Chapter 72
What Is an Algorithm?
Traditional vs. Intelligent Algorithms

Julia de Miguel
The London School of Economics and Political Science, UK

J. Ángel Velázquez-Iturbide
https://orcid.org/0000-0002-9486-8526
Universidad Rey Juan Carlos, Spain

ABSTRACT

Algorithms have emerged in past years as an object of public interest and debate. However, this term is used to name very different conceptions. The chapter presents the different definitions of the term "algorithm," especially the traditional conception of algorithms as used in informatics and the novel conception of (intelligent) algorithms that have emerged in the last years. The main contribution of the chapter is the characterization of both types of algorithms in terms of the problems they are intended to solve. Furthermore, the chapter contributes by analyzing other uses of the word "algorithm" where it is an inadequate term. Finally, the chapter discusses misconceptions on algorithms present in other disciplines, which is an obstacle to mutual understanding and a source of mismatch between the disciplines.

INTRODUCTION

In the last few years, "algorithm" has become a trendy word, even almost a buzzword. In the past, it was almost exclusively limited to the informatics[1] community, whereas it has now been extended to many application areas with high social impact and polarized debates (Burrell, 2016). The main contribution of the chapter is to clarify the features of both types of algorithms. The elements and properties that characterize each kind of algorithm are identified, as well as their similarities and differences. Moreover, the purpose of this chapter is to provide a comprehensive overview of the different meanings of the word "algorithm". Consequently, another contribution of the chapter is to identify several situations where there is an abuse of the word "algorithm" by either communication media or researchers, and where an alternative term would be more informative. Finally, it is also noted that conceptions of algorithms vary within the disciplines.

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The structure of the chapter is as follows. The background section presents a short historical introduction to algorithms. The focus section contains the bulk of the chapter, with a detailed analysis of different types of algorithms and non-algorithms, and an emphasis on "traditional" algorithms and the emerging "intelligent" algorithms. The directions for research identifies the most current research trends, especially related to intelligent algorithms. A short conclusions section closes the chapter.

BACKGROUND

The word "algorithm" seems to derive from the name of the ninth-century Persian mathematician al-Khwarizmi (Knuth, 1985), altered under the influence of the Greek word "arithmos" (i.e., number)[2]. However, the word has a long tradition, first in mathematics and later in informatics. Along the centuries, mathematicians have proposed different methods to solve mathematical problems, which are precise enough to be considered algorithms. Although algorithms can be traced back to the Babylonians (Knuth, 1972), the oldest algorithms with a name are Greek, e.g., the sieve of Eratosthenes or Euclid's algorithm. In subsequent centuries, the mathematicians elaborated many algorithms, mainly calculation formulae (e.g., how to solve a second-order equation) and precise methods (e.g., Gauss-Seidel method to solve systems of linear equations).

However, it was with the advent of computers that algorithms were studied systematically. Furthermore, their scope was widened from mathematical problems to information processing problems, such as sorting the elements in a sequence. Some authors even consider that "*computer science is primarily the study of algorithms*" (Knuth, 1985). Moreover, the possibility of automatically applying the algorithms by means of computers gave rise to some concerns on algorithms that did not exist previously, mainly the analysis of their efficiency (in their use of time and space) and the theoretical issues of computability and tractability.

The high relevance of algorithms within informatics was early reflected on curricula. Thus, the Association for Computing Machinery (ACM) Curriculum 68 (Atchison et al., 1968) had a first course B1, "Introduction to computing", with the following initial descriptor: "*algorithms, programs, and computers*". About twenty years later, the ACM and the Computer Society of the Institute of Electrical and Electronics Engineers (IEEE-CS) joined forces to develop curricular recommendations. The Denning report (Denning et al., 1989) was the first tangible outcome of this collaboration, setting the bases for future recommendations. It identified nine subareas of informatics, being "algorithms and data structures" the first one. It is introduced in the following way: "*This area deals with specific classes of problems and their efficient solutions. Fundamental questions include: For given classes of problems, what are the best algorithms? (…) How general are algorithms – i.e., what classes of problems can be dealt with by similar methods?*" This relevant situation did not change in subsequent curricular recommendations for computer science (e.g., ACM & IEEE-CS, 2013).

In parallel, research on algorithms and their properties was acknowledged as one of the fields of informatics for decades. It comprises both theoretical elaborations (notably, the theory of computability and complexity), mathematical and experimental methods to analyze algorithms with respect to clearly defined criteria, a corpus of efficient algorithms for highly relevant problems, and methodical approaches to algorithm design.