Cybernetics

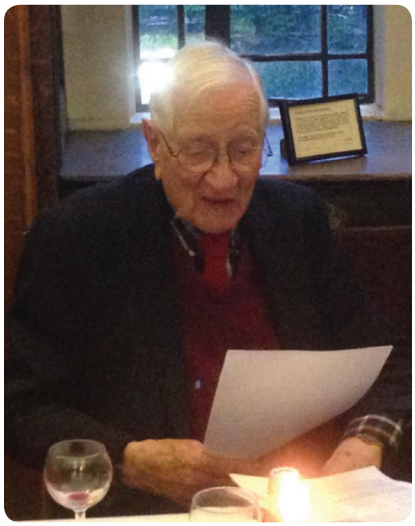
The history of cybernetics is a fascinating one for anyone interested in control. The term was not particularly popular in my generation, to say the least. For many, cybernetics conveyed an obscure syncretic movement rather than a scientific discipline. However, *cyberphysics* has become a popular term lately, and the *cybernetics moment* [2] might soon be back.

The leading excerpt from the preface of Wiener's monograph [1] (also reproduced in the historical account [3]) is not short of ambition. The coining of a new term, the use of Latin and Greek, and a reference to a paper by Maxwell himself all contribute to the gravity of the declaration. Yet, in retrospect, Wiener's preface reads perhaps more like an end than a beginning. The praise for a unified discipline embracing control and communication, animal and machine intelligence was conceived before a formal distinction was introduced between modeling the continuous and the discrete. In cybernetics, feedback makes automata adaptive and allows continuous systems to switch between discrete modes.

To that extent, Wiener's program was defeated at the very time of the publication of *Cybernetics: Or Control and Communication in the Animal and the Machine*. Shannon's 1948 paper introduced a fundamentally discrete theory of information. Crick and Watson's 1952 paper launched a fundamentally discrete theory of biology. The 1946 ENIAC machine established a fundamentally digital age of technology. From 1948 on, the discrete and the continuous became distinct and increasingly separated. The analog concepts of feedback regulation, adaptation, homeostasis, animal physiology, continuous sensing, and actuation gradually became the heritage of a distant past, the age of calculus. They soon would only be tolerated to the extent that they could be digitally emulated.

> We have decided to call the entire field of control and communication theory, whether in the machine or in the animal, by the name *Cybernetics*, which we form from the Greek χυβερνήτης or *steersman*. In choosing this term, we wish to recognize that the first significant paper on feedback mechanisms is an article on governors, which was published by Clerk Maxwell in 1868, and that *governor* is derived from a Latin corruption of χυβερνήτης.[1]
>
> —NORBERT WIENER

An excerpt from Norbert Wiener's monograph *Cybernetics: Or Control and Communication in the Animal and the Machine [1]*.



Horace Barlow, recalling his memories of the Ratio Club at the workshop Biological Control Across Scales, Cambridge, United Kingdom, June 2016.

The divide between the digital and analog did not happen overnight. The immediate reception of *Cybernetics: Or Control and Communication in the Animal and the Machine* was frantic. The book publication triggered a media craze that will perhaps sound familiar to today's reader. Newspapers acclaimed the book with article titles that seem to have been copied from 2020: "The Brain Is a Machine" (*Newsweek*), "In Man's Image" (*Time*), "Machines That Think" (*Business Week*), "Mechanical Slaves Forecast," and "Devaluing Brains in Industry" [2]. This was all before the appearance of what we would dare to call a computer.

The cybernetics craze was short lived. The cybernetics Macy Conferences were held between 1946 and 1953. They can be considered an attempt to accomplish Wiener's dream through the brand-new theory of information.

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The triumph of the digital age seems definitive.

By 1954, most scientists (including Shannon) had distanced themselves from the cybernetics dream. Following the cybernetics moment, information theory prevailed.

The cybernetics moment was also a vibrant one on the other side of the ocean. I had not heard of the name Ross Ashby until I joined Sidney Sussex College in Cambridge in 2013, learning from *Wikipedia* that he was both an alumnus of the college and the father of British cybernetics. His two books (*Design for a Brain* [4] and *An Introduction to Cybernetics* [5]) offer another fascinating account of a discipline in which feedback plays a central role but cannot survive a divide between the analog and digital. Ashby was trained as a psychiatrist in the 1920s. British cybernetics grew from early attempts by therapists to think of the human brain as a regulated machine. Later in his career, he built the homeostat, an early machine example of regulated automaton.

Ashby moved to the United States in 1960 and became a professor of electrical engineering at the University of Illinois at Urbana–Champaign. He is a founder of the Ratio Club, a British club of cyberneticists who gathered in London and Cambridge between 1949 and 1958. Many participants of the Ratio Club became world renowned, including Alan Turing and John Wescott (founder of the Control Group at Imperial College). The only surviving member of the Ratio Club is Horace Barlow, 98, a prominent biologist who pioneered computational models of the visual system. Barlow made moving recollections of the Ratio Club at the workshop Biological Control Across Scales organized in Sidney Sussex College, the University of Cambridge, in 2016. Today's meetings centered on control, synthetic biology, and neuroscience, probably bear striking similarities to those early encounters aimed at the thinking of animals and machines in a common framework.

Most of us were born long after control had become an integral part of the digital age. The first feature article of this very issue is about the use of control in computer technology, and the "25 Years Ago" column illustrates the state of the art of computer control at the turn of the century. The triumph of the digital age seems definitive. Some might consider that digital computation has become the one paradigm sufficient to embrace control and communication, whether in the machine or the animal. However, others think that the metaphor of the brain as a computer may one day be regarded as a short-lived moment in history. In the midst of a renewed debate over artificial intelligence, control theorists and control engineers may want to go back to the books of Wiener and Ashby and contemplate the possibility that the cybernetics moment was, in some ways, ahead of its time.

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Computational Mathematics: A Child of Two Extremes

Mathematics is an art of discovering the real facts about imaginary objects.

Engineering is an art of constructing the real objects based on imaginary facts.

Computational mathematics is an art of producing imaginary facts about imaginary objects.

—Yurii Nesterov, Francqui Inaugural Lecture