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Review Article

Ada Lovelace: the Prophet of Computer Age

Pritha Rai

Student at B. Tech CSE 22, PCTE Institute of Engineering & Technology.

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E-mail Id:
pritharai873@gmail.com
Orcid Id:
https://orcid.org/0009-0002-4490-3183
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A B S T R A C T

Ada Lovelace, mathematician and the first computer programmer (1815-1852) was born in London, England. She was the first and the foremost pioneer of computer programming in the 19th century. This paper focuses on her works regarding the translation and notes of the working of Analytical Engine invented by Charles Babbage. For a woman with limited resources and living in a society where women's education was actively discouraged, she was not only the pioneer of computer evolution but also a torch bearer of women in technical fields for the next centuries. Studies were conducted to find an alternative but the first computer program created by her and the notes providing the limits and the expectations of the analytical engine remain the foundation of modern computing till date.

Keywords: Prophet, Computer, Women, Technical Fields, Modern Computing

Introduction

Ada Lovelace, born December 10, 1815, in now London, England was an English mathematician and an associate of Charles Babbage. She was the only child of Annabella Milbanke and the poet Lord Byron. Her mother insisted that Ada study mathematics and sciences.

At the age of 17, Lady Byron took Ada to Babbage's house. Where he showed off an invention of his, called the "Difference Machine," a tower of numbered wheels that could make reliable calculations with the turn of a handle. Ada, intrigued by the

incomplete prototype, struck up a correspondence with Babbage about its potential. The letters between them span from June 10, 1835, to August 12, 1852; he told her about his plans, and she wrote to him of her ambition.

Ada requested Babbage copies of the machine's blueprints, as she was determined to understand how it worked. She would then continue to visit factories with her mother to understand the working of steam driven machines.

In 1834, a year before Ada married, Babbage had begun to plan what he called an Analytical Engine—a proposed computing system that used punched cards to multiply and divide numbers and perform a variety of data tasks.

The analytical engine concept was completely groundbreaking, and a work of incredible genius on Babbage's part; it was the world's first programmable computer. In modern terms, the analytical engine would be described as Turing-complete. To be built using mechanical parts and powered by hand-cranking or steam!

In 1842, an Italian mathematician, Louis Menebrea, published a memoir in French on the subject of the Analytical Engine titled "Notions sur la machine analytique de Charles Babbage". Ada Lovelace decided to translate the memoirs of Louis Menebrea for Analytical Engine. It took nine months of hard work from 1842-43 to translate and provide notes of her own to it.

The memoirs by the French engineer were around 8000 words while the translation by Lady Lovelace and her notes account for triple the original document. She provided seven notes to the translation.

Lady Lovelace wrote letters to Babbage almost every day asking questions, showing her work while he would

reply with comments and answers. Through the letters it seems that Ada understood she was in charge of bringing Babbage's Analytical Engine to the upfront, hence she was very cautious of what she was including in the papers.

Ada had a general idea of what the Analytical Engine was and what it could be capable of in the future. Both the limitations and advantages hence her notes embodied constructive visions of this engine:

Again, it [the Analytical Engine] might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and which should be also susceptible of adaptations to the action of the operating notation and mechanism of the engine . . . Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent.

Quoted from Note A, this annotation gives the engine a "metaphysical view". It was revolutionary at that moment to think of a machine that could work on operations apart from the mathematical calculations. As a matter of fact, when Babbage had the idea of Difference Engine and Analytical Engine it was out of sheer frustration from the errors of human calculations. She saw the potential of the machine and went on to describe it to be capable of not only working on abstract operations but also composing music.

Interestingly she explained the working of Difference Engine and what sets the Analytical Engine of Babbage's from the previous machine. The Difference Engine as she explained is designed to "tabulate accurately and to an unlimited extent, all series whose general term is integral of

$\Delta^7 u = 0$

It can also tabulate approximately between intervals of greater or less extent, all other series which are capable of tabulation by the Method of Difference."

Whereas she pointed out how the analytical engine can "develop and tabulate any function whatever…. [Analytical Engine] being the material expression of any indefinite function of any degree of generality and complexity, ...".

Lady Lovelace took reference of the Jacquard Loom to explain the mechanism of the engine. The Jacquard loom was controlled by punch cards, with one card equal to one row of the textile being woven. If the card was punched, the loom thread would be raised. If the card was not punched, the loom thread would be left alone. In other words, the punch cards issued instructions to the machine. They were a simple language, or putting it another way, machine code.

She explains the working of the punch cards through cases of functions and how "these cards contain within themselves … the law of development of the particular function that may be under consideration, and they may compel the mechanism to act accordingly in a certain corresponding order."

"The Analytical Engine," she said, "weaves algebraic patterns, just as the Jacquard-loom weaves flowers and leaves."

She has added a footnote to clarify the readers' doubts regarding the implementation of the cards and their classes.

In her famous Note G, she uses Bernoulli's Numbers to explain how actually the machine would work given such tricky questions. Initially she required some assistance from Babbage in order to figure out how to implement the calculation. He sent his work to Ada but she detected what Babbage himself called a 'grave error'. She created the Bernoulli Number Algorithm which became the world's first published computer program.

Apart from that her Note G is also controversial for her statement "The Analytical Engine has no pretensions whatsoever to originate anything. It can do whatever we know how to order it to perform. It can follow analysis; but it has no power of anticipating any analytical relations or truths."

Though Lady Lovelace was working on the invention of Charles Babbage, these notes help us understand that even Charles Babbage himself could not estimate the value of his machine the way Lovelace did.

Ada Lovelace had greater ambitions than to just translate and annotate the papers. She was never in the race of fame. Hence the translator of Menebrea's paper remained anonymous until the last page where she signed as A.A.L.

