ARTIFICIAL INTELLIGENCE: DEFINITION, TRENDS, TECHNIQUES, AND CASES

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Summary

We give an overview of the field of Artificial Intelligence. First, some different definitions of Artificial Intelligence are considered. After that, a short overview of its history is given. Next, we will describe the current trends in Artificial Intelligence. An introduction to the other chapters on Artificial Intelligence is included. We will present several cases presented in order to give an impression of the current activities in Artificial Intelligence, and will end with our concluding remarks and some references.

1. Introduction

The goal of this article is to provide an outline of the field of Artificial Intelligence (AI). We will discuss the definition of Artificial Intelligence, look at some trends in Artificial Intelligence, treat some of the trends in more detail, and discuss a number of case studies and applications. Due to the nature of the subject, we cannot be exhaustive, but rather want to give a feeling for research in the field of Artificial Intelligence.

1.1. Definition of Artificial Intelligence

The prospect of creating intelligent computers has fascinated many people for as long as computers have been around and, as we shall see in the historic overview, the first hints in the direction of Artificial Intelligence date even before that. But what do we mean by Artificial Intelligence, if even the term intelligence itself is difficult to define?

The precise definition and meaning of the word intelligence, and even more so of Artificial Intelligence, is the subject of much discussion and has caused a lot of confusion. One dictionary alone, for example, gives four definitions of Artificial Intelligence:

- An area of study in the field of computer science. Artificial intelligence is concerned with the development of computers able to engage in human-like thought processes such as learning, reasoning, and self-correction.
- The concept that machines can be improved to assume some capabilities normally thought to be like human intelligence such as learning, adapting, self-correction, etc.
- The extension of human intelligence through the use of computers, as in times past physical power was extended through the use of mechanical tools.
- In a restricted sense, the study of techniques to use computers more effectively by improved programming techniques.

(*The New International Webster's Comprehensive Dictionary of the English Language, EncyclopedicEdition*)

The definitions have also changed in the course of time, due to the rapid developments. Definitions that are more recent speak of "imitating intelligent human behavior," which is already a much stronger definition.

For some time now, the Artificial Intelligence community has been trying to imitate intelligent behavior with computer programs. This is not an easy task because a computer program must be able to do many different things in order to be called intelligent.

Instead of looking at a general definition of Artificial Intelligence, one can also restrict oneself to the definition of artificially intelligent systems. There are many definitions around, but most of them can be classified into the following four categories:

- systems that think like humans
- systems that act like humans
- systems that think rationally
- systems that act rationally.

1.2. The Turing Test

If we have a system, how can we check that it is (artificially) intelligent? Or is there a difference between humans and computers, as far as intelligence is concerned? Alan

Turing has proposed a game that can be played in order to answer the question "Can a machine think?" This imitation game is now known as the Turing test. Turing himself described this test as follows:

It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either "X is A and Y is B" or "X is B and Y is A".
[. . .]

We now ask the question: "What will happen when a machine takes the part of A in this game?" Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace the original question "Can machines think?"

Of course, the set-up of the test should make it impossible to decide who is who by measuring response-time, voice characteristics, or similar criteria. The Turing test is controversial because many believe it is possible to deceive C without having a "really" intelligent program, but at least it provides us with some criterion.

To pass the Turing test, a computer would need at least the following skills:

- *Natural language processing:* it needs to be able to communicate in a natural language like English.
- *Knowledge representation:* it needs to be able to have knowledge and to store it somewhere.
- *Automated reasoning:* it needs to be able to do reasoning based on the stored knowledge.
- *Machine learning:* it needs to be able to learn from its environment.

1.3. Final Introductory Remarks

The traditional ways of designing intelligent systems, like rule-based systems, never achieved the results that were expected at the time people started to realize that computers could be used for more than just calculating numbers. So far, it has not been possible to construct a set of rules that is capable of showing really intelligent behavior. There are some expert systems able to compete on a specialist-level in narrow areas, but there is no general AI program yet that is capable of functioning in everyday situations. It is said that "Expert systems know everything about almost nothing," which means among other things that they are quite different from human experts. However, in practice, many systems use AI techniques, and in this sense the AI community has made quite a big impact without reaching the original goals (yet). Also, note the fact that a person who can play chess at a high level is usually considered very intelligent, independent of his or her other achievements.

