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Book review: Alan M. Turing, B. Jack Copeland (ed.), *The Essential Turing: The ideas that gave birth to the computer age*, New York: Oxford University Press, 2004, 613, 14.99 GBP, ISBN 0-19-825080-0.

Time magazine's "The Century's Greatest Minds" rated Turing up there with Einstein. In The Essential Turing, Professor B. Jack Copeland, the Director of the Turing Archive for the History of Computing and a renowned Turing scholar, delivers a sophisticated, compelling, and philosophically competent account for the role that Alan Mathison Turing has been playing in the information revolution.

There is little debate on Turing's contribution to the foundations of computer science. In 1936, the twenty-four years old Turing wrote 'On computable numbers', an article which at once laid the elements of computing and shaped the central and the most influential paradigm of the 20th century. Turing's theorem outlines the precise limits of mechanical and electronic computers. Although since 1936 generations of programming languages, transistors, printed circuits, and microprocessors came and went, and the computing power of digital computing machines has improved in at least four orders of magnitude, Turing's abstract computing machine has proven to be computationally equivalent to almost any conceivable digital computing machine, including the generations of electronic, biological, and quantum computers to come, the precise limits of which have carefully been laid out in Turing's paper.

Indeed, Since Turing wrote 'On computable numbers', software has become a central player in modern life: it governs the majority of communications and mass media, controls the sale and purchase of stocks in stock exchanges, counts votes in national elections, guides 'smart bombs' and operates machine guns, decides which vaccination our children receive, shortlists job applications, treats depression, operates artificial limbs, guides the navigation of automated and semi-automated vehicles, controls to some degree almost every single home appliance, and constitutes the subject matter of a growing proportion of scientific experiments. The prosperity of the 21st century industrialized (and industrializing) world has come to largely depend on cheap and efficient computing power. The most important constant emerging from these changes has been Turing's contributions. Notwithstanding the contributions made by Gödel, Church, Post, and Kleene, much of the theory of computing can be taken to be little more then footnotes to Turing's work.

The Essential Turing beautifully unravels Turing's role in this revolution well beyond theoretical computer science. Copeland treatment of each one of Turing's papers shows that Turing has also established

the central paradigms in artificial intelligence, artificial life, and the philosophy of mind. Turing's notion of abstract automata has also had profound implications on every branch of science, including psychology, physics, and genetics. Processes in any branch of science are first and foremost analyzed in terms of a turing automaton. In particular, Turing's automata were used to model the operation of quantum gates, DNA sequences, and even the process of intelligent thinking. Indeed, Turing automata have come be part of the *lingua franca* of the scientific investigation of every physical, chemical, biological, and psychological process that came under scrutiny

But Turing's contributions have gone even further. Turing's profound insights into the philosophy of mind, metaphysics, and science offer compelling answers to questions that have remained open: What are the possible consequences of running a computer program? Is there a limit to the extent to which the behaviour of computing machines can be predicted? Can machines be said to think? Can computers behave intelligently? For example, in 1950, having devised that which came to be known as Turing's Test (Ch. 11, "Computing Machinery and Intelligence"), Turing predicted that the day in which digital computing machines will pass for humans is near. Although Turing's time frame has proved somewhat inaccurate (see: (Moor 2000)), it has become evident that Turing is right to a large and ever increasing degree. Turing even foresaw the 'software crisis' twenty years before it was declared, suggesting already in 1950 that surprises are inherent to computer programming. These and additional snapshots from Turing's crystal ball are beautifully unravelled in The Essential Turing.

Copeland's edition is a first-class guide to Turing's canon. The anthology includes a complete, annotated version of every important manuscript that Turing wrote. Turing's manuscripts and Copeland's commentary thereof are organized into four sections, each of which is dedicated to Turing's contributions to a separate discipline: the foundations of computing, the construction of the Enigma computer during WWII, artificial intelligence, and artificial life. The anthology also includes a transcript of a BBC program from 1952 during which Turing spoke on the problems of thinking machines (Ch. 14, "Can Automatic Calculating Machines Be Said to Think?").

Although Turing wrote (and spoke) mostly plain and always very coherent English, the technical depth of his discussion may put the non-expert at a disadvantage. Difficulties in reading Turing may explain some of the common misinterpretations of Turing's work, which are subjected to Copeland's ruthless examination. In particular, Copeland wages a war on Church-Turing Fallacies. According to one, in 'On computable numbers' Turing has set limits to human intelligence. A

similar fallacy in physics takes Turing's work to suggest limits to the capabilities of any physical process processes of computation (the Maximality Thesis). Copeland closely examines each misconception and carefully refutes it. Copeland's effortless and skilful writing clarifies the precise nature of the difficult problems Turing tackled without trivializing them. He engages in translating Turing's conjectures into the language of contemporary science, thereby simplifying the technical parts of Turing's work and allowing the reader to appreciate Turing's work in full.

Copeland insightful, illuminating and very intelligent commentary also bracket Turing's work in historical context. As much of Turing's work is over 50 years old, the accompanying commentary helps the non-expert reader to bridge the time gap created by the evolution of the English language. For example, the naïve reader may mistake the 'computers' mentioned in "On computable Numbers" to stand for digital computing machines. This is an easy mistake to make, given that Turing has taken active part (and even a leading role, for example in the case of Enigma, discussed in the second part) in developing some of the very first digital computers. Contributing to this confusion are theorems which prove that Turing's notion of abstract automaton precisely defines the limits of computations performed by *any* digital computing machine. But as Copeland points out, the first digital computing machines came to existence only over a decade *after* Turing wrote 'On computable numbers'. Rather, the term 'computer' in this paper is taken to mean a person performing a task of computing which does not require imagination or creativity. As it turned out, Turing's analysis has set the limits to the technology which has evolved during the seven decades which followed in ways which nobody has envisaged. Evidently, Turing's prophetic power can come to full view only when such terminological nuances are established. Copeland's attention to detail is geared to root out any misconceptions arising from misreading Turing's words.

No bibliography on the foundations of computing is complete without The Essential Turing. This attractive package offers an essential text for any scholar of the history, philosophy, or the future of computing, and an excellent textbook for every academic programs concerned with philosophy of mind, artificial intelligence, or artificial life. Copeland's commentary effortless writing turns reading the works of the father of the digital age into a pleasure, making The Essential Turing an accessible bestseller in popular science.

References

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