Network Action Proposal

Title:	Connect with AI
Membership number(s)	105
Member name(s)	Sethu Vijayakumar
Member institute/company name(s)	University of Edinburgh
Goals of the action	To create an education tool which reflects the basic message of embodied 'cognition' by developing a robotic arm playing the Connect4 game with public with real time vision and HCI interface (See attached case for support)
Principal activity to which it contributes o Community Outreach o Scientific Outlook o Education & Training	Community Outreach Education and Training
Concrete outcomes of the action (at least one of which should be material suitable for publication on the euCognition website)	1. **Creation of educational tools** to introduce the area of cognitive science through the field of robotics and vision to schools and public in general. 2. **Create awareness** amongst public of the interesting issues tackled by cognitive robotics and vision 3. Generate **publicity and teaching aid** material for 'cognitive science' aimed at high school and general public. Materials including robotics setup manual, control and vision software, publicity material, presentations, videos and reports from classroom session will be uploaded on the euCognition website. (see attached case for support)
Effort in person-days that will be charged to the Network Action (if any)	26 non-contiguous person days (calculated as 8 hours/day)
Expected start and duration in months	February 2007 (development and deployment: 3 months, class visits: one year pilot before establishing as regular program)
The requested funding, under the following headings: o Travel Costs o Other Costs (check with the Network Coordinator if you aren't sure about eligibility of these costs) o Labour Costs (identify the number of person-days and the rate per day).	Materials Cost: € 3,216 Labour Cost: € 3,720 (26days @ 8 hrs/day @ ₤12.00/hr) (For detailed breakup of budget, please see attached case for support)
Please identify any other sources of funding that contribute to this Action (actions to support events such as workshop and conferences should include an outline budget identifying the total cost)	• University of Edinburgh funding for prototype already developed. • UK research council funding initiative "Walking with Robots" and "Robot Thought". • Subsidized workshop support for hardware development from University of Edinburgh.

EuCognition Network Action Proposal: Case for Support

Connect with AI

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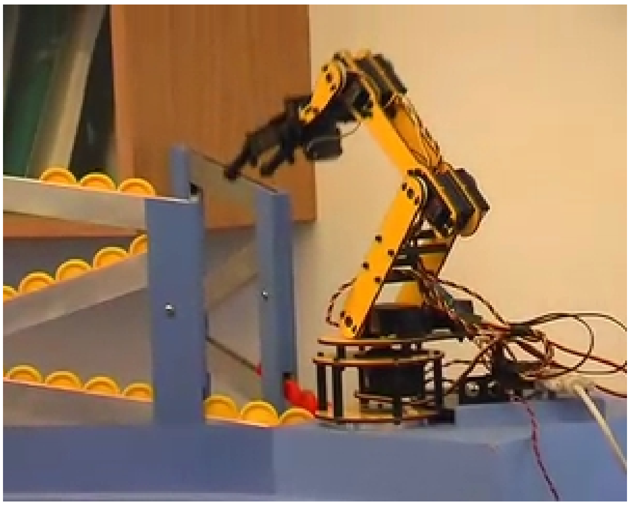
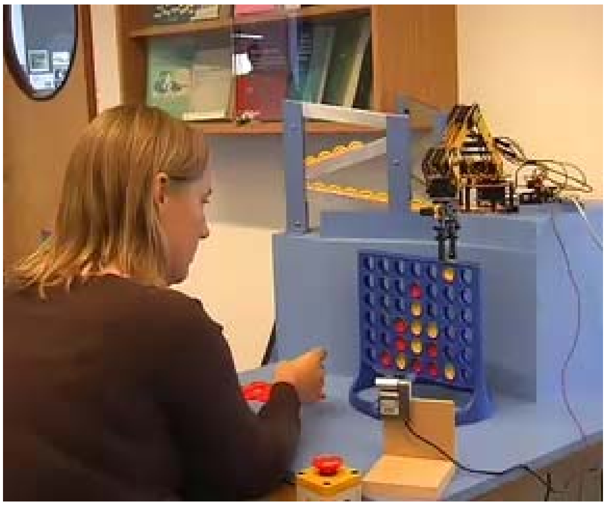
Introduction

We propose a network action that encompasses Community Outreach and Education & Training aspects of the euCognition funded network activities. It involves developing a simple yet 'intelligent' robotic platform to interact with public and generate interest and motivation amongst the community towards the concept of an embodied cognitive agent.

