# Turing And The Universal Machine Icon Science The Making Of The Modern Computer

In 1936, when he was just twenty-four years old, Alan Turing wrote a remarkable paper in which he outlined the theory of computation, laying out the ideas that underlie all modern computers. This groundbreaking and powerful theory now forms the basis of computer science. In Turing's Vision, Chris Bernhardt explains the theory, Turing's most important contribution, for the general reader. Bernhardt argues that the strength of Turing's theory is its simplicity, and that, explained in a straightforward manner, it is eminently understandable by the nonspecialist. As Marvin Minsky writes, "The sheer simplicity of the theory's foundation and extraordinary short path from this foundation to its logical and surprising conclusions give the theory a mathematical beauty that alone guarantees it a permanent place in computer theory." Bernhardt begins with the foundation and systematically builds to the surprising conclusions. He also views Turing's theory in the context of mathematical history, other views of computation (including those of Alonzo Church), Turing's later work, and the birth of the modern computer. In the paper, "On Computable Numbers, with an Application to the Entscheidungsproblem," Turing thinks carefully about how humans perform computation, breaking it down into a sequence of steps, and then constructs theoretical machines capable of performing each step. Turing wanted to show that there were problems that were beyond any computer's ability to solve; in particular, he wanted to find a decision problem that he could prove was undecidable. To explain Turing's ideas, Bernhardt examines three well-known decision problems to explore the concept of undecidability; investigates theoretical computing machines, including Turing machines; explains universal machines; and proves that certain problems are undecidable, including Turing's problem concerning computable numbers.

This book introduces two conceptual models of photography: the Turin Shroud and the universal Turing machine. The Turin Shroud inspires a discussion on photography’s frequently acclaimed ‘ontological privilege’, which has conditioned an understanding of photography as a sui generis breed of images wherein pictorial representation is coextensive with human vision. This is then contrasted with a discussion of the universal Turing machine, which integrates photography into a framework of media philosophy and algorithmic art. Here, photography becomes more than just the present-day sum of its depiction traditions, devices and dissemination networks. Rather, it is archetypical of multiple systems of abstraction and classification, and various other symbolic processes of transformation.

"On Computable Numbers, with an Application to the Entscheidungsproblema, Alan Turinga (TM)s paper of 1937, contained his thesis that every effective computation can be programmed on such an automation as that called Turing machine. Furthermore it proved the unsolvability of the halting problem and of the decision problem for first order logic, and it presented the invention of the universal Turing machine. It is that publication that will presumably be acknowledged as marking sub specie aeternitatis the beginning of the "computer agea . This volume recognizes the still continuing influence of the Turing machine concept by collecting contributions from international specialists in logic, computability, mathematics, biology, physics, linguistics, and cognitive science, thus signalling the exceptionally wide scope of that concept.

Volume 10 in the Babbage Reprint Series contains two archival papers by Alan Turing-the ACE report (1945), a seminal paper detailing the design for an electronic universal machine called the Automatic Computing Engine (ACE), and Turing's Lecture to the London Mathematical Society (1947) amplifying the ideas outlined in the ACE report. Turing's report was the first time that the notion of artificial intelligence was discussed as a real possibility and Turing went on to devote the next decade to AI. Michael Woodger's paper, The History and

Present Use of Digital Computers at the National Physical Laboratory (1958) gives a brief history of the construction of the pilot ACE, the first functional version of Turing's universal machine.

Chapters “Turing and Free Will: A New Take on an Old Debate” and “Turing and the History of Computer Music” are available open access under a Creative Commons Attribution 4.0 International License via link.springer.com.

This volume commemorates the work of Alan Turing, who not only introduced the most influential concept of a machine model of effective computability, but who also anticipated in his work the diversity of topics brought together here. Among his major contributions, Turing's "On Computable Numbers, With an Application to the Entscheidungsproblem," first published in 1937, is acknowledged as a landmark of the computer age. Part I of this volume explores historical aspects with essays on background, on Turing's work, and on subsequent developments. Part II contains an extensive series of essays on the influence and applications of these ideas in mathematics, mathematical logic, philosophy of mathematics, computer science, artificial intelligence, philosophy of language, philosophy of mind, and physics.

