

## Introduction

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Information Technology has fundamentally changed the way of life of people in the developed world because it has fundamentally changed the way that society is organised and controlled. We tend to think of information technology in terms of computer software, emails, shopping online, easy access to bank accounts, paying bills and so on. But behind these modern conveniences lies the infrastructure of the global information and communication technology industries. This infrastructure represents a vast electronic nervous and circulatory system through which the economic life-blood of the world is pulsing. From global financial markets, down to buying groceries, this system is the means whereby the economies and governments of the developed world are able to operate.

Given the pervasiveness and basic importance of information technology in modern life, the number of people employed in information processing tasks, the increasing integration of computerised information systems into the workplace and the assumption that every citizen must be computer literate, it is perhaps surprising that we spend so little time and effort critically appraising the uses to which we are putting this technology. As each new advance emerges, as changes sweep through the economy at an unprecedented rate, many of us remain engaged in simply keeping up with the pace of innovation. Increasing global competition and decreasing job security all serve to concentrate the attention on the present. But when we take technological change to be an inevitable external force, we forget that all innovation, invention, investment and deployment of technology have an essentially human origin. It is we, collectively, who chose this path and it is we who support its continued development.

That is not to say there isn't a considerable literature that critically examines the impact of technology on society. The problem is that this literature is rarely introduced to those people who will actually make the day-to-day decisions about how information technology is deployed, i.e. computer science and information technology graduates. Further, as we race into a technological future, it becomes harder for us to see technology *objectively*. We are so immersed in an urban, electronic world, that we take the presence of technology as a matter of course, with each new generation less able to conceive of a world that could have been different. This process is erasing our sense of the past, our continu-

ity with the origins of our culture and our knowledge of *how* we arrived in our current situation.

It is to these issues that the current book is addressed. It is specifically designed as an undergraduate text for computer science and information technology students and aims to investigate the phenomenon of information technology within the broader context of human culture and civilisation. This task is not easily achieved within the confines of a small volume, or a single undergraduate subject, and we must necessarily provide a high level view rather than a detailed analysis of the subject matter. However, it is a high level understanding that we are aiming for in the first place. This is a book about asking questions and challenging assumptions, not about absorbing a large and fixed body of information. For we are living *in* the information age. It will lie with the future to label, categorise and judge the place information technology finally takes in the history of human civilisation. For now, we must do the best we can to grasp this phenomenon as it unfolds.

The book is also designed to fill a significant gap in the standard information technology degree curriculum. This gap is best described as a lack of historical perspective. That is not to say that the history of computing is not well covered in many undergraduate degrees. But knowing the date that Charles Babbage started building the first difference engine does not qualify as having historical perspective. Possessing historical perspective means connecting one's knowledge of the present with the past in such a way that the present is no longer the sole standard by which everything else is judged. Having such perspective means one is not uncritically *immersed* in the modern world - some distance has been achieved, some independence from immediate circumstances. This is the great gift that an appreciation of history can provide - to become free from the prejudices of the present.

But, as with all other eras, we do not see our prejudices easily. Our scientific and technological achievements have wrought such changes in our day-to-day living that many see the ways of life of the past as irrelevant and uninteresting. A certain cultural chauvinism informs our view, we judge according to our own times the behaviour and achievements of our predecessors, we see them as inferior scientists, guided by ignorance and superstition, suffering from a poor quality of life. We forget that for the people of the past, the past was their *present*. They did not see their situation in terms of all the technological conveniences that were lacking and would not necessarily have found our world as marvellous as we might think. For example, imagine transporting someone from a distant agrarian past into the middle of present day Sydney. How do you think they would react? Consider the noise, the traffic, the lack of community, the lack of a commonly held faith, the regulations, the need for an education, for a bank account, an identity, a driver's licence, the absence of nature, of animals, of wilderness and the dependence on money to procure survival. Consider also

that the most likely destination for such a person would be an immigration detention centre or a prison. Do you think they would find our way of life quite so congenial? Or, to put things closer to home, consider the experience of the Australian aboriginals in coming to terms with the forced introduction of European culture and technology over the past two centuries.