We have developed a prototype autonomous ***Connect4*** playing robot (see pictures below) for use as a demonstration tool for university open days and it has proved to be a great success in capturing the interest of children and adults alike. A robot playing a popular game against human opponents appeals to a broad spectrum of people including those who have had no previous interest in artificial intelligence. The robot uses an off the shelf web-cam to capture images of the board, performs robust image processing to extract state of the game and uses inverse kinematics to grasp and drop the Connect4 coins into the slot during its move. As the robot integrates work from machine vision, artificial intelligence and robotic control, it has allowed staff manning this demonstration to: *(i)* engage people in discussion about each of these fields, *(ii)* provide an opportunity to get people to think about how computer's abilities currently differ from our own, and (iii) give them a brief exposure to the world of cognitive science and artificial intelligence.





Proposal

Given that the prototype has proved that

(i) the technology functions well in the public arena,

(ii) the robot has a natural appeal to children,

it is proposed to build two further units, make the prototype more robust, incorporate better user interfaces and take them out into local schools as teaching aids to encourage interest in science and engineering, especially AI and cognitive science.

It is possible to use the robot arm to explore a broad range of education themes:

- how machine's abilities differ from our own, *e.g.* which is the hardest task for a machine – seeing, picking up a piece or planning its moves – and why this should be different for us;
- how we program computers to "think";
- how our engineering of the environment makes it easy for the robot arm, and do we do the same for ourselves;
- state of the art in AI, machine vision and robotics;
- with house hold robots becoming more and more ubiquitous, what do we actually want robots to do?

We already have contact with a number of local schools who have expressed interest in workshops on AI and robotics. The school visits would form part of our developing programme for widening participation (encouraging students from a greater diversity background to apply to University).

Concrete Outcomes

Creation of educational tools that would continue to be used in local schools in the UK, at the Edinburgh science festival and open days to interest children and the general public in science, engineering and especially AI and cognitive science.

Material for classroom developed and uploaded on the website: Materials including software for robot control and vision processing, operation manuals, advertisement flyers, scientific and technical briefs, photographs and videos of classroom work etc. will be published on the euCognition website. We will also maintain a dedicated website describing this initiative such that this can be easily replicated at programs across Europe.

Positive publicity for the field of AI and robotics: We will receive local and national coverage for this work through the school and outreach programs already in place in the UK. In particular, the work can be promoted, and potentially rolled out to other Universities through the UK funding council supported initiative "Walking with Robots".

Learning and Adaptation exhibited by the System

The game of Connect4 has been solved [James D. Allen, 1998; Victor Allis, 1998] and it is known that a perfect player who goes first always wins. It is therefore possible to construct an AI player which always wins if it goes first. A more interesting and unsolved problem for machine learning is how to play against a fallible human opponent when the human goes first. To allow exploration of this question the completed system will have a number of different game-play algorithms which can be selected. As well as a perfect (if it goes first) algorithm and a simple limited horizon min-max algorithm, there will also be algorithms that learn from previous games and adapt their game play. Examples of two "learning" game-play algorithms that will be implemented are (i) a simple rote learner that memorise previous games and (ii) an algorithm that adjusts the weighting of the heuristics used to evaluate moves, in light of experience. Further learning game players using, say, Bayesian networks, could be easily added to the prototype system.

A possible drawback of *learning* game-play algorithms is the number of games they have to play before any change in play is perceivable. To bring machine learning to life in the context of a two hour classroom session, we would add visualisation of the machine's cognitive processes such that the change can be observed. To emphasise what learning can achieve, one of the two arms could demonstrate early 'naïve' heuristic behaviour and the other, the learnt behaviour, *i.e.* before and after snapshots of a learning system. If learning game players are too slow to learn in the classroom, then an alternative option might be to put a game-play algorithm on the web and have it learn from games played on-line. This could form a deliverable which appears on the euCognition web site.