Alan Turing, pioneer of computing and WWII codebreaker, is one of the most important and influential thinkers of the twentieth century. In this volume for the first time his key writings are made available to a broad, non-specialist readership. They make fascinating reading both in their own right and for their historic significance: contemporary computational theory, cognitive science, artificial intelligence, and artificial life all spring from this ground-breaking work, which is also rich in philosophical and logical insight. An introduction by leading Turing expert Jack Copeland provides the background and guides the reader through the selection. About Alan Turing Alan Turing FRS OBE, (1912-1954) studied mathematics at King's College, Cambridge. He was elected a Fellow of King's in March 1935, at the age of only 22. In the same year he invented the abstract computing machines - now known simply as Turing machines - on which all subsequent stored-program digital computers are modelled. During 1936-1938 Turing continued his studies, now at Princeton University. He completed a PhD in mathematical logic, analysing the notion of 'intuition' in mathematics and introducing the idea of oracular computation, now fundamental in mathematical recursion theory. An 'oracle' is an abstract device able to solve mathematical problems too difficult for the universal Turing machine. In the summer of 1938 Turing returned to his Fellowship at King's. When WWII started in 1939 he joined the wartime headquarters of the Government Code and Cypher School (GC&CS) at Bletchley Park, Buckinghamshire. Building on earlier work by Polish cryptanalysts, Turing contributed crucially to the design of electro-mechanical machines ('bombes') used to decipher Enigma, the code by means of which the German armed forces sought to protect their radio communications. Turing's work on the version of Enigma used by the German navy was vital to the battle for supremacy in the North Atlantic. He also contributed to the attack on the cyphers known as 'Fish'. Based on binary teleprinter code, Fish was used during the latter part of the war in preference to morse-based Enigma for the encryption of high-level signals, for example messages from Hitler and other members of the German High Command. It is estimated that the work of GC&CS shortened the war in Europe by at least two years. Turing received the Order of the British Empire for the part he played. In 1945, the war over, Turing was recruited to the National Physical Laboratory (NPL) in London, his brief to design and develop an electronic computer - a concrete form of the universal Turing machine. Turing's report setting out his design for the Automatic Computing Engine (ACE) was the first relatively complete specification of an electronic stored-program general-purpose digital computer. Delays beyond Turing's control resulted in NPL's losing the race to build the world's first working electronic stored-program digital computer - an honour that went to the Royal Society Computing Machine Laboratory at Manchester University, in June 1948. Discouraged by the delays at NPL, Turing took up the Deputy Directorship of the Royal Society Computing Machine

Laboratory in that year. Turing was a founding father of modern cognitive science and a leading early exponent of the hypothesis that the human brain is in large part a digital computing machine, theorising that the cortex at birth is an 'unorganised machine' which through 'training' becomes organised 'into a universal machine or something like it'. He also pioneered Artificial Intelligence. Turing spent the rest of his short career at Manchester University, being appointed to a specially created Readership in the Theory of Computing in May 1953. He was elected a Fellow of the Royal Society of London in March 1951 (a high honour).

This book constitutes the thoroughly refereed post-conference proceedings of the 16th International Conference on DNA Computing and Molecular Programming, DNA16, held in Hong Kong, China, in June 2010. The 16 revised full papers presented were carefully selected during two rounds of reviewing and improvement from 59 submissions. The papers are well balanced between theoretical and experimental work and address all areas that relate to biomolecular computing, including demonstrations of biomolecular computing, theoretical models of biomolecular computing, biomolecular algorithms, computational processes in vitro and in vivo, analysis and theoretical models of laboratory techniques, biotechnological and other applications of DNA computing, DNA nanostructures, DNA devices such as DNA motors, DNA error evaluation and correction, in vitro evolution, molecular design, self-assembled systems, nucleic acid chemistry, and simulation tools.

