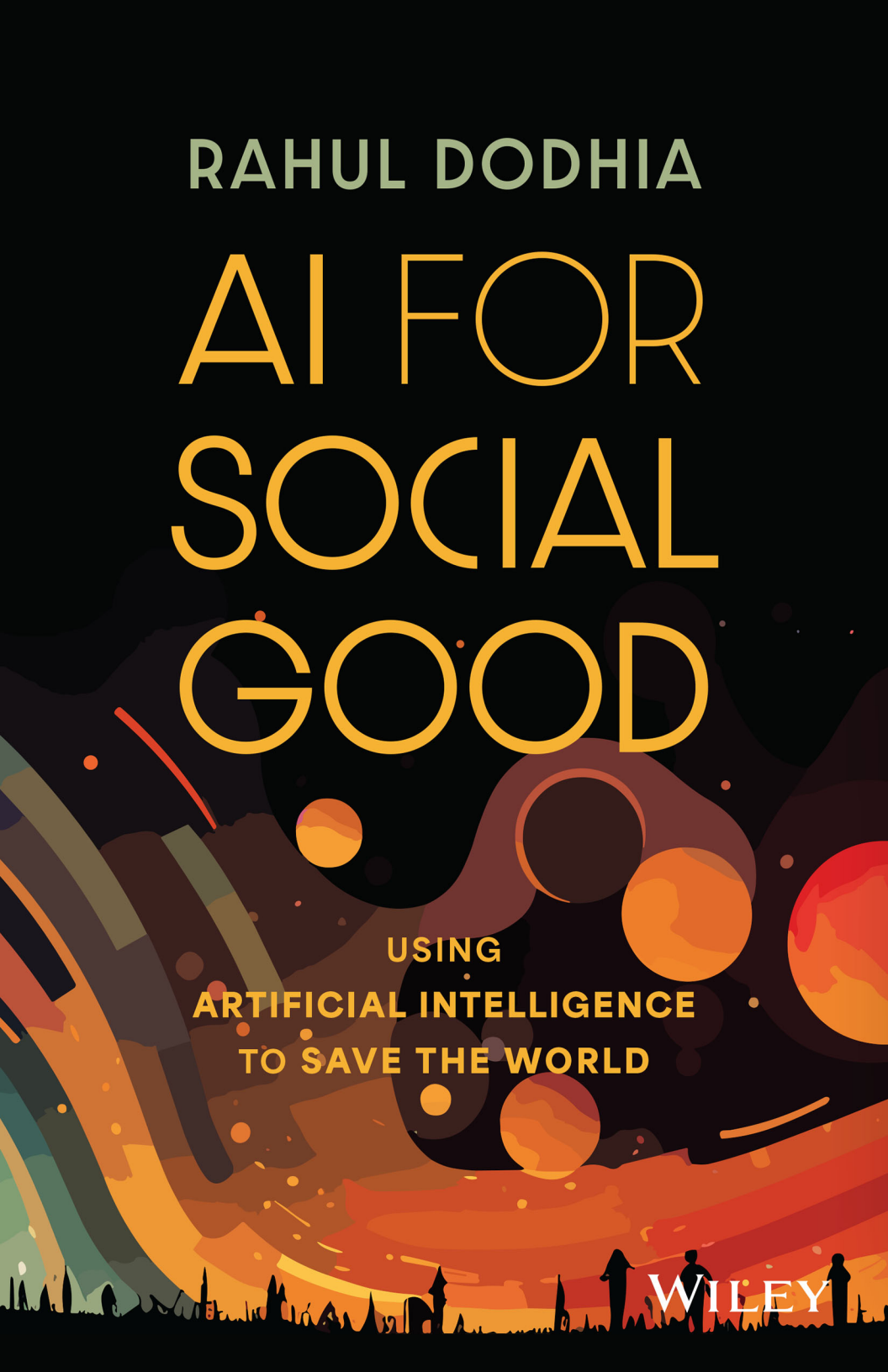
RAHUL DODHIA
AI FOR SOCIAL GOOD
USING ARTIFICIAL INTELLIGENCE TO SAVE THE WORLD
WILEY

Praise for *AI for Social Good*

An inspiring overview of what machine learning and artificial intelligence can already do to make the world better, and what can be done to use these tools more effectively.

