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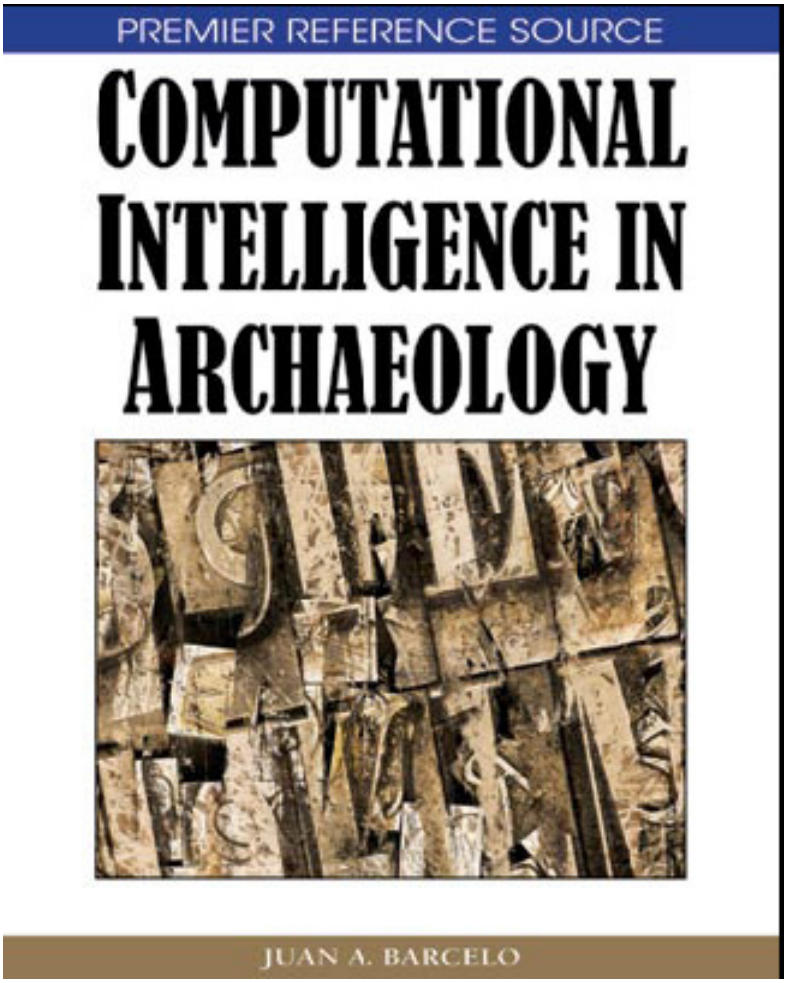
Computational Intelligence in Archaeology



Is it possible to build a machine to research archaeology? Will this machine be capable of acting like a scientist? Will this machine be capable of understanding how humans act, or how humans think they acted in the Past? This book tries to offer some possible solutions to these questions and to investigate what does it means to solve "automatically" archaeological problems.

Juan A. Barceló is archaeologist, and he is specialised in research in archaeological techniques and theory. He has developped computer applications in archaeology, notably in the domains of Spatial Analysis, Statistics, Artificial Intelligence and Computer aided Visualization. As archaeologist he has done excavations in Spain, Portugal, Italy, Syria, Nicaragua and Argentina.

It is important to realize that any formal definition of an automaton includes both human beings and the so called "intelligent" robots within the same reference class. In the specific case of scientific method, thinking can be construed as manipulating or processing information, whereas performing computations on strings of digits is the way the computer process information.

Here I am assuming that explanations are for our automatic archaeology machine a form of behaviour (Donahoe and Palmer 1994, Kirsch and Maglio 1995). If the human archaeologist has eyes, ears, and other organs for sensors and a brain, together with other body parts for actuators, then robotic archaeologists might have cameras and infrared range finders for sensors and a computer program for cognitive activity. A human has input senses, a muscular output and a cognitive ability to use this to great effect (excavating old sites, drawing finds, interpreting data, teaching archaeology, etc.). The automated archaeologist receives numbers, file contents as sensory inputs and acts on the environment by displaying on the screen, writing files. Although a human has an inner structure of wondrous complexity, which is the seat of consciousness and intelligence, mathematically even the best of us can be described as an automaton.

