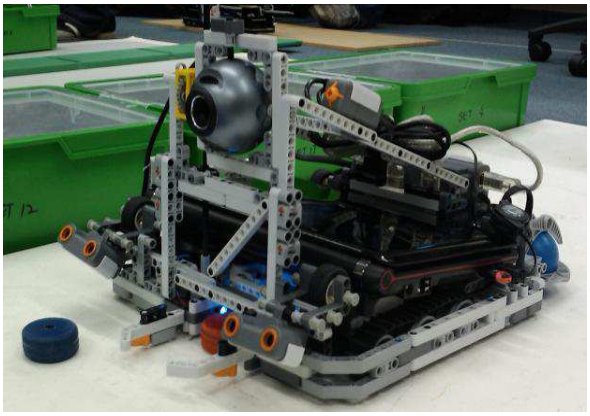

Figure 4. The puck collect entry [8]

Our students have entered sumo robots to the competition in the past as well and two won second and third prizes on different occasions.

Other projects that were robotics based but not specifically for the robot challenge includes that of Ed Laurence who did a project titled: 'Application of Adaptive Neural Networks for Hover Control of an Autonomous Helicopter'. The helicopter used was a single rotor and the student investigated two approaches to configuring the network, namely Feedforward

Neural Networks (FFNN) and Elman's Recurrent Neural Networks (ERNN). The student achieved the highest possible mark for this work and it was truly outstanding.

Another example from a student this year who is a distance learner is that of Pamela Hardaker whose project is titled 'Using EMG signals for real time control of a microprocessor controlled prosthetic limb'. She carried out experiments in the use of an Electromyographic sensor to determine whether a person is standing, walking or running. She captured the output of the sensor in a variety of ways in order to find out which features could be observed to change as the person changed the type of movement. She then trained an Artificial Neural Network so that it could recognise each state and hence give a real time signal to a prosthetic leg.

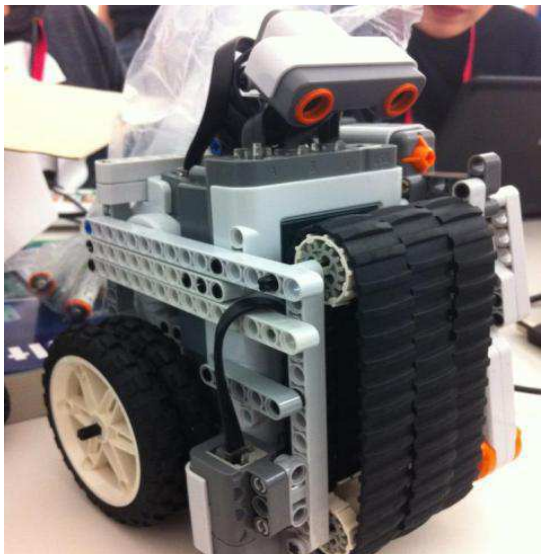

Figure 5. The sumo entry

In this section we have presented some illustrative examples of the work of students on the Applied CI module. The next section provides a discussion about the kind of work that results from the students studying on this module and we believe it to be an example of good practice.

IV. Discussion

The examples given illustrate the breadth of projects undertaken by our students but also show the depth that they are able to reach in their choice of application area by being given the freedom to choose and work in a project based way. Telling them that they can build on this work for their main project and providing them with examples of how past students have done this gives them a better understanding of how to go about planning and carrying out the assessed work for the module. Although the original design of the module was not centred on a specific learning style we believe that the module is an example of project based learning as defined in [9].

The presentations sessions are always the best part of the module. The topics that the students present are quite diverse which adds to the interest level and usually they are very enthusiastic and there are lots of clever ideas. The students in the audience usually join in asking questions as well which adds to the conference feel. If the students do then publish their work later they will have already had a chance to practise presenting in front of other people.

The distance students can come in to the conference sessions and present on-site if they wish and some choose to do this. Most distance students present by Skype to the two tutors and this works well. It is unfortunate that they miss out on the group presentations though and we hope to find ways around this. One approach that goes some way to at least sharing content is giving all students the facility to upload their presentations with sound if possible to a wiki on Blackboard so that other students can listen in their own time. So far only a few students have ever taken up this opportunity to upload their presentations in this way as it is voluntary but we may make it a compulsory part of the module in future so that everyone can see everyone else's presentation if they wish to.

We have found it very advantageous to have the written reports submitted using one of the IEEE conference templates. It is a good way of getting a sensibly formatted piece of work and it is easy to limit the length (e.g. by specifying 4-6 pages) without thinking about word counts. The students also seem to be happy doing this as they see how their work might look if it was to be published, as they do not have to make decisions about formatting and it gives them practise for the future.

Quite a few students have continued with the work that they started in this module for their MSc projects and for their PhD. One student in this year's cohort wrote a very detailed plan of work that was divided into work packets – the first being for this module, the second for his project and the third for a PhD which he has already applied for (and been accepted on) even though he still has his project to complete. This could be viewed as anecdotal evidence to suggest the approach taken in the module may encourage students to stay with us.

V. Conclusions

In this paper we have described the Applied Computational Intelligent module on the MSc Intelligent Systems (IS) and the MSc IS & Robotics courses at De Montfort University as an example of a project base module and a good example for flexible design. We have given example of projects undertaken by students with a particular emphasis on those that have a robotics focus. We believe that the approach taken encourages the students to undertake challenging projects that are of interest to them and as a result we see some excellent and innovative work, some of which has been published and some that has been developed further leading to MSc projects and in some cases PhDs.

Acknowledgments

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