This book presents a proof of universal computation in the Game of Life cellular automaton by using a Turing machine construction. It provides an introduction including background information and an extended review of the literature for Turing Machines, Counter Machines and the relevant patterns in Conway's Game of Life so that the subject matter is accessibly to non specialists. The book contains a description of the author’s Turing machine in Conway’s Game of Life including an unlimited storage tape provided by growing stack structures and it also presents a fast universal Turing machine designed to allow the working to be demonstrated in a convenient period of time.

The breathtakingly rapid pace of change in computing makes it easy to overlook the pioneers who began it all. Written by Martin Davis, respected logician and researcher in the theory of computation, The Universal Computer: The Road from Leibniz to Turing explores the fascinating lives, ideas, and discoveries of seven remarkable mathematicians. It tells the stories of the unsung heroes of the computer age – the logicians.

Written by a distinguished cast of contributors, Alan Turing: Life and Legacy of a Great Thinker is the definitive collection of essays in commemoration of the 90th birthday of Alan Turing. This fascinating text covers the rich facets of his life, thoughts, and legacy, but also sheds some light on the future of computing science with a chapter contributed by visionary Ray Kurzweil, winner of the 1999 National Medal of Technology. Further, important contributions come from the philosopher Daniel Dennett, the Turing biographer Andrew Hodges, and from the distinguished logician Martin Davis, who provides a first critical essay on an emerging and controversial field termed "hypercomputation".

The computer unlike other inventions is universal; you can use a computer for many tasks: writing, composing music, designing buildings, creating movies, inhabiting virtual worlds, communicating... This popular science history isn't just about technology but

introduces the pioneers: Babbage, Turing, Apple's Wozniak and Jobs, Bill Gates, Tim Berners-Lee, Mark Zuckerberg. This story is about people and the changes computers have caused. In the future ubiquitous computing, AI, quantum and molecular computing could even make us immortal. The computer has been a radical invention. In less than a single human life computers are transforming economies and societies like no human invention before.

This book describes reversible computing from the standpoint of the theory of automata and computing. It investigates how reversibility can be effectively utilized in computing. A reversible computing system is a “backward deterministic” system such that every state of the system has at most one predecessor. Although its definition is very simple, it is closely related to physical reversibility, one of the fundamental microscopic laws of Nature. Authored by the leading scientist on the subject, this book serves as a valuable reference work for anyone working in reversible computation or in automata theory in general. This work deals with various reversible computing models at several different levels, which range from the microscopic to the macroscopic, and aims to clarify how computation can be carried out efficiently and elegantly in these reversible computing models. Because the construction methods are often unique and different from those in the traditional methods, these computing models as well as the design methods provide new insights for future computing systems. Organized bottom-up, the book starts with the lowest scale of reversible logic elements and circuits made from them. This is followed by reversible Turing machines, the most basic computationally universal machines, and some other types of reversible automata such as reversible multi-head automata and reversible counter machines. The text concludes with reversible cellular automata for massively parallel spatiotemporal computation. In order to help the reader have a clear understanding of each model, the presentations of all different models follow a similar pattern: the model is given in full detail, a short informal discussion is held on the role of different elements of the model, and an example with illustrations follows each model.

Provides an expansion of Turing's original paper, a brief look at his life, and information on the Turing machine and computability topics.

Exploring the cultural results of the current high-tech revolution, an expert in artificial intelligence examines the effect of computers upon art, science, education, and medicine

The description for this book, Automata Studies. (AM-34), Volume 34, will be forthcoming.

Alan Turning is widely known as the cryptographer extraordinaire of Bletchly Park, the man who broke the Nazi Enigma code. He has also been described as the father of the modern computer, dreaming of a machine that could think adn inaugurating a scientific revolution that we are deep in the midst of today. His work entailed too a challenge to the science of ourselves, exploring the limits between the human and technological.

Alan Turing has long proved a subject of fascination, but following the centenary of his birth in 2012, the code-breaker, computer pioneer, mathematician (and much more) has become even more celebrated with much media coverage, and several meetings, conferences and books raising public awareness of Turing's

life and work. This volume will bring together contributions from some of the leading experts on Alan Turing to create a comprehensive guide to Turing that will serve as a useful resource for researchers in the area as well as the increasingly interested general reader. The book will cover aspects of Turing's life and the wide range of his intellectual activities, including mathematics, code-breaking, computer science, logic, artificial intelligence and mathematical biology, as well as his subsequent influence.