The so called "intelligent" machines incite instinctive fear and anger by resembling ancestral threats -a rival for our social position as more or less respected specialists. But robots are here, around us. I've never heard of a claim against wash machines selecting "intelligently" the best way to wash a specific tissue, or a photo camera with an "intelligent" device measuring luminance and deciding by itself the parameters to take the picture. So, why to have fear of a machine classifying a prehistoric tool and deciding "intelligently" its origin, function and/or chronology? Rather than use intuition as the sole guide for formulating explanations of past human behavior, we need a theory of why a specific computation or a group of related computations should be performed by a system that has certain abilities.

The discussion is between what is considered an artificial way of reasoning (computer programs), and a natural way of reasoning (verbal narrative). Critics of computationalism insist that we should not confound scientific statements with predicate logic operations, since discursive practices or argumentations observed in a scientific text are not "formal". By that reason, they are tributary, to a certain extent, from the Natural Language and the narrative structure (literary) of which scientific texts derive. I take the opposite approach: scientific problem solving stems from the acquisition of knowledge from a specific environment, the manipulation of such knowledge, and the intervention in the real world with the manipulated knowledge. The more exhaustive and better structured the knowledge base, the more it emulates a Scientific Theory and the easier will be the solution to the scientific problem, and more adequate the interpretations we get.

My personal approach is based on a fact that archaeologist couldn't evaluate 15 years ago: Computer programs do work in real science, not only in archaeology. Maybe they are more successful in other "harder" sciences (see Liao 2003, 2005), but we cannot deduce from this fact that Archaeology is a different kind of science. We should instead rebuild archaeology.

Simulating or reproducing the way archaeologists think today is not the guide to understand archaeology, because we are doing archaeology in the wrong way! Computable archaeology –if you do not like the expression "automatic archaeology" is the proper way of exploring new ways of thinking old concepts.

In other scientific domains the performance of humans at a particular task has been used to design a robot that can do the same task in the same manner (and as well) (Moravec 1999, Nolfi and Floreano 2000, Bryant et al. 2001, Murphy 2002, Florian 2002, Santore and Shapiro 2004, Kovacs and Ueno 2005, Trafton et al., 2004, King et al. 2004, Tamburrini and Datteri 2005, Datteri and Tamburrini 2005). In many different domains it has been shown how 'robot scientists' can interpret experiments without any human help. Such robots generate a set of hypotheses from what it is known about a scientific domain, and then design experiments to test them. That is, a robot scientist can formulate theories, carry out experiments and interpret results. The Robot Scientist can infer hypotheses to explain observations, infer experiments that will discriminate between these hypotheses, actually do the experiments and understand the results (Bryant et al. 2001, King et al. 2004). Consequently, the design of an automated archaeologist should not be considered a mere science fiction tale. It is a technological reality.

Research in cognitive robotics is concerned with endowing robots and software agents with higher level cognitive functions that enable them to reason, act and perceive in changing, incompletely known, and unpredictable environments. Such robots must, for example, be able to reason about goals, actions, when to perceive and what to look for, the cognitive states of other agents, time, collaborative task execution, etc. In short, cognitive robotics is concerned with integrating reasoning, perception and action within a uniform theoretical and implementation framework. The question of whether it is possible to such machines to automate the scientific process should be of both great theoretical interest and increasing practical importance because, in many scientific areas, data are being generated much faster than they can be effectively analyzed.

Don’t panic! I am not arguing that an artificial archaeologist will substitute human archaeologists, because it works better and cheaper than us. Nevertheless, computer-based models mimic human behaviour, and therefore they are good models of behaviour rather than models of brains or minds.

I have tried to create an analogy with an "intelligent" machine, to understand the way we think. In so saying, I am not arguing that artificial archaeologists (computer programs) run like human brains or that computer representations should be isomorphic to “mental” states. I am not pretending to simulate me, when I am doing archaeology, but to create something different. I want to understand mental processes by understanding the underlying abstract causal nature behind brain function. This structure can be understood objectively and duplicated in different materials-in computers, for example. If a computer can be programmed to perform human-like tasks it offers a “model” of the human activity that is less open to argument than the empirical explanations that are normal in philosophy. The purpose is to understand how intelligent behaviour in archaeology is possible. I have suggested building our "virtual" automatic archaeologist in such a way that the shortcomings of natural archaeology be avoided.

This work resumes almost ten years of research on computational techniques for scientific visualization and artificial intelligence applied on archaeological research.

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References

"Computational Intelligence in Archaeology". Juan A. Barceló, IGI Global, Information Science Reference, Henshey (VA), USA), 436 pp. , july 1, 2008.

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