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History by Algorithms

AI and the Future of Historical Research

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Preface

Herodotus of Halicarnassus, the Father of History, first recorded history "so that the actions of people will not fade with time, including other things and especially the cause for which they went to war with one another." In our current age of big data, we record history as it happens and soon move on, overwhelmed by unprecedented modern documentation. History is a complex, evolving field that is rapidly expanding both in resources and accessibility. Our stories are buried while they are being written (Fig. 1).

Thus, the need for intelligent machines to understand our personal and cultural narratives becomes more imperative than ever. Having machines understand what our history is and why it happened would allow a dialogue that makes use of man's directing and machine's endless memory [1]. The first step to getting machines to understand narrative was taken in my book, *Analyzing Narratives in Social Networks*.

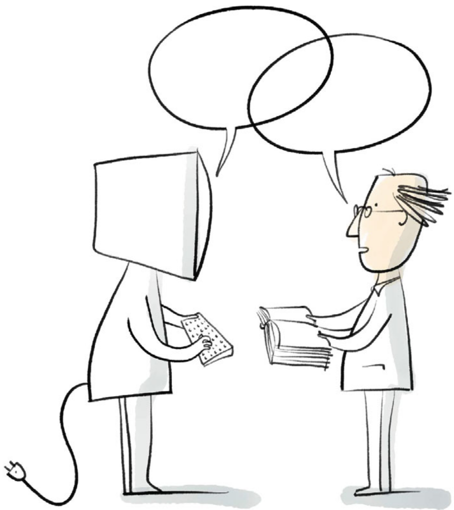

Fig. 1 Cartoon about a dialogue between man and machine about history

[2] We now propose to continue this journey into the different structure of never-ending stories: Historical narratives.

Overview

The book is divided into three main parts. In Part I, we discuss the mathematical language of history; Part II uses simple models to analyze historical law written in mathematical language; and the Part III discusses the implications of general Large Language Models (LLMs) for the study of history.

Synopsis

For machines to participate in the study of history, it is necessary to develop mathematical tools capable of describing historical narratives. In the first part of the book, we take the first steps toward achieving this goal. Tools such as big-O notation and the relative to history are discussed in Chap. 1.

We continue to develop mathematical tools needed to describe historical narrative in Chap. 2, where we discuss the implementation of Category Theory to the study of history and suggest that the definition of historical concepts should be defined using function diagrams and natural language definition simultaneously. For example, we use a function diagram to define reading against the grain. This approach reveals that reading against the grain actually compares past and present archives In our function diagram, we are forced to discuss the present as the element of comparison of the present to the past. This exact definition suggests that there is a reversed reading against the grain where the past archives try to read the future archives.

In Chap. 3, we develop the mathematical tools for describing battles, a central theme of history. We use the Lanchester differential equation in two-dimensional space-time and extend it for the case where one army surrounds another. This is the central element in the study of history and a typical narrative of great battles. Analyzing the Battle of Cannae led by Hannibal, we were able to study it in greater detail than ever before. Calculations were made using the extended Lanchester equation. The mathematical tools used in this chapter are differential equations, which are basic tools in exact science, but are rarely used in studying history.

In Chap. 4, we extend the concept of the counters into clocks. In many digital history research books, the counters are heavily used. The standard methodology is to define subsets of words and then count their appearance in the documents. From that, the researchers tend to conclude some facts about the document. However, there is no methodology for comparing these counters, and what is their meaning from a mathematical point of view? We identify those counters with clocks and develop the theory of many clocks with respect to historical narratives. We show how to find the time when the clocks deviate from each other. This method allows machines to point to the critical event in the historical narrative. This concludes Part I of the book, which develops the mathematical tools for historical narratives.

In Chap. 5, we introduce the concept of Networks and Macrohistory. We start with the definition of a network and provide several examples of graphs and their basic data structures. Then, we move to discuss some basic computational geometry with application to history. We end up this chapter with a causal graph.

In Chap. 6, we introduce Microhistory. We use social networks as a mathematical model that describes society. We develop several rules of thumb on social networks, which allow us to resurrect ancient networks only from the seizure of societies. This allows us to compare ancient social networks and compute the meaning of the destruction of old cities such as Carthage by the Romans. A social network is a mathematical model that describes the fabric of society and is therefore useful when one tries to model historical events.

Chapter 7 is the introduction to Part II of the book, where we discuss the implications of the historical narrative on mathematical language. The following chapters will provide several examples of historical processes that can be modeled using simple mathematical models and provide windows to the mathematical laws of history.

Chapter 8 discusses the historical question: Is the history of the core similar or different from the history of the periphery? This question is central to the philosophy of history since most of our data related to historical revolution/process is of the core, and we are missing the data of the periphery. By modeling the relationship between the core and periphery through social networks, we are able to categorize social revolutions and provide critical conditions on when the history of the core is relevant to the history of the periphery.

Chapter 9 provides an example of historical law that focuses on the author instead of the historical event. The law says that any tremendous historical figure needs an antipodal figure that will be compared to him and will be worth it. This law comes not from history but from the historical narrative. Therefore, the author of history tends to pick evil characters in history after the witness disappears. In the context of philosophy, this uses the fact that according to Kant, when we analyze reality, we always have to go through the perception of reality. In science, there is always reality and perception of reality. This chapter also discusses the connection between history and distributed computing. It mainly analyzes the ability of society to reach an agreement after the witnesses die through game theory and shows that it is necessary for collective memory to form the historical canonical text. Without the existence of a canonical historical text, the narrative will evaporate.

