Robots with Anticipation and Attention

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1 Introduction

Artificial intelligence is becoming ubiquitous in our daily life. With increased intelligence, equipment can be made more efficient and more adaptive to changes in its environment. Still, the intelligence of machines is quite weak, and even if there exist vacuum cleaners that vacuums on their own and cars that have intelligent systems that compensate for different weather types this kind of intelligence are hard to compare with human intelligence. One major difference between human intelligence and the intelligent machines of today is perhaps our unique ability to change our behavior as new information is learned, and our ability to generalize behavior to different situations. Most important, we have an ability to use previously learned knowledge to anticipate the outcome of an action even if we have never seen it being performed before. This is an ability that is absolutely essential for an intelligent system.

To improve the intelligence of the equipment that is available today, a number of different cognitive functions must be added. One of these is the ability to anticipate actions and choices made by the intelligent system itself, but also those made by agents in its surroundings. The vacuum cleaner should not only learn to clean all corners of the room. It should also learn to anticipate the actions needed.

For example when assigned the cleaning the room of the 10 years old boy it may choose to do this every Saturday afternoon, because on Saturday morning the boy is supposed to pick up all his toys laying around the floor. It should learn to anticipate that when it's raining outside, it may not be a good idea to vacuum in the hallway if someone has just come in from the rain. Instead it if it raining, the best solution may be to start clean the hallway before anyone enters the door completely soaked in water.

Another case would be to control the attention of the machine depending on the situation. For example, again the vacuum cleaner should assign more of its attention towards the doorway when working and be prepared to move if anybody enter.

The cognitive processes behind anticipation are hard to fully model, but there exist models of partial anticipatory system. We believe that it is necessary to develop anticipatory system to progress further toward truly intelligent systems, and the goal for the next three years is to develop a robot with anticipatory system. As participants in the Mind RACES project, some of Europes top researches in the field will work together to achieve this goal.

2 Mind RACES

Mind RACES are a 4 year EC funded research project. It involves eight research centers in Europe, each with their own special knowledge to contribute to the project. These are the Institute of Cognitive Sciences and Technologies (Italy), Lund University Cognitive Science (Sweden), University of Wrzburg (Germany), New Bulgarian University Central and East European Centre for Cognitive Science (Bulgaria), Instituto Superior Tcnico (Portugal), Austrian Research Institute for Artificial Intelligence (Austria), Istituto Dalle Molle di Studi sull'Intelligenza Artificiale (Switzerland) and Noze s.r.l. (Italy).

The project is focused on the specific hard problem of the nature and the function of anticipation and will provide a theoretical clarification of:

- the nature of constructive perception,
- the way actions are pro-actively selected through reasoning,

This work was supported by the EU project MindRaces, FP6-511931.

- the role of memory in predictive model building,
- the role of anticipatory emotions in autonomous behavior.

The project started in October 2004, and during the first year existing models will be tested and validated. Because of participant's broad knowledge of anticipatory systems, we hope to produce a complete analyse of the existing models.

With the result from the first phase of the project, the task of the next year will be to improve these models and if necessary construct better or more generalized models. Today there exist models that could be used to reach parts of the desired goals in the project. Some of the models are very specific and change of context or task are not possible without major changes to the models. Therefore, a solution could be to generalize already existing models to fulfill the goals of the project. By examining different techniques like neural networks, control theory and classifier systems in anticipatory situations, the strengths and waeknesses in the techniques will be revealed. In the last year of the project, some of the models will be implemented in embodied robots and tested in real environment. This will produce more data on which models are able to cope with the real world and not only simulated environments.

3 LUCS part in Mind RACES

LUCS will contribute with our special knowledge on cognitive functions such as attention, vision, learning and our experience of modeling cognitive functions. LUCS main assignment will be to investigate the roles of attention, monitoring and controlling in anticipatory behavior. This involves a number of research areas that aims at:

- understanding the cognitive role of epistemic actions (any action aimed at acquiring knowledge from the world) in cognitive systems and model a set of them: active perception, monitoring, checking, testing, ascertaining, verifying, experimenting, exploring, enquiring, give a look to, etc. A special focus is assigned to epistemic controls (i.e. actions aimed at checking whether the expected events/results are actually realized).
- Investigating the role of attention in epistemic control and monitoring of the environment; the shift and the fixation of attention will be considered as a specific type of epistemic action. We will model this cognitive function in cognitive systems.
- Showing how top-down processes, internal controls (depending on expectations) determines the shift and the fixation of attention and so how they influence perception.
- Understanding the differences between deliberate shift of attention and automatic ones.
- Understanding the role of context effects and positive/negative priming: how priming and context effects, that activate certain concepts, affect the way we make certain implicit predictions about the relevance of our actions or thoughts. Understand how implicit predictions affect the shift of the attention towards certain inputs or certain regions of the space. Understand how those phenomena constrain even perception, driving what the agent seeks for and which are his questions to the world.

The best suited attention models will be implemented in real robots. Models will be tested in both a single robot scenarios and multi robots scenarios. In multi robot scenarios, the robots should interact with each others in different ways and anticipate each others goals and actions.

Our idea is to let the robots play children's games were surprisingly many relevant cognitive functions must be used. For example, the use of anticipation, attention, goal-driven behavior and planning are absolutely necessary. Because of the huge work of true human like anticipatory system a simplification of the work that will be necessary and therefore we have chosen children's games because of their ability to scale. At the beginning, a very easy game could be used with a single robot, although this may not be too impressive for someone not involved in the project. Because of the complixity of anticipatory system and attention, small steps will be taken toward a common goal. Hopefully, the final result will be an advanced game with multiple robots interacting with each other.

As mentioned earlier, existing models should be examined and used if proven good enough. One of the biggest challenges is to find test beds where the models suitability can be measured for specific task. To make a fair judgment of the models they should be tested in a similar environment with similar input information. Our solution is to perform the tests in a playground. In this play area, we can change the environment and track the behaviors of the robots. A possible measure could be the time spent searching for a goal using different models or reactions times in change of context.

The robots will be controlled by a system called IKAROS developed at LUCS for the purpose of making simulations of brains or brain system, but also to control robots. IKAROS is a collection of modules that each is responsible for a specific task. A very interesting feature of the IKAROS system is that we can connect different modules in any order, for example, when there exist two different types of models for anticipation. In one of the cases a classifier system is used and in the other a neural network. Instead of building two systems (one for the classifier system and one for the neural network), the same basic modules could be used and only the control module could be switched in these case only the module for the classifier system or the neural network has to be changed. Modules for motor control, navigation, sensory input, target prediction and brain regions involved in cognitive function already exist in the system.

We have just started to experiment with our playing robots. The first couple of month in the project has been used to build the robot platforms. We are using small robots that communicate via Bluetooth and are controlled by a stationary computer. Today we have six robots that have some ability to navigate through the game area. Now we focus on the theoretical analysis of existing anticipatory attention systems. The next couple of month, we hope to put together a complete theoretical analysis of existing models and the work will continue with testing of these models to collect empirical data on their performance.

Anyone interested in the project is welcome to contact us at christian.balkenius@lucs.lu.se or birger.johansson@lucs.lu.se for more information. See also www.lucs.lu.se and the project homepage: www.mindraces.org.

Acknowledgements

We would like to thank Magnus Johnsson for constructive comments.