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The Anthropology of Computing
Fall 2004 MIT

WORLD WAR TWO: CYBERNETICS, COMMUNICATION, AND CONTROL
Lecture 4. October 4

Another 19th century person we need to know about: George Boole (1815-1864)

Beginning as an elementary school instructor, Boole opened his own school at age 20. Unsatisfied with mathematics texts of the time, he set about reading Laplace, Leibniz, and others. He emerged with new ideas on the calculus of variations and, even as an outsider, succeeded in having them published in *The Cambridge Mathematical Journal*.

1854 *An Investigation into the Laws of Thought, on which are founded the Mathematical Theories of Logic and Probabilities*.

Boole approached logic in a new way reducing it to algebra, incorporating logic into mathematics. He pointed out an analogy between algebraic symbols and those representing logical forms. LOGIC WAS A FORM OF MATH, NOT OF PHILOSOPHY.

"We ought no longer to associate Logic and Metaphysics, but Logic and Mathematics"

> Remember Ada Lovelace's notion that the Analytical Engine made use of operations and objects of operations and that it could be a completely general machine if both were written in the same language?
>
> Boole's idea was that mathematizing logic would translate operations (logic) and objects of operations (mathematical objects for example) into the same language.

You could represent logical statements (like syllogisms and other things with sets of AND, OR, and NOTs) as mathematical statements that were TRUE or FALSE, and then represent this outcome as on or off, 1 or 0. Boolean algebra was algebra on logic statements, not numbers (even though statements could be written in numbered code, like a binary code).

As you saw in the Norbert Wiener, Claude Shannon, while a grad student ay MIT, recognized the analogy between electronic circuits and Boolean algebra that became essential to the design of digital computers.

Shannon showed that Boole's TRUE & FALSE could represent functions of switches in electronic circuits.

Boolean logic can be used to describe electromagnetically charged memory locations or circuit states that are either charged (1 or true) or not charged (0 or false). Computer can use an AND gate or OR gate operation to obtain a result that can be used for further processing.

Two things that Boole did became important for later CS:
1. his logical system — or rather, the reduction of logic to math

2. and the use of a binary representation

Bush, Vannevar. 1945. As We May Think.

''Born in Massachusetts, educated at Tufts, graduating in 1913. Joined the Department of Electrical Engineering at MIT in 1919, and was a professor from 1923-32. He constructed a Differential Analyser, an analog computer that could solve differential equations with as many as 18 independent variables, based on Charles Babbage's Difference Engine. An offshoot of the Differential Analyser was the birth of digital circuit design theory by one of Bush's graduate students, Claude Shannon.

In 1940, Bush became chairman of the National Defense Research Committee and in 1941 director of Office of Scientific Research and Development, which controlled the Manhattan Project and coordinated wartime scientific research during World War II. He recommended the creation of what would become the National Science Foundation in order to cement the ties between science, industry and the military that had been forged during the war.''

links to Leibniz and Babbage.

“whenever thought for a time runs along an accepted groove - there is an opportunity for the machine”

“The human mind does not work that way. It operates by association.”

Memex: “It consists of a desk, and while it can presumably be operated from a distance, it is primarily the piece of furniture at which he works.” people think of this as hypertext.

“We know that when the eye sees, all the consequent information is transmitted to the brain by means of electrical vibrations in the channel of the optic nerve. This is an exact analogy with the electrical vibrations which occur in the cable of a television set.” Cybernetics

“intelligence, whether of sound or sight” link to Babbage

“A girl strokes its keys languidly and looks about the room and sometimes at the speaker with a disquieting gaze.”

Wiener, Norbert. 1961. Cybernetics: or Control and Communication in the Animal and the Machine, second edition. Cambridge: MIT Press, 1985, first edition 1948, Introduction, I, V, VIII (pp. 1-44, 116-132, 155-165).

professor of mathematics at MIT from 1919 to 1964.

INTRO

Wiener interested in an interdisciplinary science of CONTROL AND COMMUNICATION IN THE ANIMAL AND THE MACHINE; brought to fruition by the war — common problems across disciplines: anti-aircraft apparatus was its mascot.

proper computing machine has features on p. 4, *nervous system also has these features*

“It will be seen that I had become engaged in the study of a mechanico-electrical system which was designed to usurp a specifically human function — in the first case, execution of a complicated patterns of computation, and in the second the forecasting of the future” (p. 6).