The breathtakingly rapid pace of change in computing makes it easy to overlook the pioneers who began it all. Written by Martin Davis, respected logician and researcher in the theory of computation, The Universal Computer: The Road from Leibniz to Turing explores the fascinating lives, ideas, and discoveries of seven remarkable mathematicians. It tells the stories of the unsung heroes of the computer age – the logicians. The story begins with Leibniz in the 17th century and then focuses on Boole, Frege, Cantor, Hilbert, and Gödel, before turning to Turing. Turing’s analysis of algorithmic processes led to a single, all-purpose machine that could be programmed to carry out such processes—the computer. Davis describes how this incredible group, with lives as extraordinary as their accomplishments, grappled with logical reasoning and its mechanization. By investigating their achievements and failures, he shows how these pioneers paved the way for modern computing. Bringing the material up to date, in this revised edition Davis discusses the success of the IBM Watson on Jeopardy, reorganizes the information on incompleteness, and adds information on Konrad Zuse. A distinguished prize-winning logician, Martin Davis has had a career of more than six decades devoted to the important interface between logic and computer science. His expertise, combined with his genuine love of the subject and excellent storytelling, make him the perfect person to tell this story.

Documents the innovations of a group of eccentric geniuses who developed computer code in the mid-20th century as part of mathematician Alan Turin's theoretical universal machine idea, exploring how their ideas led to such developments as digital television, modern genetics and the hydrogen bomb.

The history of the computer is entwined with that of the modern world and most famously with the life of one man, Alan Turing. How did this device, which first appeared a mere 50 years ago, come to structure and dominate our lives so totally? An enlightening mini-biography of a brilliant but troubled man.

In this 2013 winner of the prestigious R.R. Hawkins Award from the Association of American Publishers, as well as the 2013 PROSE Awards for Mathematics and Best in Physical Sciences & Mathematics, also from the AAP, readers will find many of the most significant contributions from the four-volume set of the Collected Works of A. M. Turing. These contributions, together with commentaries from current experts in a wide spectrum of fields and backgrounds, provide insight on the significance and contemporary impact of Alan Turing's work. Offering a more modern perspective than anything currently available, Alan Turing: His Work and Impact gives wide coverage of the many

ways in which Turing's scientific endeavors have impacted current research and understanding of the world. His pivotal writings on subjects including computing, artificial intelligence, cryptography, morphogenesis, and more display continued relevance and insight into today's scientific and technological landscape. This collection provides a great service to researchers, but is also an approachable entry point for readers with limited training in the science, but an urge to learn more about the details of Turing's work. 2013 winner of the prestigious R.R. Hawkins Award from the Association of American Publishers, as well as the 2013 PROSE Awards for Mathematics and Best in Physical Sciences & Mathematics, also from the AAP Named a 2013 Notable Computer Book in Computing Milieux by Computing Reviews Affordable, key collection of the most significant papers by A.M. Turing Commentary explaining the significance of each seminal paper by preeminent leaders in the field Additional resources available online

The breathtakingly rapid pace of change in computing makes it easy to overlook the pioneers who began it all. The Universal Computer: The Road from Leibniz to Turing explores the fascinating lives, ideas, and discoveries of seven remarkable mathematicians. It tells the stories of the unsung heroes of the computer age – the logicians.

'Boldly reactionary... What looks like feast, Carr argues, may be closer to famine' Sunday Times 'Chilling' The Economist In this ground-breaking and compelling book, Nicholas Carr argues that not since Gutenberg invented printing has humanity been exposed to such a mind-altering technology. The Shallows draws on the latest research to show that the Net is literally re-wiring our brains inducing only superficial understanding. As a consequence there are profound changes in the way we live and communicate, remember and socialise - even in our very conception of ourselves. By moving from the depths of thought to the shallows of distraction, the web, it seems, is actually fostering ignorance. The Shallows is not a manifesto for luddites, nor does it seek to turn back the clock. Rather it is a revelatory reminder of how far the Internet has become enmeshed in our daily existence and is affecting the way we think. This landmark book compels us all to look anew at our dependence on this all-pervasive technology. This 10th-anniversary edition includes a new afterword that brings the story up to date, with a deep examination of the cognitive and behavioural effects of smartphones and social media.