AI has always had its showcases. Playing games, chess in particular, has always been the "fruit fly of AI," to borrow a phrase from the Russian AI researcher A. Alexander

Kronrod quoted by one of the founding fathers of AI, John McCarthy (the fruit fly was indeed studied extensively by the geneticists). Indeed, programs are now quite well able to play games like chess. Another showcase is the field of robotics. Here one can try various AI algorithms, for example in steering robots that play soccer. In the international RoboCup competition, teams compete each year in a number of leagues (see Section 5.4).

The overview of the later parts of the article is as follows. In Section 3, we shall discuss some recent trends in Artificial Intelligence. In Section 4, we note that AI consists of many different techniques; we will briefly mention these techniques, which are explored further in subsequent articles. We will give the central area of Natural Computation some more attention. Section 5 discusses some case studies. Finally, we will provide some concluding remarks and references. But first, we shall give a short overview of Artificial Intelligence's history.

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Biographical Sketches

Walter Kosters is a researcher at LIACS, the Computer Science department of Universiteit Leiden. His PhD thesis in the field of mathematics (1985, Universiteit Leiden, the Netherlands) is entitled Harmonic Analysis on Symmetric Spaces. Later on he became interested in computer science, in particular analysis of algorithms and Artificial Intelligence. His current research interests include heaps, genetic algorithms, neural networks, data mining, and concrete mathematics.

Joost Kok is professor at Leiden University. He has worked at the Free University in Amsterdam, at the Centre for Mathematics and Computer Science in Amsterdam, at Utrecht University, and at the Åbo Akademi University (Finland). Currently, he is the head of the group Algorithms and Foundations of Programming, and Director of Computer Science Education at Leiden University. He is currently the President of the Dutch/Belgium AI society, docent at the computer science department of the Åbo Akademi University, advisor at the Centre for Mathematics and Computer Science, and member of the editorial board of Fundamenta Informaticae, associate editor of Natural Computing journal, and editor of the Series on Natural Computing of Springer Verlag.

His research is concentrated around the topics of co-ordination, optimization and data mining.

- Co-ordination. Software systems are difficult to maintain due to their inherent complexity. Co-ordination of components in Software Systems studies how complex systems can be constructed from components using a clear distinction between individual components and their co-ordinated interaction.
- Optimization. Many problems can be described as an optimization problem in which, within certain constraints, optimal values have to be found for the variables. The techniques that are used are stemming from Simulated Evolution, in particular from Evolutionary Computation. Research is being done on the development of new algorithms, on the applicability on benchmark problems and on concrete "real-life" cases.
- Data Mining. Data Mining looks for hidden patterns in large amounts of data. The focus is on association rules and on techniques from the area of Natural Computation.

Peter van der Putten is Senior Research Scientist at Frictionless Commerce Inc., Cambridge, USA (http:// www. frictionless.com), where he is responsible for decision support, data mining and analysis. Before that he was part-time (0.7) consultant at Sentient Machine Research, Amsterdam, the Netherlands and part-time (0.3) researcher; leading to a Ph.D. at the Leiden Institute of Advanced Computer Science, Leiden University. His research interests include automation of data mining algorithms and meta learning; neural networks, nearest neighbor and naive algorithms; business applications of data mining; and agent mediated e-markets, b2b e-commerce and e-sourcing. Currently he is working on a special project in the area of using data fusion for data mining and personalization. Data fusion algorithms provide the ability to link customer information from different sources, so that there is more integrated data to mine in.

Mannes Poel is faculty member of the Department of Computer Science of the University of Twente, the Netherlands. He received his Ph.D. in Mathematics from the University of Utrecht. After his Ph.D. he was visitor at MIT. His current research interests are design and verification of neural networks and AI-systems.

Egbert Boers is a Ph.D. researcher at Leiden University. His main research interest is Artificial Intelligence, and more particularly neural networks. He has been employed at NLR, the Dutch National Aerospace Laboratory.