Obituary

Claude E. Shannon (1916–2001)

Claude E. Shannon died on February 24, 2001, in Medford, Mass., at the age of 84. After Herbert Simon, another giant of the sciences of the artificial has left us.

Information, entropy, communications, networks, digital transmission, 'bits' of information – it all came to pass and it all became a part of our information-processing culture. Claude Shannon and his information theory stood at the roots of it all.

So, what is information? A symbolic description of action – past, present and future. It can be numbers, words, labels, pictures, etc., all symbols of reality. So, how do we communicate information over electric channels? What else than digital symbols: symbols can only be described by symbols. Here comes Shannon and his M.I.T. master's thesis, 'A Symbolic Analysis of Relay and Switching Circuits'. What is the right mathematical language, what are the symbols describing the behavior of the increasingly complex switching circuits, in telephones, computers and communication devices?

When humans are not present, when humans do not interpret the information transferred, what are machines to do? What is being coded, transferred, decoded and relayed over the human-free circuits? How do they communicate, how do they 'understand each other'?

Shannon showed that just two symbols are needed: 1 and 0. The manipulation of the stream of 1s and 0s can be carried out automatically with electrical switching circuits. The symbol 1 could be represented by a switch ON; 0 would be a switch OFF. The digital computers have started to learn how to talk. Analog computers à la: 'differential analyzer' of Vannevar Bush were history. If all messages, if all information can be coded by 1s and 0s, in 'binary digits' or bits, then of course machines can transmit and manipulate any information at high speeds – as they have done ever since.

Claude was born in Petoskey (or Gaylord), Mich., on April 30, 1916 – the day my father was born, far away from that spot. Claude Elwood Shannon became a mathematician, earning a bachelor degree in mathematics and electrical engineering from the University of Michigan in 1936. He got both a master's degree in electrical engineering and his PhD in mathematics from M.I.T. in 1940. At M.I.T. he did work with Dr. Vannevar Bush, mastering the systems of shafts, gears, wheels and disks to solve equations. His digital negation of the analog world was total and complete.

Shannon had to come up with a precise definition of information and he did: the *information content* of a message has nothing to do with the message content, its meaning or its interpretation – that is for humans to grapple with. Information, for machines, is related to the number of 1s and 0s that it takes to transmit it. If there is order in the string of 1s and 0s, then there is information. If there is disorder or chaos, then there is entropy, the opposite of information. Both order and disorder can be measured and thus transmitted. Q.E.D. Nothing more and nothing less. The simplicity of this insight is that of a genius and its impacts on the evolution of Digital Economy are towering.

After graduating from M.I.T. in 1940, Dr. Shannon took a job at AT&T Bell Laboratories in New Jersey. In 1948 he published his masterpiece: 'A Mathematical Theory of Communication', giving birth to modern *information theory*. His 1949 book, *The Mathematical Theory of Communication*, co-authored with Warren Weaver, became a classic. How do we transmit messages, coded as information of bits, while keeping them from becoming garbled, distorted and mangled by channel noise. The concept of coding *redundancy* was born. If enough extra bits were added to a message, to help correct for errors, it could pass through the noisiest channels, yet arriving intact and fully recoverable at the end. There is the beginning of today's error-correction codes that ensure the integrity of transmitted data, modern cryptography, probability theory, etc. Shannon's famous entropy measures are based on probabilities of a particular state being on or off.

Shannon taught that – for machines – the nature of the message did not matter – it could be numbers, words, music notes, video images, etc. Ultimately – to a machine – it is all just 1s and 0s.

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Unfortunately, the two-symbol logic was invented by George Boole, who called it 'The Laws of Thought'. Even Shannon understood that a computer is 'a lot more than an adding machine'. The binary digits could be used to represent words, sounds, images – perhaps even ideas. Ideas?

The labels like information, communication, intelligence, and thought started to sound awfully human. The theories of machine information, communication and 'intelligence' were thoughtlessly applied to human systems, social systems and human communications – as if humans were 1–0 processing machines. They were not.

Information theory was applied to economics, management, decision making, investment theory, even biology, linguistics and literature. Hundreds of interpreters applied Shannon's measures of information, entropy and redundancy to 'everything under the sun', forgetting that human communication, knowledge and information is about *content, context and meaning*, not about 1s and 0s. Decades were lost by treating people as machines and ignoring the much-needed study of human knowledge and communication.

Dr. Shannon could only bitterly complain about what he called a 'bandwagon effect'. He lamented: 'Information theory has perhaps ballooned to an importance beyond its actual accomplishments'. Shannon himself left information theory after 1958, devoting his retirement years to mathematics of juggling, analog computer designed to beat roulette, and a system for playing stock market using probability theory. Yet, even today, one still finds works happily applying entropy, variety, redundancy, fuzziness and other exquisitely content-free, context-free measures to decidedly human pursuits of decision making, knowledge management and communication. Blissfully, Dr. Shannon did not know, fighting his long struggle with Alzheimer's disease.

Claude Shannon taught us – in a very powerful way – what the real and fundamental difference between machines and humans is. He has taught us, like Norbert Wiener and Ross Ashby before him, how little humans resemble machines, analog or digital, how little their exquisite theories of cybernetics, requisite variety and information apply to human affairs. But then, computers and communication networks are human affairs, aren't they? So, much has been gained, even more was lost, but a whole new world of knowledge, knowledgement and knowledge management awaits its ultimate unfolding . . . in both men and machines.

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