Babbage’s *memory* and *anticipation* will become crucial for cybernetics.

Explain cybernetics? $\chi\psi\beta\varepsilon\rho\nu\eta\tau\eta$ s

“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” (p. 11). *steersman, governor*

The message: “the problems of control engineering and of communication engineering were inseparable, and that they centered not around the technique of electrical engineering but around the much more fundamental notion of the message, whether this should be transmitted by electrical, mechanical, or nervous means. The message is a discrete or continuous sequence of measurable events distributed in time” (p. 8).

THE MESSAGE IS THE MEDIUM FOR COMMUNICATION AND CONTROL

Messages can have digital or analog representation.

What are messages for? FEEDBACK: MAINTENANCE OF THE SYSTEM

What about INFORMATION? What is it?

“we have made of communication engineering design a statistical science… To cover this aspect of communication engineering, we had to develop a statistical theory of the *amount of information*” (p. 10). *statistical theory of prediction based on incomplete information*

> “Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization” (p. 11). Information = negentropy
>
> this brings info within the realm of physics, as a thing in the world independent of meaning. BUT also, strangely, VICE VERSA independent of material instantiation.
>
> Leibniz as patron saint of cybernetics: brings together universal symbolism and a calculus of reasoning. 12 logic and machines]
>
> INFORMATION LOSES ITS BODY “dematerialized materialism” (p. 104).
>
> Wiener says humans are patterns, not their physical matter, struggle against entropy.

cybernetics has potential for good or evil, reference to Samuel Butler. Mechanical labor is slave labor and any persons obliged to compete with it become no better than slave labor.

pause on PAGE 27, 28 The open market is anathema to the proper use of cybernetics
COMPARE BABBAGE? cybernetic anxiety

1 NEWTONIAN AND BERGSONIAN TIME

I'm chiefly interested, in this chapter, in this phrase of Wiener's: "The thought of every age is reflected in its technique" (p. 38). "Craftsmen made their tools in the image of the heavens" Clockwork. "If the 17th and 18th centuries are the age of clocks, and the later eighteenth and 19th centuries constitute the age of steam engines, the present time is the age of communication and control" (p. 39). WHAT DOES THIS MEAN?

> We are no longer interested in economy of energy, but in accurate reproduction of a signal.
>
> simulacra of living things "expressed in the living technique of the age" (p. 39) "the present automaton opens doors by means of photocells, or points guns to the place at which a radar beam picks up an airplane" (p. 40). Clockwork automata is its prehistory.
>
> (critique of Descartes)

"in short, the newer study of automata, whether in the metal or in the flesh, is a branch of communications engineering, and its cardinal notions are those of message, amount of disturbance or 'noise' — a term taken over from the telephone engineer — quantity of information, coding technique and so on. In such a theory, we deal with automata effectively coupled to the outside world, not merely by their energy flow, their metabolism, but also by a flow of impressions, of incoming messages, and of the actions of outgoing messages" (p. 42). **FROM ENERGY TO INFORMATION**

> Newtonian — the time of high level physics phenomena — is reversible. Bergsonian time, the time of living organisms making their way against entropy is not reversible.
>
> "Within any world with which we can communicate the direction of time is uniform" (p. 35). statistics and probability are of use here, since we cannot predict exactly (let alone retrodict). we are in the realm of thermodynamics and statistical mechanics.
>
> "Bergson emphasized the difference between the reversible time of physics, in which nothing new happens, and the irreversible time of evolution and biology, in which there is always something new" (p. 38).

V COMPUTING MACHINES AND THE NERVOUS SYSTEM

"Computing machines are essentially machines for recording numbers, operating with numbers, and giving the result in numerical form" (p. 116).

“the computing machine must be a logical machine as well as an arithmetic machine and much combine contingencies in accordance with a systematic algorithm” (p. 118). And the brain is “a logic machine” (p. 124).