—Andrew Gelman
Professor of Statistics and Political Science,
Columbia University

Our evolution has been an ascent toward increasing consciousness, with tools, fire, domestication of animals, and agriculture as stepping-stones along the way. Computers, the internet, and now AI have emerged rapidly to become a major part of the technological landscape. Rahul Dodhia's book *AI for Social Good* is a comprehensive exploration of this transformative field, which for technologically challenged non-experts like myself, brilliantly demystifies this exciting field. It leaves you with the hope that AI will be harnessed for the good of the planet and used ethically and responsibly. This book is a must-read for anyone interested in understanding AI's past and present, as well as its profound influence on the future of humanity on planet Earth.

—Louise Leakey
Paleoanthropologist,
Turkana Basin Institute, Kenya

In his important new book, leading AI practitioner Rahul Dodhia takes us on a highly accessible whirlwind tour of how AI works, what it can and cannot do, and why it sometimes goes off the rails. You will find inspirational stories on how AI can be used for good and cautionary tales that temper your hubris. Bringing his considerable experience to bear, Dodhia's compelling nuts-and-bolts discussion of how to set up teams that make the most of this potentially transformative technology is a must-read for anyone leading AI-based projects. This book has something in it for everyone seeking to understand and make the most of this rapidly evolving tool.

—Jacob N. Shapiro
Director, Empirical Studies of Conflict Project,
Princeton University

Just as the dawn of the nuclear age simultaneously shaped our hopes and our greatest fears for the future of the planet in the last century, so too for artificial intelligence in our century. The world's deeply vulnerable environment and its communities are at a crossroads: one path leading to ecosystem collapse, triggering extreme poverty and violence, the other toward balance and recovery. Our ability and determination to choose the right path are profoundly linked to the choices we make on the use of this nascent technology. In his writing, Rahul provides the critical thinking to channel our choices on the use of AI into a force for long overdue positive change.

—Emmanuel de Merode
Director of Virunga National Park

AI for Social Good is a compelling book that explores the responsible use of AI as a force for positive and transformative change. It offers a valuable guide for those interested in leveraging AI to tackle the urgent challenges of our time. Against the backdrop of our rapidly changing world and the unprecedented threats we face, the book provides concrete examples of how AI is already playing a crucial role in enhancing our understanding of, preparedness for, and response to global challenges. These examples range from the development of early warning systems for droughts and rapid disaster response programs to aiding decision-making in support of food and water security and the creation of innovative medical solutions.

Rahul, a prominent voice in the emerging AI for Social Good movement, underscores the potential of this rapidly advancing technology as an "essential ingredient in our efforts to create a better world for future generations."

His book offers an insightful overview of AI and its evolution, providing tangible examples of its diverse applications and ability to drive positive change. It underscores the critical importance of ethics and regulation in the field of AI and provides a glimpse into the future technologies that will further propel its applications and impact.

In an era where AI is both celebrated and met with significant apprehension, *AI for Social Good* serves as an excellent guide, offering practical advice, real-world examples, and a compelling vision for harnessing AI to address our most pressing challenges. It is an invaluable resource for anyone navigating the rapidly evolving AI landscape in the pursuit of societal betterment. It serves as a resounding call to action, encouraging individuals to become part of the movement for positive change.

—Inbal Becker-Reshef
Program Director of NASA Harvest

AI FOR SOCIAL GOOD

RAHUL DODHIA

AI FOR SOCIAL GOOD

USING ARTIFICIAL INTELLIGENCE TO SAVE THE WORLD

WILEY

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

Library of Congress Cataloging-in-Publication Data:

Names: Dodhia, Rahul, author.
Title: AI for social good / Rahul Dodhia.
Description: Hoboken, New Jersey : Wiley, [2024] | Includes index.
Identifiers: LCCN 2023047408 (print) | LCCN 2023047409 (ebook) | ISBN 9781394205783 (cloth) | ISBN 9781394205837 (adobe pdf) | ISBN 9781394205790 (epub)
Subjects: LCSH: Artificial intelligence—Moral and ethical aspects.
Classification: LCC Q334.7 .D634 2024 (print) | LCC Q334.7 (ebook) | DDC 174/.90063—dc23/eng/20231103
LC record available at https://lccn.loc.gov/2023047408
LC ebook record available at https://lccn.loc.gov/2023047409

Cover Design: C. Wallace
Cover Image: © EpicEtch / Adobe Stock
Author Photo: Courtesy of the Author

Dedicated to my late mother, whose memory still guides me, and my father, who taught me compassion and to care for the world.

Contents

Acknowledgments

MANY OF THE examples in the book come from projects led by past and present members of the AI for Good Research Lab. Their intelligence and dedication to improving the world around them inspire me every day. For the work they have done, thanks to Anthony Ortiz, Zhongqi Miao, Caleb Robinson, Meghana Kshirsagar, Simone Fobi Nsutezo, Juan Lavista Ferres, Shahrzad Gholami, Felipe Oviedo, Thomas Roca, Akram Zaytar, Gilles Hacheme, Lucas Meyer, Girmaw Abebe Tadesse, Md Nasir, Mayana Pereira, Yixi Xu, Darren Tanner, Amrita Gupta, Will Fein, Tammy Glazer, Anusua Trivedi, Siyu Yang, Ming Zhong, Hyojin Song, Sumit Mukherjee, and John Kahan.

Thanks also to Dan Morris, who personifies the AI for Good ethos, and Cameron Birge, who helped bring about several of the projects discussed in the book. And special thanks to the larger AI for Good Lab at Microsoft, of

which the Research Lab is a part, for continually fueling the momentum of the AI for Social Good movement.

Finally, thanks are also due to my daughter, Arya, for her inquisitive nature that keeps me on my toes and her frequent wrestling matches, providing much-needed screen breaks. I also owe gratitude to my wife, Annette de Soto, who reviewed this book and offered questions, revisions, and a close reading of the text honed from too many years at the University of Chicago.

About the Author

Rahul Dodhia heads the AI for Good Research Lab at Microsoft, based in Redmond, Washington. He leads a team of AI researchers dedicated to addressing global challenges using artificial intelligence. His work focuses on sustainability, humanitarian action, and health issues, paying special attention to climate adaptation in the Global South.

Prior to his current role, he led machine learning teams at several corporations, including eBay, Amazon, and Expedia. He also served at the NASA Ames Research Center, where he applied foundational research on human memory to address safety concerns in general aviation and space flight.

Rahul's undergraduate education was at Brandeis University, earning a BA in Mathematics, with the highest honors, summa cum laude. His journey into the world of artificial intelligence began during his graduate studies

in the psychology department at Columbia University. He conducted extensive research on human memory and decision-making models there, ultimately earning his PhD.

Rahul grew up in Thika, Kenya, a place that has seen profound ecological change. In addition to his research interests, he was a competitive sheepherder with his beloved Border collie, Artoo Dogtoo.

Introduction

In 2022, the world was horrified by the earthquake that devastated Turkey and Syria. Like many people around the world, my team at Microsoft, the AI for Good Research Lab, wondered how we could help from so far away. Having previously utilized satellite imagery to identify areas of destruction, the Lab sprang into action, providing maps of areas in need to the authorities. When the historic town of Lahaina in Hawaii was engulfed in flames the following year, we supported the American Red Cross with maps with localized estimates of destruction, enabling them to disburse aid in record time to those most in need. Meanwhile, in drought and locust-stricken Kenya, we collaborated with the Nature Conservancy to identify smallholder farms and devise irrigation solutions. In the United States, as disinformation endangered lives and democracy, we developed tools to assess and trace the origins of false information. These initiatives all had in

common new computing tools developed within the last few years: artificial intelligence that mimicked the neuronal processes of living brains.