### **Developing Historical Perspective**

Developing historical perspective of course requires a familiarity with historical facts. But, even in physical science, facts alone are not enough. We require some underlying explanation that connects individual facts into a comprehensible unity. Again, if we consider physics, the underlying explanation is provided by mathematical models that predict the outcomes of physical experiments. In history, however, it is far from clear what the underlying, unifying model should be. In part, the way we interpret history is a creative act, dependent on what it is we would like to explain and on the particular intelligence we bring to bear on the problem. And, in a sense, we are all historians who have come to a particular view of ourselves, our lives, our place in the world and how we arrived here. The question is, are we *conscious* historians, or have we unreflectively accepted a view of the past, and hence the present, handed down by an unreflective society?

Perhaps the greatest prejudice of all human communities is to believe that whatever it is that the majority of members believe must be correct. Throughout history we can see that different human societies can be persuaded to believe the most extraordinary things. Consider the ancient Egyptians and their idea of the immortality of the pharaoh, and the immense energies expended in building the pyramids. Or consider Nazi Germany and the people's adulation of Hitler, their belief in the Arian master race and their pre-ordained right to rule over other peoples. And these are not just isolated instances. We need only consider the recent history of Australia, the all-white immigration policy and the status of the aboriginal population. Now racism is condemned by the majority, so racism is wrong. But how was it when the majority held racist views? How would you have behaved, if you had been born into that world?

Of course, it is not that simple. Not everything that the majority believe is necessarily wrong. But I wonder how the future will judge us? Consider our treatment of the natural environment, of the animals, our neglect of the millions who live in poverty, our wanton consumption of goods and services we did not really need, our obsession with work, our lack of time for human relationships, for culture, for art, for love. Will we figure as the twenty-first century barbarians in the history of a future humanity? The answer is almost certainly yes.

So, developing historical perspective is firstly a matter of stepping *outside* of the norms of contemporary life, of seeing that people throughout history have lived vastly different lives and believed vastly different things. History

then reveals that our way of life is not *normal* or pre-ordained. It is a temporary phase, something that will pass soon enough and something that *could be otherwise*. It is from this place that I want to survey the development of information technology. However, it is important to see that the book itself embodies a particular historical perspective and that simply accepting this perspective is not what is intended. If we are to be true to the aim of developing an unconditioned perspective, then everything in the book should also be subject to criticism and doubt. The task is not to arrive at or agree with the book's perspective, but to arrive at your own, freed from the confines of an "unexamined life."<sup>1</sup>

### **Explicating the Foundations: An Overview of the Book**

The term *Foundations of Computing* typically identifies a sub-discipline of computer science concerned with providing theoretical and technical definitions and explanations of what computation is. Within this field, there is a general consensus that computation can be understood using formal models such as Turing machines or finite state machines. Given a formal model, we can then address questions of computability (i.e. whether it is possible to compute an answer to a problem) and computational complexity (i.e. the computational cost of solving a problem).

In this book, we too are interested in providing an understanding of what computation is, but we are taking the foundations of computing to be considerably broader than a standard technical treatment would usually allow. Firstly, we are taking it as basic that all technology has its ultimate foundation in the community of human subjects that conceived and constructed the technology in the first place. Hence our emphasis on understanding the historical context and evolution of technology. However, as we have already discussed, all histories possess a certain perspective through which the facts are selected and made coherent. Often this perspective is left for the reader to identify. It may be an implicit theory that the determining factors of history are the decisions and actions of a few powerful individuals. Or it may be the idea that the fates of nations are swayed by the evolution of ideas, or by the development of the technical means of production, and so on.