Alan Turing was an inspirational figure who is now recognised as a genius of modern mathematics. In addition to leading the Allied forces' code-breaking effort at Bletchley Park in World War II, he proposed the theoretical foundations of modern computing and anticipated developments in areas from information theory to computer chess. His ideas have been extraordinarily influential in modern mathematics and this book traces such developments by bringing together essays by leading experts in logic, artificial intelligence, computability theory and related areas. Together, they give insight into this fascinating man, the development of modern logic, and the history of ideas. The articles within

cover a diverse selection of topics, such as the development of formal proof, differing views on the Church–Turing thesis, the development of combinatorial group theory, and Turing's work on randomness which foresaw the ideas of algorithmic randomness that would emerge many years later.

"Taken as a trilogy, consent not to be a single being is a monumental accomplishment: a brilliant theoretical intervention that might be best described as a powerful case for blackness as a category of analysis."—Brent Hayes Edwards, author of Epistrophies: Jazz and the Literary Imagination In The Universal Machine—the concluding volume to his landmark trilogy consent not to be a single being—Fred Moten presents a suite of three essays on Emmanuel Levinas, Hannah Arendt, and Frantz Fanon, in which he explores questions of freedom, capture, and selfhood. In trademark style, Moten considers these thinkers alongside artists and musicians such as William Kentridge and Curtis Mayfield while interrogating the relation between blackness and phenomenology. Whether using Levinas's idea of escape in unintended ways, examining Arendt's antiblackness through Mayfield's virtuosic falsetto and Anthony Braxton's musical language, or showing how Fanon's form of phenomenology enables black social life, Moten formulates blackness as a way of being in the world that evades regulation. Throughout The Universal Machine—and the trilogy as a whole—Moten's theorizations of blackness will have a lasting and profound impact.

This book constitutes the refereed proceedings of the 5th International Conference on Machines, Computations, and Universality, MCU 2007, held in Orleans, France, September 10-13, 2007. The 18 revised full papers presented together with 9 invited papers were carefully reviewed and selected. The topics include Turing machines, register machines, word processing, cellular automata, tiling of the plane, neural networks, molecular computations, BSS machines, infinite cellular automata, real machines, and quantum computing.

Alan Turing is regarded as one of the greatest scientists of the 20th century. But who was Turing, and what did he achieve during his tragically short life of 41 years? Best known as the genius who broke Germany's most secret codes during the war of 1939-45, Turing was also the father of the modern computer. Today, all who 'click-to-open' are familiar with the impact of Turing's ideas. Here, B. Jack Copeland provides an account of Turing's life and work, exploring the key elements of his life-story in tandem with his leading ideas and contributions. The book highlights Turing's contributions to computing and to computer science, including Artificial Intelligence and Artificial Life, and the emphasis throughout is on the relevance of his work to modern developments. The story of his contributions to codebreaking during the Second World War is set in the context of his thinking about machines, as is the account of his work in the foundations of mathematics.

This book offers an original and informative view of the development of fundamental concepts of computability theory. The treatment is put into historical context, emphasizing the motivation

for ideas as well as their logical and formal development. In Part I the author introduces computability theory, with chapters on the foundational crisis of mathematics in the early twentieth century, and formalism. In Part II he explains classical computability theory, with chapters on the quest for formalization, the Turing Machine, and early successes such as defining incomputable problems, c.e. (computably enumerable) sets, and developing methods for proving incomputability. In Part III he explains relative computability, with chapters on computation with external help, degrees of unsolvability, the Turing hierarchy of unsolvability, the class of degrees of unsolvability, c.e. degrees and the priority method, and the arithmetical hierarchy. Finally, in the new Part IV the author revisits the computability (Church-Turing) thesis in greater detail. He offers a systematic and detailed account of its origins, evolution, and meaning, he describes more powerful, modern versions of the thesis, and he discusses recent speculative proposals for new computing paradigms such as hypercomputing. This is a gentle introduction from the origins of computability theory up to current research, and it will be of value as a textbook and guide for advanced undergraduate and graduate students and researchers in the domains of computability theory and theoretical computer science. This new edition is completely revised, with almost one hundred pages of new material. In particular the author applied more up-to-date, more consistent terminology, and he addressed some notational redundancies and minor errors. He developed a glossary relating to computability theory, expanded the bibliographic references with new entries, and added the new part described above and other new sections.