At Microsoft's AI for Good Research Lab, my team dedicates itself daily to tackling humanity's global challenges using artificial intelligence. Despite numerous instances of AI being employed for positive purposes, many remain unaware of this side of the story of AI. Inspired by the work of the Lab, I wrote *AI for Social Good* for those looking to grasp the basics of AI and its real-world applications that affect positive change in society. The book clarifies AI concepts and offers a lucid and direct explanation of the technology and its numerous applications for positive impact. Whether you are new to the AI world or already working with AI, I hope this book will enhance your understanding and spark innovative applications of AI for the greater good.

Interest in artificial intelligence surged in 2023, catalyzed by the remarkable launch of ChatGPT. For generations that grew up with narratives of robots and computers with human-like intelligence, it appeared as if the future had finally arrived. However, admiration for large language models like ChatGPT has been dampened by their inclination to lead people astray. Concerns about AI's rapid, unchecked development have become louder, and respected AI researchers and leaders in technology have joined in with warnings that technology is advancing at a pace greater than our ability to absorb it. The speed at which AI is evolving makes it difficult to accurately predict its outcomes, underscoring the urgent need for a comprehensive set of guidelines to navigate this uncharted territory. Many of us are now advocating for

the incorporation of ethical principles at the heart of AI development.

All of this is unfolding against a backdrop of significant transformation in the global ecosystem. Beyond perennial issues, such as employment and livelihoods, exacerbated by fears of AI usurping them, we are now also confronted with the challenges posed by climate change. Natural disasters may be growing more devastating, and food and water insecurity are rearing their ugly heads. This multitude of problems seemed overwhelming, but now AI offers some hope. We may be on the verge of discovering new solutions to these problems.

A movement that can be termed AI for Social Good has arisen to counter the dystopian narrative of AI that builds on fears of economic setbacks and global war. It manifests in various ways, from nonprofit organizations to private sector projects, from academic conferences to online communities. It is not an organized movement where members pay dues and have newsletters. But it captures the spirit of people who are troubled by what they see coming in the future, and it has been embraced by dedicated young people with a burning desire to be a part of the solution.

The book is structured to be read sequentially, but each chapter stands on its own so readers with particular interests can jump around. Here is a brief summary of each chapter.

Chapter 1 traces a brief history of artificial intelligence, how it arose from the early days of computing in the 19th century to its emergence, in fits and starts, within the last few decades. This foundation for understanding AI's development highlights key individual

achievements while acknowledging the collective efforts of their peers.

Chapter 2 is a textbook-style exposition of the components that constitute AI. It introduces the reader to the terms commonly used by practitioners of AI. Terms such as neural networks, machine learning, and large language models are explained here. The history of AI from the previous chapter is appended by more stories of how technical aspects of AI came into being.

Chapter 3 highlights AI's potential to drive positive change for the reader to envision novel ways in which AI can be harnessed to address the pressing issues of our time. Several examples of how AI is used for social good are given, with an emphasis on humanitarian and environmental issues. It explores how newly available data, such as satellite and drone images and recent advancements like foundation models for language, creates opportunities for breakthroughs in the challenges plaguing society.

Chapter 4 continues the discussion of AI for social good but focuses more on scientific endeavors. By showcasing the real-world applications and implications of AI in these crucial scientific domains, the chapter aims to enlighten the reader on the indispensable role of AI in addressing contemporary scientific challenges and advancing human knowledge. Examples from biodiversity, astronomy, and proteomics illustrate this impact. The reader is not expected to have prior knowledge of these fields, and Chapter 4 introduces their significance.

Chapter 5 dispels the notion of an AI utopia. It addresses the potential pitfalls of AI and explains the fears raised by prominent technologists, again with several examples. We look particularly at how AI can supercharge

propaganda and disinformation and how societal biases are mirrored in AI, a reflection of our own inclinations and actions. The chapter aims to foster a more nuanced understanding of the potential repercussions of AI, urging the reader to approach its development and deployment with a balanced perspective and a critical eye.