The Notes of Lovelace were forgotten until after a century being rediscovered by a Nuclear Physicist and Minister of Science and Education Bertram Bowden.

He penned a book about computers, "Faster Than Thought". He located the successor of Lovelace, the granddaughter Lady Wentworth. She provided him with some papers of Lovelace. Bowden republished her notes within his book in 1955.

On the other hand, Alan Turing in 1936 studied Lovelace's translations and Notes and inspired his work on the modern computers. It had come to his realisation that a century ago Babbage had already created the idea of a machinery that had met all the requirements of a modern universal computer from Arithmetic Logic Unit, conditional branching and loops, and integrated memory or then known as store.

In the 1980s the US Department of Defence decided to honour Ada Lovelace and her contributions to the modern

computing by naming a programming language after her. It was a boon for software development and still is used in secure software development even if in a niche group.

Ada had expressed her concern about the difficulty of the user not being able to communicate with the machine. Yet she envisioned a language such as ADA and its successor ADACORE

"A new, a vast and a powerful language is developed for the future use of analysis," she wrote, "in which to wield its truths so that these may become of more speedy and accurate practical application for the purposes of mankind."

In 2009 Suw Charman-Anderson founded the Ada Lovelace Day to celebrate the achievements of women in STEM on the second Tuesday of October every year. This day aims to promote and bring the spotlight on the women who were the engine of the society and yet unappreciated much.

Nvidia launched Lovelace GPU in honour of Ada Lovelace. It was powered by Ada Lovelace architecture which relies on AI to create realistic images in gaming. The Lovelace architecture is said to be "ideal for general-purpose, graphics-heavy workloads-… creating physically accurate lightning… building digital twins with NVIDIA's Omniverse Software Platform.

Recognition for Charles Babbage and Countess Ada Lovelace came late but today Babbage is recognised as the Father of Computer while Lovelace the Prophet of Computer Age.

Soon after the sketch of the analytical engine was published Ada Lovelace got sick.

She succumbed to uterine cancer on November 27, 1852 after staying bedridden for months at the age of 36 and was buried next to her father.

The Difference Engine I and II were later on built in the 1960s. But the Analytical Engine could never see the light of the day.

What if?

What if she did stay alive? Babbage continued to live on for the next 35 years. Babbage and Lovelace could not see the Analytical Engine come to life. Maybe it would have been otherwise if she were alive.

Lovelace had shown desires of reviewing other works of sciences too like that of Ohm's and Whewell. But her health did not cooperate.

Reading her letters to Babbage, her tutors Mary Sommerville, Augustus De Morgan and her husband William King one could deduce Lady Lovelace was invested in maths and sciences. That did not reduce her interest in arts and music.

After analysing her Notes, Turing mentioned Lady Lovelace's Objections in his 1950 paper "Computing Machinery and Intelligence." Referring to her rejecting the idea of computers having a mind of their own. Alan Turing stood in opposition of this idea and claimed that in a few years the machines could surpass human capabilities. The Lovelace Test was introduced in 2001 by Selmer Bringsjord, Paul Bello and David Ferrucci to prove her theory. In 2024, we still are not able to prove Lady Lovelace wrong. To prove Lovelace wrong, humanity has yet to create something which is not dependent upon human inputs, which might not be possible for the next 20-30 years.

AIs like ChatGPT, Bard and many more can learn and adapt but no AI, no matter how extensively fed with data can "think" on its own. The potential risk of inaccuracy of the AIs creates a mongering fear for how much we rely on it. It is possible for a specifically trained system to not respond correctly or go haywire.

She brought a revolution in technology in the 19th century when women excelling in technical fields was not something openly encouraged. Women still did not have the access to the Royal Library and men would mock women regarding their capabilities given the opportunity.

Lady Lovelace's contributions to the Analytical Engine were debated upon for years. People claimed she was rather a self-proclaimed genius. But the proofs of her contributions lay in the British Museum. To be capable of creating and envisioning a knowledge so advanced a century ahead was a feat that Babbage-Lovelace needed to get acknowledged for.

Conclusion

In conclusion, Ada Lovelace's remarkable contributions to the field of computing transcend her time and continue to shape our technological landscape today. Born into a society where women's education was discouraged, Lovelace defied expectations and became a pioneer in mathematics and computer programming. Her collaboration with Charles Babbage on the Analytical Engine laid the foundation for modern computing, as she not only translated and annotated its workings but also conceived of its potential applications far beyond mathematical calculations.

Lovelace's insights into the Analytical Engine's capabilities, including its potential to process abstract operations and even compose music, demonstrated her visionary thinking. Her creation of the world's first published computer program, based on the Bernoulli Number Algorithm, exemplifies her technical prowess and innovation. Despite facing skepticism and being overshadowed in her time,

Lovelace's work was later recognized and celebrated, inspiring subsequent generations of computer scientists and engineers.

The impact of Lovelace's contributions extends beyond her era, influencing figures like Alan Turing and shaping the development of modern computing languages such as ADA. Her legacy is honored through events like Ada Lovelace Day, which celebrates the achievements of women in STEM fields, and through technological advancements like the Ada Lovelace architecture in GPUs.

As we continue to grapple with the complexities of artificial intelligence and machine learning, Lovelace's cautionary insights about the limitations of machines to "think" autonomously remain relevant. Her foresight reminds us of the importance of responsible innovation and the ongoing need for human oversight in technology development.

In recognizing Ada Lovelace as the Prophet of the Computer Age, we acknowledge not only her pioneering intellect but also her enduring impact on shaping the future of technology and society. Her story serves as a testament to the transformative power of determination, creativity, and foresight in the face of adversity.

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