The vision system segregates the Connect4 pieces from the background based on colour information. This segregation is learnt by a decision tree based on examples. Given a new environment in which the vision behaves poorly, the system can be readily trained to cope with the novel illumination and the variation in the colour temperatures.

Identifying the location of the Connect4 board in the image is done in real time using a combination of feed-forward and feed-back techniques which allow pixel level visual information to be combined with high level knowledge such as the structure of a Connect4 board. This allows the system to rapidly adapt to variation in the position of the board in the image and the angle from which the board is viewed (camera can be offset by ±30° to either side of the board). The same visual process also identifies images where the board is either not present or is partially obscured.

Work Required

It is proposed to build two new ***Connect4*** robots primarily to allow classes to be broken up into smaller groups and to simultaneously cover a broader audience: the demand has been very high on the prototype system. Building two new arms also has the additional advantages of allowing improvement on the mechanical design over the prototype system and providing redundancy against breakage or failure. Each ***Connect4*** robot consists of robotic arm kit, a base which supports the arm, a portable computer, a webcam and a Connect 4 board plus pieces. Costings for each of these parts and labour for their assembly are detailed below.

The main improvements required to the existing prototype are: *(i)* making the software more robust; *(ii)* simplifying the user interface; (*iii*) incorporate adaptive game playing algorithms, (iv) add visualisations which allow learning to be observed and *(v)* providing "documentation on the arms operation".

In summary, the work required to achieve the above objectives consists of:

- Improving the robustness of the prototype system
  - Hardware: making the motor system more robust
  - Software: Improving the motor control and making the vision processing more robust.
- building two new ***Connect4*** robots by assembling the robot kit, creating platforms for the rig and setting up the game and vision system hooked up to the laptop system with appropriate software;
- incorporating 'learning and adaptation' in the game playing, opponent modelling and vision processing;
- development of supporting poster/handout/website materials explaining scientific background;
- undertaking school visits.

Cost of each school visit consists of payment to postgraduate students to attend schools in order to assemble and operate arms, and talk to students about the various areas identified above. This effort is estimated at around 3 hours per visit; 1 hour for set up and 2 hours interaction with students.

Added Value and Additional Contributions

- Both Informatics and the University of Edinburgh have an ongoing commitment to engage and interest the public in AI, robotics, cognitive science and computer science, and have already provided direct funding for the development of the prototype.
- This proposal will leverage funding from UK funding councils for public communication of science (specific current projects include 'Robot Thought' and 'Walking with Robots') which will support training in public communication skills for young scientists, communication of best practice, publicity co-ordination and evaluation of impact of the initiative.
- School visits beyond those funded by this network action will continue to use the robots created by this network action.
- In-house software development using students' skills and the use of existing University workshop (for hardware) facilities will maximise value for money in the construction of the two new robots.

Costings

2 Robot Kit Parts [Lynx 6 Robotic Arm 5DOF + gripper]	£600	€ 900
Assembly of two robot kits (12 hours @ £12/hour)	£144	€ 215
2 Bases & Pairs of Feeders, Material	£100	€ 150
Base construction – in house workshop (40 hours)	£200	€ 300
Webcams, games, electronics, power supplies, cables	£300	€ 450
Basic software development, testing and upload (50 hours @ £12/hour)	£600	€ 900
Adding learning and adaptation algorithms (40 hours @ £12/hour)	£480	€ 720
Documentation, posters, webpage (25 hours @ £12/hour)	£300	€ 450
2 Laptops [basic compact notebooks]	£1,000	€ 1,500
25 School visits (3 hours per visit @ £12/hour)	£900	€ 1,350
TOTAL COST:	£4,624	€ 6,936

References

[1] James D. Allen announced a solution using search in a rec.games.programmer posting on 1st Oct. 1988.

[2] Victor Allis, *A Knowledge-based Approach of Connect-Four, The Game is Solved: White Wins*, Department of Mathematics and Computer Science, Vrije Universiteit, Masters Thesis, October 1988.