Chapter 6 elaborates on one of the book's central themes: AI development should be based on a core of ethics and agreed-upon standards. The need for regulation is necessary to mitigate the negative implications of AI. History shows us the need for reining in the more negative aspects of humanity, a sort of societal superego to balance the Id's baser instincts. This chapter explores the nuances of regulating AI by examining case studies and global approaches. It calls for international collaboration to establish guidelines protecting individual rights while allowing controlled experimentation. Core themes include transparency, consent, data security, algorithmic fairness, and human oversight for high-stakes decisions. Though an imperfect process, mindful governance of AI via laws, industry standards, and social norms is vital to realizing its benefits without unacceptable risks.

In **Chapter 7**, I draw on my experience running AI teams to offer practical advice for constructing effective teams, bridging knowledge gaps, and aligning technical capabilities with real-world utility. Developing impactful AI requires a team with diverse expertise, effective collaboration, and core roles like the project manager, domain expert, and AI expert who each contribute unique perspectives. Frequent communication and feedback loops ensure the AI model matches real-world requirements. However, challenges inevitably arise regarding data quality, model

accuracy, and ethical implications. A thoughtful, human-centric approach is crucial, with human oversight playing a pivotal role in deploying reliable AI.

Chapter 8, the last chapter, looks ahead to future technologies and the immense changes that AI might wreak on our society. We are merely at the beginning of our journey with a new form of intelligence, with technologies already in the pipeline, such as quantum computing and DNA storage, that could radically redefine our conception of what we think it means to be human.

This book aspires to disseminate innovative ideas and serve as a source of inspiration for those eager to harness the power of AI to address some of the most critical challenges facing society today. If this book leaves you eager for more, an upcoming book going deeper into the topics covered here will be coming soon. Authored by several members of the AI for Good Research Lab, it will be a non-technical but in-depth discussion of the projects the lab has undertaken.

1

A Brief History of Artificial Intelligence

"Artificial intelligence is growing up fast, as are robots whose facial expressions can elicit empathy and make your mirror neurons quiver."

– Diane Ackerman

"The science of today is the technology of tomorrow"

– Edward Teller

In 1997, IBM's Deep Blue computer famously defeated world chess champion Garry Kasparov in a six-game match. This event marked a major milestone in the development of AI, as it demonstrated that a machine could outthink a human in a complex game with countless possible moves. The jubilation felt on achieving such a feat was mixed with hand-wringing that the age of machines was about to eclipse the age of humankind. Kasparov himself could not believe a machine could have defeated him and insisted this was a modern version of the Mechanical Turk, a 19th century con where a small person hid inside a supposed automaton and played chess.[1,2] Despite these expressions of disbelief, the match captured the world's attention. Chess was, after all, an ancient game highly revered as an expression of human mental ability. This event sparked a new interest in the abilities of machines that could think and adapt and even outshine humans.

Nearly seven decades since the prefix "artificial" was attached to intelligence, we live on the cusp of one of the largest disruptions in human society. When the CEO of Google, Sundar Pichai, calls AI one of humanity's most profound inventions,[3] and other tech luminaries such as Bill Gates argue, "The development of AI is as fundamental as the creation of the microprocessor, the personal

computer, the Internet, and the mobile phone,"[4] and Elon Musk goes so far as to deem it potentially more dangerous than nuclear weapons,[5] it is hard to dismiss the furor around this new technology as hyperbole. We may indeed be living in a time of profound change.

Artificial intelligence's rise and awesome potential have been a topic of discussion among tech insiders for quite some time. Now, with the emergence of ChatGPT, a much greater slice of humanity is witnessing firsthand the impact of this technology in their daily lives. If there are skeptics questioning the impact and abilities of artificial intelligence, their doubts are certainly being challenged.

AI manifests in our lives in the form of self-driving cars, virtual assistants such as Alexa and Siri, and unprecedented information via search engines. It is even more prevalent behind the scenes, powering medical assistants, farming, and disaster response. AI developments are quickly transforming the way we work, communicate, and even think. The invention of the automobile changed landscapes and economies, while radio and telephone transformed communications and society. AI is poised to join these ranks of major disruptors in the coming years. We are witnessing the birth of a transformative force that will change how we make decisions and perceive the world around us.