> i.e. BOOLEAN ALGEBRA: this logical system (algorithm) “like the binary arithmetic, is based on the dichotomy, the choice between yes and no, the choice between being in a class or outside” programs can be represented as numbers
>
> Lovelace: operators and objects to be operated on. In Boolean algebra, these are in the same code, 0 and 1s.

the brain is an analog of a single run of a machine (nonreversible?)

the materiality of storage? “we have already seen that substances with high quantum degeneracy appear to be associated with many of the problems of metabolism and reproduction. It is probably not an accident that here in a nonliving environment, we find them associated with a third fundamental property of living matter: the ability to receive and organize impulses and make them effective in the outer world.” (p. 124).

WHAT **IS** INFORMATION?

“Information” has historically had two primary meanings. The first is simply a quantitative measure of the complexity of a linear code or message and has nothing to do with what the code or message means. How much information is there?

The second, associated with computer programming, attaches to the concept of instruction or program, for which meaning is of utmost concern. Information sometimes refers to abstract form and sometimes to content.

VIII INFORMATION, LANGUAGE AND SOCIETY

“In connection with the effective amount of communal information, one of the most surprising facts about the body politic is its extreme lack of efficient homeostatic processes” (p. 158). Free market does NOT lead to this, since it controls means of communication without true communication. Small “primitive” communities have this.

can’t use cybernetics to understand society because there is no objective, outside place from which to stand and assess how well communication is going. And this is because the observer is INSIDE the system. NOT SOMETHING BABBAGE RECOGNIZED. Social sciences have to deal with short statistical runs from which generalizations cannot be made.

> EDWARDS
>
> “Knowledge of the mind as an information-processing device developed in a ‘circular relation’ to high-technology military power” (p. 176).
>
> How was the organism/mind/cyborg militarized? Examples?

insertion of soldiers into electromechanical systems led to tools and metaphors, insertion of psychologists into war problems. social relations of militarism embedded in cybernetic devices.

“Cybernetic psychology began as an effort to theorize humans as component parts of weapons systems and continued, after the war, to draw crucial models and metaphors from those concerns” (p. 180).

“cybernetics would transcend the boundary between machines and organisms. It would do this not by rejecting concepts of purposes goals and will (as in behaviorist psychology), but by expanding the category of machines via the concept of feedback , to include these notions” (p. 182).

“cybernetic psychology, as both theory and practice, both mirrored and transformed the chain of command” (p. 207). People transformed into conduits of information whose performance could be optimized.

Hayles, N. Katherine. 1999. Liberal Subjectivity Imperiled: Norbert Wiener and Cybernetic Anxiety. From How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics. Chicago: University of Chicago Press.

Hayles writes she is interested in the "mindsets of those who constructed themselves and their machines in a cybernetic image" (p. 91). Mindset of Wiener? Anxious Liberal Subject

definition of **liberal**?

1. Liberalism as a Political Theory Liberty
'By definition', Maurice Cranston rightly pointed out, 'a liberal is a man who believes in liberty' (Cranston, 459). In two different ways, liberals accord liberty primacy as a political value. First, liberals have typically maintained that humans are naturally in 'a State of perfect Freedom to order their Actions…as they think fit…without asking leave, or depending on the Will of any other Man' (Locke, 1960 [1689]: 287). Mill too argued that '[T]he burden of proof is supposed to lie with those who are against liberty; who contend for any restriction or prohibition…. The a priori assumption is in favour of freedom…'(Mill, 1991 [1859]: 472). This might be called the Fundamental Liberal Principle (Gaus, 1996: 162-166): freedom is normatively basic, and so the onus of justification is on those who would limit freedom. It follows from this that political authority and law must be justified, as they limit the liberty of citizens. Consequently, a central question of liberal political theory is whether political authority can be justified, and if so, how. It is for this reason that social contract theory, as developed by Thomas Hobbes, John Locke, Jean-Jacques Rousseau, is usually viewed as liberal even though the actual political prescriptions of Hobbes and Rousseau, have distinctly illiberal features.''