In Chap. 10, we analyze the conversion of the averaging process in the collective memory formation game and show that if the nodes have a correct categorization of their neighbors' opinions, the average process converges to the Nash equilibrium and can be used as a separate scheme that defines the different historical entities. A simple example is gun control in the USA. If you know a person's opinion about gun control, you can glean their political opinion.

In Chap. 11, we analyze the collective memory formation game in the case where some nodes have the wrong categorization of their neighbors' opinions. In such instances, the average process converges to zero opinion, and the historical event becomes unimportant. The different parties cannot disagree on the historical event using just the averaging process as the separation process. However, if we wish to use the historical events as a separation event, we need to move the averaging process away from zero. This can be done by amplifying the probabilities in each step to amount to 1. This suggests that propaganda is necessary to use such events as separation.

In Chap. 12, we model a stochastic terrorism network and explain the mechanism that generates random violence events using queuing theory.

Chapter 13 defines the general historical machine and sets the scene for generating history by machines. In the chapter, we define the relationship between historical entities, machines that write history, and the historical narrative. The central idea in this chapter is universal consciousness, which is the subject of historical narratives such as society, state, country, and more. This ends the second part of the book.

In Chap. 14, we begin the third part of the book, which explains how history transforms from text-based science to science based on information.

In Chap. 15, we provide a general introduction to machine learning and the way AI can be used in the study of digital history. The chapter is divided into two parts. The first part is a general discussion of AI and the way historians may use it. The second part discusses LLM and prompt engineering in general.

Chapter 16 deals with the new ways in which historical narrative can be represented. We move from textual-based to video-based historical narrative. The chapter provides several algorithmic methods to take any text and transform it into a video.

Chapter 17 explains how to use LLM as an expert system in historical text analyses. We provide several examples of expert systems, such as psychiatric experts, political science experts, and emotion analysis experts. We develop a method that takes any historical document, breaks it into paragraphs, transforms it into numerical values, aggregates those numbers into functions, and runs standard analysis tools on those functions. To demonstrate this method, we provide an analysis of Hitler's Mein Kampf [3] and Churchill's My Early Life [4].

In Chap. 18, we develop a methodology to analyze historical videos together with machine learning tools to study history.

Lastly, Chap. 19 discusses Fake History from the perspective of the philosophy of science. This chapter provides several rules of thumb for Fake History and its evolution.

Download Materials

Code and data from the book are available at https://github.com/zvilo/History-by-Algorithm. Any future updates to the materials will be made directly in the same GitHub repository.

Why Should You Read This Book?

Most of the books written about digital history synthesize the philosophy of history with technical details from computer science. However, digital history borrows many philosophical aspects from computer science.

According to McLuhan [5], the medium is the message. If that is the case, in digital history the message is the machine, since the machine is the medium. Therefore, to understand digital history, one needs to understand the philosophy of the machine.

This book tries to demonstrate how the philosophy of the machine, as developed by computer scientists, influences the study of digital history. Historians face technical difficulties when encountering the language of computer science for the first time. However, we believe that historians who wish to work in the area of digital history should be familiar not only with the philosophy of history but also with the philosophy of computer science, since digital history is the fusion of both disciplines.

To bridge the language barrier between historians and other readers with a humanities background, we provide several appendices filled with prompts that can be used to converse with modern AI tools. We believe that these prompts can ease the process of bridging the language gap, making the whole process possible.

Those with a background in exact sciences are much more familiar with the mathematical language used in the book. For them, reading the book should be easier. We hope that it will prompt them to develop the exact science of digital history.

One of the advantages of the book is that it exposes the reader to a variety of toolboxes from exact science that can be used during research in digital humanities. Most of the books in digital history study history using computer science programming languages. For example, many works are based on counting the frequency of specific words in historical texts. For now, let's call them "counters". However, none of them ask what the mathematical properties of these counters are and how we can compare them. The purpose of this book is not to analyze a historical text, but rather to develop the mathematical theory needed for doing digital history.

The main difference between exact science and the humanities is that while exact science tries to predict, the humanities try to interpret. This is the major obstacle when performing digital humanities. The problem is that once we transform the historical document from words to numbers, we may forget that we are still talking about interpretation, not prediction. Numbers tend to have a unique interpretation, and therefore the research tends to lose the freedom of interpretation. Researchers in digital humanities need to remember that in order to save the freedom of interpretation, we are forbidden to fully define how to transform the text into numbers. We should never forget that when we cross the bridge from text to numbers, we perform interpretation, and different bridges will generate different numbers, and therefore, we will have different interpretations. By understanding that transforming the text to numbers is an interpretation, we maintain the desired freedom of interpretation.

The book can be used as a textbook for a single-semester advanced course on digital history in the Faculty of Engineering.

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Contents

About the Author

Zvi Lotker is Full Professor in the Faculty of Engineering at Bar-Ilan University, Israel since 2018. He graduated with a double B.Sc. in Mathematics, Computer Science, and Industrial Engineering, from Ben Gurion University in 1991. In 1997, he obtained an M.Sc. in Mathematics, and in 2003, obtained his Ph.D. in Distributed Algorithms, both from Tel Aviv University. He was Postdoctoral Fellow at the CWI in Amsterdam, MPI in Saarbrücken Germany, and Mascotte in Nice France from 2003 to 2006. He was Full Professor in the Communication Systems Engineering department at Ben Gurion University in Beer Sheva in the Communication Systems Engineering department from 2010 to 2020. His main research areas are communication networks, online algorithms, sensor networks, and recently, social networks.

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