However, the implications of this technological transformation are not without their challenges. There are concerns over privacy, security, and job displacement. Evidence shows that AI reflects some of society's worst habits, such as racial and societal bias. As AI continues to become more sophisticated and more integral to our lives, individuals and society must carefully consider its

ethical implications. With the proper safeguards in place, the undeniable benefits of AI could usher in a new era of progress and prosperity for all.

How Innovators Throughout History Paved the Way for Modern AI: From Babbage to Turing

Artificial intelligence was long the province of fiction, fantasy, folklore, and myth. Inanimate objects developing human-like intelligence and abilities beyond our own are common in the stories we share. From figures such as mystical golems in Jewish tales and enigmatic homunculi of the Middle Ages to the evil computer HAL in *2001: A Space Odyssey* and the iconic droids in *Star Wars*, these legends reflect our curiosity and desire to create intelligence in our image.

Next, we trace the broad outlines of AI's emergence, from early conceptualizations of universal calculating machines to the first manifestations of what we today call AI.

Charles Babbage

The first practical steps toward AI happened in the last 200 years. Charles Babbage (Figure 1.1) emerged as a seminal figure in the history of AI, revered by many as the progenitor of this field. Babbage, a brilliant mathematician and inventor, possessed an indomitable spirit, a penchant for spectacle, and an insatiable curiosity that led him to his brilliant achievements in computing.[6,7] His fascination with automatons mimicking human intelligence was sparked at age eight when his mother whisked

Figure 1.1 Drawing of Charles Babbage

Credit: The Illustrated London News / Wikimedia Commans / Public Domain.

him away to a museum of scientific artifacts and wonders. There, he saw an artful creation—a dancer cradling a bird—so exquisitely crafted that it appeared lifelike. From that moment forward, Babbage's destiny was irrevocably entwined with the pursuit of crafting machines capable of emulating human behavior.

In his late 20s in the early 1800s, Babbage designed the first mechanical computer, the Difference Engine. This groundbreaking machine could perform complex mathematical calculations, such as producing tables of logarithms.[8,9] Indulging his showman tendencies, Babbage delighted in donning extravagant attire as he showcased his creation to the venerable Royal Society in London and other esteemed venues across England.

Tales of his eccentricities, ranging from chasing musicians away from his abode when they impinged on his concentration to his fastidious craftsmanship, where gears and tools personally ground by him remained in use long after his death, embellished the legend of this extraordinary man.

The Difference Engine was never completed during Babbage's lifetime. It wasn't until the 1990s that it was finally built according to Babbage's design. It is on display at the London Science Museum, and a second one remains in the possession of a private donor who financed its creation.

Although Babbage was not able to see his design take life, it inspired his later, more audacious creation, the Analytical Engine. This was a much more ambitious endeavor, surpassing the Difference Engine in its versatility. Babbage intended it to be a general-purpose computing machine that could be instructed to perform any type of calculation. He envisioned tables of mathematical values being formulated, and these tables of values would inform calculations of things like dates of eclipses. Crucially, the Analytical Engine encompassed the fundamental duality of modern computers: the ability to store and process vast troves of data.

Regrettably, quarrels with his engineers and the drying up of funding meant that the Analytical Engine, like the earlier Difference Engine, was never built. It nevertheless stands as a major milestone in the history of computing. It was the first machine designed to be truly programmable. And it also helped to popularize the idea of artificial intelligence.

Ada Lovelace

Now recognized as the world's first computer programmer, Ada Lovelace (Figure 1.2) collaborated with Charles Babbage on his prototypes. When recounting the history of science and technology, the contributions of women have often been overlooked or underrepresented. But Ada Lovelace, daughter of the romantic poet Lord Byron and Anne Isabelle Milbanke, left her mark as indelibly as any male pioneer. Despite being born in the 19th century, when women's opportunities were limited, Ada Lovelace defied societal norms and fervently pursued her passion for mathematics and science. Her mother was responsible in large part for Ada's education. Seeking to shelter Ada from her father's perceived and infamous instabilities, she ensured Ada got a firm grounding in logic and mathematics.[10]

Figure 1.2 Ada Lovelace, watercolor painting, possibly by Alfred Edward Chalon in 1840

Credit: Science Museum Group / Wikimedia Commans / Public Domain.