"As a political tradition liberalism has varied in different countries. In England -— in many ways the birthplace of liberalism -— the liberal tradition in politics has centred on religious toleration, government by consent, personal and, especially, economic freedom. In France liberalism has been more closely associated with secularism and democracy. In the United States liberals often combine a devotion to personal liberty with an antipathy to capitalism, while the liberalism of Australia tends to be much more sympathetic to capitalism but often less enthusiastic about civil liberties. To understand this diversity in political traditions, we need to examine liberalism as a political theory. ''

Definition of **subjectivity**: ? Liberal subjectivity: "a coherent, rational self, the right of that self to autonomy and freedom, and a sense of agency linked with a belief in an enlightened self-interest" (pp. 85-86).

cybernetics: boundaries between humans and machines are constructed and not given

Whence the anxiety? the cybernetic anxiety is: where does it stop?

Weiner: "Envisioning new ways to equate humans an machines, he also spoke up for strongly liberal humanist values" (p. 85). in common between cybernetics and liberal humanist subjectivity? Self-regulating and autonomous. **BUT**, there are differences, too — how do you know the limits of the subject?

I suggest we think about this through examining Wiener's favorite mode of thinking:

ANALOGY: Resemblance of relations or attributes forming a ground of reasoning.

What were the structuring analogies? Machine/organism — both info processing

Communication is at the heart here.

Animals and machines are both COMMUNICATION devices

Communication can be understood PROBABILISTICALLY

probability is a necessary feature of the finite knowledge available to subjects in a Bergsonian universe; human finitude results from being caught in an unpredictable universe. For Wiener, statistical mechanics reflects this communicative REALITY

"communication was about relations, not essence, and analogy is not merely an ornament of language, but a powerful conceptual mode that constitutes meaning through relation." (p. 91)

"When analogy is used to constitute arguments in cybernetic discourse, it makes an end run around questions of essence, for objects are constituted through their relations to other objects" (p. 91)

In other words, computers and brains are LIKE each other — but analogy makes us FORGET they are made of different stuff, that this may matter! Genetic code e.g.

flip side of drawing analogies is constructing boundaries.

i.e. in order for an analogy to work (between organisms and machines) you must put boundaries around some things (materiality) and not speak of them: "What tends to drop from sight is the fact that the equation between organism and machine works because it is seen from a position formulated precisely so that it will work" (p. 94).

cybernetics only analogies? Wiener: "analogical relations … are not merely rhetorical figures but are systems that generate the only kind of significance available to us as perceiving, finite beings with no access to unmediated reality" (Hayles. p. 97)

"Linking probability with information allowed Wiener to script the cybernetic subject into a cosmological drama of chaos and order" (p. 100).

Since the boundaries have been breached, what does Wiener do?

There are GOOD and BAD machines! Which are which?

the struggle against entropy! info as opposite of entropy, life as swimming against entropic tide. the good cybernetic subject (animal or machine) does this!

cybernetic machines are siblings to humans – bad machines are inflexible, become rigid and slide toward frozen order "When the boundaries turn rigid or engulf humans so that they lose their agency, the machine ceases to be cybernetic and becomes simple and oppressively mechanical" (p. 105).

Augustinian and Manichean opponents: Nature versus wily opponent. Galison argues that cybernetics poses the opponent, the enemy (Germans), as Manichean and in the process makes the cyborg *necessarily* conniving — not friendly.

So, Wiener was afraid of this feature of the cyborg. Wanted to contain it. How?

looks into the mirror of the cyborg and withdraws (p. 108)

knows that "personal identity and autonomous will are merely illusions that mask the cybernetic reality" Hayles says that he withdraws whenever he is about to recognize and pronounce this, and that every time he is about to pronounce it, it is on a sexual subject (hormones p. 157, savage) or about recognizing intimacy in general.

"the crux of the argument: The danger of cybernetics from Wiener's point of view is that it can potentially annihilate the liberal subject as the locus of control" (p. 110).

Solution: say that cybernetics should NOT apply to society! CONTRAST BABBAGE.

Wiener was not successful in containing the menace of cybernetics — or the promise, depending on how you see it. CYBORGS.

NEXT TIME:
lessons: militarization of the mind, dematerialization of information. More about this in THE CLOSED WORLD.

Possible topics for papers

punch cards	core memory
floating-point hardware	vacuum tubes
the transistor	disk storage 1957
UNIVAC	memory drums
operating system	compilers
FORTRAN	COBOL
Mainframe	chip