This workshop on stochastic theory and adaptive control assembled many of the leading researchers on stochastic control and stochastic adaptive control to increase scientific exchange and cooperative research between these two subfields of stochastic analysis. The papers included in the proceedings include survey and research. They describe both theoretical results and applications of adaptive control. There are theoretical results in identification, filtering, control, adaptive control and various other related topics. Some applications to manufacturing systems, queues, networks, medicine and other topics are gien.

Turing Machines is about the theoretical foundations of computer science. It offers a bird's-eye view of all possible algorithms. This viewpoint is very rewarding but at the same time very abstract.This book strikes a balance between theory and applications, mathematical concepts and practical consequences for computer programs, and the usual dilemma of any textbook, that of going to greater depths or covering a wider range of topics. The gently sloping learning curve is especially suitable for self-study.

Collision-Based Computing presents a unique overview of computation with mobile self-localized patterns in non-linear media, including computation in optical media, mathematical models of massively parallel computers, and molecular systems. It covers such diverse subjects as conservative computation in billiard ball models and its cellular-automaton analogues, implementation of computing devices in lattice gases, Conway's Game of Life and discrete excitable media, theory of particle machines, computation with solitons, logic of ballistic computing, phenomenology of computation, and self-replicating universal computers. Collision-Based Computing will be of interest to researchers working on relevant topics in Computing Science, Mathematical Physics and Engineering. It will also be useful background reading for postgraduate courses such as Optical Computing, Nature-Inspired Computing, Artificial Intelligence, Smart Engineering Systems, Complex and Adaptive Systems, Parallel Computation, Applied Mathematics and Computational Physics.

This book provides an overview of the confluence of ideas in Turing’s era and work and examines the impact of his work on mathematical logic and theoretical computer science. It combines contributions by well-known scientists on the history and philosophy of computability theory as well as on generalised Turing computability. By looking at the roots and at the philosophical and technical influence of Turing’s work, it is possible to gather new

perspectives and new research topics which might be considered as a continuation of Turing's working ideas well into the 21st century.

Classic graduate-level introduction to theory of computability. Discusses general theory of computability, computable functions, operations on computable functions, Turing machines self-applied, unsolvable decision problems, applications of general theory, mathematical logic, Kleene hierarchy, more.

A NEW YORK TIMES BESTSELLER The official book behind the Academy Award-winning film The Imitation Game, starring Benedict Cumberbatch and Keira Knightley It is only a slight exaggeration to say that the British mathematician Alan Turing (1912-1954) saved the Allies from the Nazis, invented the computer and artificial intelligence, and anticipated gay liberation by decades--all before his suicide at age forty-one. This New York Times–bestselling biography of the founder of computer science, with a new preface by the author that addresses Turing's royal pardon in 2013, is the definitive account of an extraordinary mind and life. Capturing both the inner and outer drama of Turing's life, Andrew Hodges tells how Turing's revolutionary idea of 1936--the concept of a universal machine--laid the foundation for the modern computer and how Turing brought the idea to practical realization in 1945 with his electronic design. The book also tells how this work was directly related to Turing's leading role in breaking the German Enigma ciphers during World War II, a scientific triumph that was critical to Allied victory in the Atlantic. At the same time, this is the tragic account of a man who, despite his wartime service, was eventually arrested, stripped of his security clearance, and forced to undergo a humiliating treatment program--all for trying to live honestly in a society that defined homosexuality as a crime. The inspiration for a major motion picture starring Benedict Cumberbatch and Keira Knightley, Alan Turing: The Enigma is a gripping story of mathematics, computers, cryptography, and homosexual persecution.