Book Review

Robot: Mere Machine to Transcendent Mind
A Review

Bonnie Holte Bennett

Hans Moravec's new book, *Robot: Mere Machine to Transcendent Mind,* will delight readers familiar with this work. Moravec's strengths—his insightful data analysis, extrapolation of technology to extreme conclusions, and provocative predictions—are all here and will probably gain him some new fans.

His insightful data analysis, for example, includes plots of computing trends of the last century, comparing mechanical, electromechanical, and electronic computing capabilities in terms of computational power per unit cost (MIPS per $1000 in 1998 U.S. dollars) across time. This summarizes the evolution of computer power per unit of cost. Readers of his previous book, *Mind Children* (Harvard University Press, 1988) will recognize the current graph as a refinement of one that appeared in the earlier book. Three things become clear from this refined analysis: (1) computing progress has been tightly coupled around a trend line; (2) this makes predictions of future technologies reasonable by extrapolation; and (3) there's been an interesting acceleration over the last 30 years, even on this logarithmic scale. The last point is a new addition to this. These data allow predictions about when computers will cross the boundaries of complexity equivalent to a lizard (approximately the years 2002–2008), a mouse (approximately the years 2008–2017), a monkey (approximately the years 2013–2028), and a human (approximately the years 2020–2030+). There are, however a few caveats to consider: (1) these are hardware estimates and (2) there is a regular escalation of the estimates of the complexity of human intelligence. With regard to the first caveat, Moravec's estimates of animal equivalence are based solely on hardware complexity. It is often the case that hardware alone cannot deliver performance, but it also requires software sufficient to the task. Thus, projecting "human equivalence" in computer hardware does not mean that "human equivalent software" will be ready to run on the hardware. With regard to the second caveat, neuroscientists regularly adjust upward the estimate of human brain complexity. This upward estimation has the effect of extending the estimated time at which comput-

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Hans Moravec, *Robot: Mere Machine to Transcendent Mind.* Oxford.: Oxford University Press, 1999. 227 pp. $25.00. ISBN 0–19–511630–5.

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ers will reach human equivalence. Indeed, Moravec's estimates have increased too. In 1988, he projected computers will reach human equivalence in a supercomputer in the years 2000 to 2005 and in a personal computer by 2028 to 2030+. The 1999 estimate is 2020 to 2030+. However, these details are minor. This graph is fascinating in its scope and breadth and particularly notable in its predictive capabilities. It is vintage Moravec.

The insightful extrapolation of data in this graph is just a foretaste of the degree to which Moravec will go in predicting the future. This book traces robotic history, projects the field's immediate future, and travels well beyond. Without giving away the ending, suffice it to say that in this book, the reader will be treated to such ideas as, "What is reality anyway?" (p. 195). Another idea is that

perhaps the most unsettling implication of this train of thought is that anything can be interpreted as possessing any abstract property, including consciousness and intelligence. Given the right playbook, the thermal jostling of the atoms in a rock can be seen as the operation of a complete, self–aware mind (after Evert) (Everett, H., *Many–Worlds of Interpretation/ Quantum Mechanics,* Princeton University Press, 1973, p. 199).

Yes, it is all here—quantum physics, chaos, cosmology, and more. Moravec's panoramic grasp of science and technology is not unlike a good carnival ride, exhilarating and sometimes exhausting. Parts of the book need to be savored and digested slowly, if only because of their density and magnitude. As for provocative predictions, this book will not disappoint. Topics include virtual immortality, ultimate transcendence, and time travel, to name just a few.

The chapters run approximately chronologically. Chapter 1, "Escape Velocity," introduces some of the themes of the book. It also includes some interesting graphs showing a correlation between U.S. air pollution and wealth that suggests that we've survived the dirty industrial revolution and are living richer and cleaner lives, having mended our evil ways. We're using our wealth to live more pristinely, and the future looks bright. Chapter 2, "Caution Robot Vehicle," traces the last 30 years of robotics research, with particular detail on the Stanford University and Carnegie Mellon University labs with which Moravec has been affiliated. It is an excellent history and summary of the progress made. Chapter 3, "Power and Presence," sets up the paradigms used throughout the rest of the book. These

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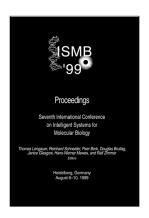
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paradigms include the basis for computational complexity; storage and processing speeds that are delineated here; and the graph predicting computer growth, along with others documenting chess successes and computational power. Chapter 4, "Universal Robots," delineates four generations of universal robots that will appear over the next half–century. The final generation includes superrational robots with emotional displays. Chapter 5, "The Age of Robots," chapter 6, "The Age of Mind," and chapter 7, "Mind Fire," look at the future, beyond the point where robots surpass human capabilities. In these chapters are concepts as intriguing as the "synchronous orbital bridge," which pro-

vides a cheap, clean access to space, and time travel.

This summary of the chapters leads to a caution I would make in recommending this book to colleagues. Some people, for example, my philosopher friends, might be less interested in the technical detail. To them I would say, "Skim chapters 2 and 5; don't let them bog you down. You can skip them for now and come back to them if you want." For analytic readers, I might encourage them to start with chapter 3 as a "hook." The point is there is something very rewarding in this book for many people, but the vastness of some sections might overwhelm them, and it would be a shame to be lost in the rich dis-

cussion of a personally uninteresting discipline so that the real reward is never reached.

Moravec's work has epic proportions. He engenders provocative discussion and provides daring insight. His new book is destined to be the classic his previous book has become.

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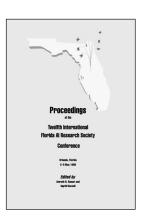
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