Artificial Intelligence and Robotics

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Abstract
Research in AI has built upon the tools and techniques of many different disciplines, including formal logic, probability theory, decision theory, management science, linguistics and philosophy. However, the application of these disciplines in AI has necessitated the development of many enhancements
and extensions. Among the most powerful of these are the methods of computational logic.
I will argue that computational logic, embedded in an agent cycle, combines and improves upon both traditional logic and classical decision theory. I will also argue that many of its methods can be used, not only in AI, but also in ordinary life, to help people improve their own human intelligence without the assistance of computers.
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1. Introduction

Artificial Intelligence and Robotics have a common root and a (relatively) long history of interaction and scientific discussion. The birth of Artificial Intelligence and Robotics takes place in the same period ('50), and initially there was no clear distinction between the two disciplines. The reason is that the notion of "intelligent machine" naturally leads to robots and Robotics. One might argue that not every machine is a robot, and certainly Artificial Intelligence is concerned also with virtual agents (i.e. agents that are not embodied in a physical machine). On the other hand, many of the technical problems and solutions that are needed in order to design robots are not dealt with by Artificial Intelligence research.

A clear separation between the fields can be seen in the '70, when Robotics becomes more focused on industrial automation, while Artificial Intelligence uses robots to demonstrate that machines can act also in everyday environments. Later, the difficulties encountered in the design of robotic systems capable to act in unconstrained environments led AI researchers to dismiss Robotics as a preferred testbed for Artificial Intelligence. Conversely, the research in Robotics led to the development of more and more sophisticated industrial robots. This state of affairs changed in the '90s, when robots begun to populate again AI laboratories and Robotics specifically addressed also less controlled environments. In particular, robot competitions1 started: indeed, they played a major role in re-establishing a strict relationship between AI and Robotics, that is nowadays one of the most promising developments of research both in the national context and at the European level.

Summarizing, the borderline between the work in Artificial Intelligent and Robotics is certainly very difficult to establish; however, the problems to be addressed in order to build intelligent robots are clearly identified by the research community, and the development of robots is again viewed as a prototypical case of AI system [29]. Following the title of the paper we shall refer to this body of research as AI Robotics.

2. Research issues

In this section we analyse the recent work which can be characterised as AI Robotics, by arranging it into the two basic issues in robot design: Action and Perception.

2.1 Action

While there is nowadays a general agreement on the basic structure of the autonomous agent/robot, the question of how this structure can be implemented has been subject to a long debate and is still under investigation. Agents and, specifically, robots, usually present various kinds of sensing and acting devices. The flow of data from the sensors to the actuators is processed by several different modules and the description of the interaction among these modules define the agent's architecture. The first, purely deliberative, architectures [12, 22] view the robot as an agent embedding a high-level representation of the environment and of the actions that it can perform. Perceptual data are interpreted for creating a model of the world, a planner generates the actions to be performed, and the execution module takes care of executing these plans. In practice a sense-plan-act cycle is repeatedly executed. The problem is that building a high-level world model and generating a plan are time consuming activities and thus these systems have shown to be inadequate for agents embedded in dynamic worlds. Reactive architectures focus on the basic functionalities

2.2 Perception

Robot perception is a prominent research field in AI and Robotics. Current robotic systems have been limited by visual perception systems. In fact, robots have to use other kinds of sensors such as laser range finder, sonar, and so on in order to bypass the difficulties of vision in dynamic and unstructured environments. A robotic agent acting in the real world has to deal with rich and unstructured environments that are populated by moving and interacting objects, by other agents (either robots or people), and so on. To appropriately move and act, a robot must be able to understand the perceptions of the environment. Understanding, from an AI perspective, involves the generation of a high-level, declarative description of the perceived world. Developing such a description requires both bottom-up, data driven processes that associate symbolic knowledge representation structures with the data coming out of a vision system, and top-down processes in which high-level, symbolic information is employed to drive and further refine the interpretation of the scene.

3. Interaction with other AI fields

As already mentioned, the research on AI Robotics intersects a number of subfields of AI. Indeed, the robotic agent can be seen as a main target for the grand goal of Artificial Intelligence, and thus for all the aspects of AI somewhat related to Robotics. Below, we address the main connections with the other AI research topics included in this collection. Machine Learning approaches are being applied to many problems arising in the design of robots. According to the structure adopted above, both action and perception can be supported by learning approaches. Moreover, several approaches that include a training step are pursued ranging from machine learning approaches to genetic programming, and neural networks. From the standpoint of action, learning approaches can be used for the basic action skills, specifically locomotion, but also learning cooperative behaviours, adaptation to the environment, and learning opponents' behaviour, among others.

Industrial Robotics: Many contact points may be found between AI, Robotics and Industrial Robotics. In early days there were not clear and cut distinctions between the two fields, as already mentioned. Today, research in Industrial Robotics is oriented towards the safe and intelligent control of industrial manipulators and in the field of service robotics. The methodologies in Industrial Robotics are grounded in Automatic Control Theory [30]. The relationship between the robot and the environment is generally modelled by means of several types of feedback systems. Moreover, methodologies are typically based on numerical methods and optimization theory.

Computer Vision: Robot Vision is specific with respect to computer vision, because Robot Vision is intrinsically active, in the sense that the robot may actively find its information sources and it can also reach the best view position to maximize the visual information. Moreover, Robot Vision must be performed in real-time, because the robot must immediately react to visual stimuli. In general, the robot cannot process for a long time the same image because the environmental conditions may vary, so the robot has to deal with approximate, but just in time information. Several research topics and debates in this field have strong correlations with AI and Robotics, for example, if a Computer Vision system may be based on inner representation of the environment or it should be purely reactive. take care of the software that makes the robot operative and autonomous.

Mechatronics: Mechatronics encompasses competencies from electrical engineering, electronic engineering,
mechanical engineering. All of these competencies are strictly related to AI and Robotics: the research
field of electrical engineering concerns motors and actuators, while electronic engineering mainly concerns

boards for robot control, for data acquisition and in general for the hardware that makes the robot operational.
Mechanical engineering concerns of course the mechanical apparatus of the robot itself. From this
point of view, Mechatronics, AI and Robotics have tight relations: Mechatronics mainly focuses on the
robot hardware at all levels, while AI and Robotics take care of the software that makes the robot operative
and autonomous.

Embedded Systems: The AI software architecture of a robot is naturally embedded into the physical apparatus of the robot. Therefore, the robot software system needs to work in real time in order to guarantee that
the robot correctly copes with the changing environment; it must be fail safe with graceful degradation in
order to ensure that the robot may operate also in case of damages; the hardware system of the robot must
be low power designed to optimize the batteries, and so on. From this point of view, several of the typical
challenges of embedded systems are also challenges for robotics systems.

4. Conclusion

I have sketched two ways in which the ALP agent model, building upon many different developments in Artificial Intelligence, can be used by ordinary people to improve their own human intelligence. It can help them express their thoughts more clearly and coherently, and it can help them make better choices. I believe that the application of such techniques is a fruitful direction of research for the future, and a promising area for collaboration between researchers in AI and researchers in more humanistic disciplines.

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