To make it explicit, in the present work we are taking the perspective that the foundations of computing and the information technology age lie in a particular turn of mind taken by Western civilisation. This turn of mind has attempted to understand and direct human existence by the cultivation and application of formal abstract conceptual thought. Such thinking is based on logical/mathematical foundations first developed by the Greeks and subsequently extended and applied in the development of modern science and technology. The specifically Western aspect of this phenomenon is characterised by a strong emphasis on facts that can be objectively observed and measured and on reasoning that can be verified using formal rules. Taken as a means of decision making

and problem solving, this mode of thought is fundamentally computational because it can be formally expressed as a computer program. The development of information technology can be understood as an externalisation or physical embodiment of this calculative mode of thought, such that we increasingly use machines to calculate and implement the decisions that direct our lives, rather than using human intelligence. This is analogous to the first phase of industrialisation that replaced human physical labour with machinery - now we are replacing human mental labour in the same way.

Throughout the book we use this perspective to connect the development of information technology with the historical past, the present organisation of society and with philosophical questions regarding the nature and value of technology. The basic theme is that technology is an outer expression of the increasing ability of human intelligence to form and manipulate abstract formal representations of the world. Using this theme, we start in Chapter 1 by examining the development of number as a pure abstraction from sensory experience. We then use the historical development of science and mathematics to highlight crucial events in the history of computing and the intellectual evolution of Western culture. The idea is to gain an appreciation of the *interconnectedness* of the development of human culture and technology, to see that information technology did not just “pop out” ready formed, but is the fruition of centuries of endeavour, as the human mind extracts itself more and more from the particular and into the abstract.

Within this narrative the development of computer and information technology takes on a special significance - for this technology is an embodiment of the logico/mathematical mode of thought that lies behind the evolution of science and technology in the first place.<sup>2</sup> To clarify this, in Chapters 5 and 6 we provide a more technical examination of what computation means and how it can be embodied in a machine. This takes our idea of computation out of the historical and grounds it in the practical reality of digital circuitry.

In Chapters 7 and 8 we look at the role that information technology plays within the broader context of modern civilisation. Here we borrow Alan Turing’s idea of an *effective method* (1936-7) as an overall metaphor for our technical approach to problem solving. We also borrow from Beniger’s *Control Revolution* (1986) and related texts that see the primary role of information technology (IT) as one of *control*. By connecting these ideas with an analysis of hierarchical and network communication structures, we first present a theoretical definition and understanding of IT. Then we trace the practical development of IT from the early days of the telegraph and the railway up to the birth of the internet and the formation of our modern global communications infrastructure. In doing this, we connect our earlier historical and technical consideration of computation with the reality of the modern world and we show

the fundamental importance of IT in the creation of a new global economic and social order.

Finally, in Chapters 9 and 10, we look into the foundational issue of the nature of science, computation and human intelligence. Here we show that science and technology have not just changed the fabric of our social organisation, but have also challenged our historical notions of what it means to be human. For, if what distinguishes us from inanimate matter is simply our ability to solve complex problems and perform complex tasks, then how are we to classify a machine that can easily beat us at chess and is already conversing with us, advising us, and enacting decisions that directly affect our day-to-day lives? To put it more directly, we are now faced with the question of whether there is any fundamental difference in kind between the computations that occur in the hardware of a computer and the events that occur inside our own brains. The importance of how we answer this question can hardly be over-emphasised. It is no longer a matter of *whether* we will be seeing machines that appear as intelligent as we are, but *when*. And yet, in the fields of enquiry most concerned with the nature of human intelligence (such as neuroscience, artificial intelligence, cognitive science and the philosophy of mind), it is mostly taken for granted that human intelligence *is* computational. We therefore conclude the book with a philosophical investigation of what it means to be intelligent. We suggest it is no accident that the current computational view of intelligence fits so well with the turn of mind that formed the foundation of our technological culture in the first place. In the final analysis, we argue that only by transcending this materialistic turn of mind will we be able to adequately understand ourselves and our place in the world we have helped to create.

## Notes

- 1 Readers familiar with Plato will recognise the voice of Socrates here and his famous phrase from the Apology: “the unexamined life is not worth living” (Plato, 1952, p. 210).
- 2 That is not to say that scientific discovery does not involve an element of creativity that cannot be explained in purely computational terms. Such questions are addressed further in Chapter 10 of the book.