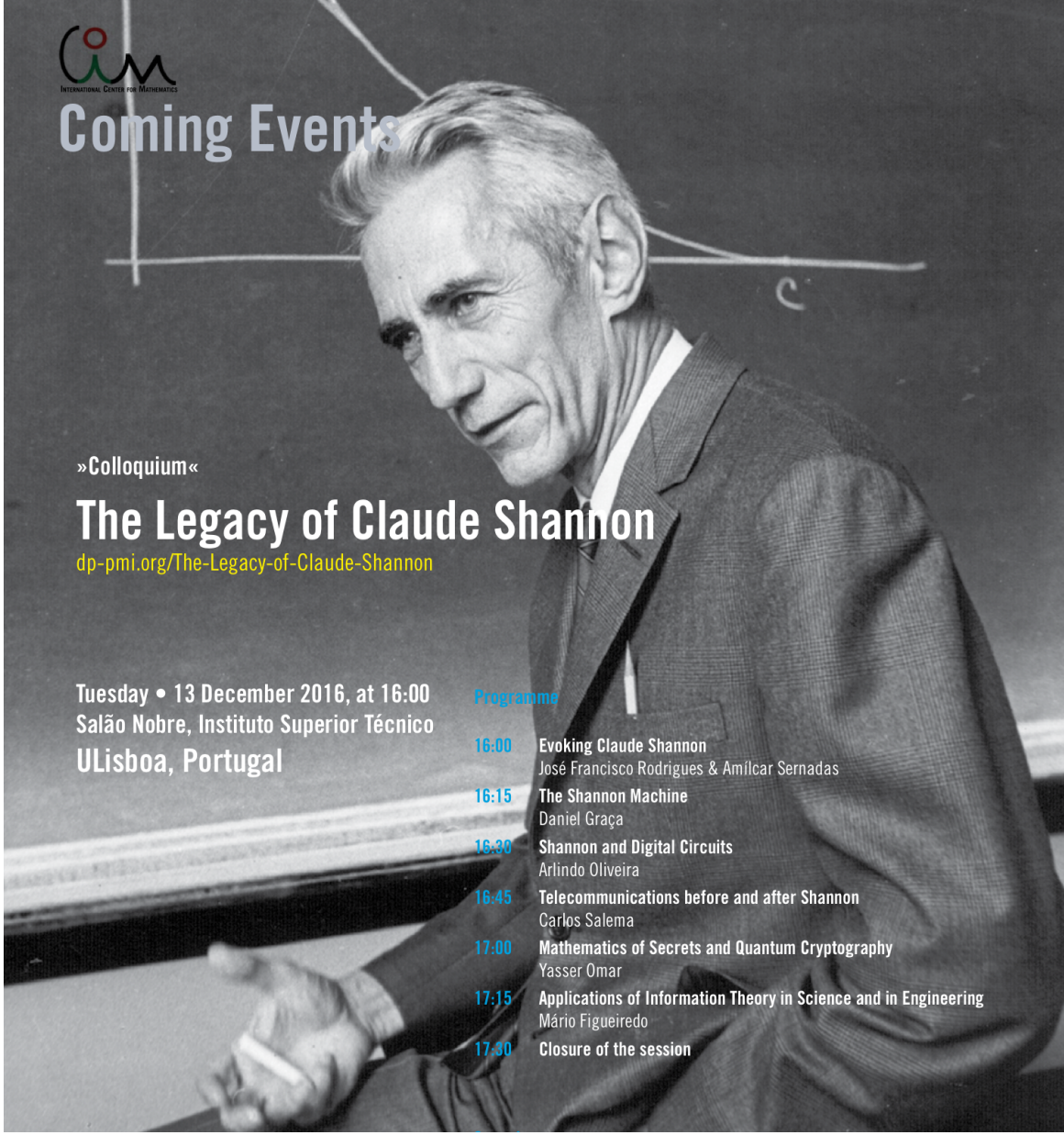
Evoking Claude Shannon



José Francisco Rodrigues *(CMAF&IO_F Ciências_U Lisboa)*
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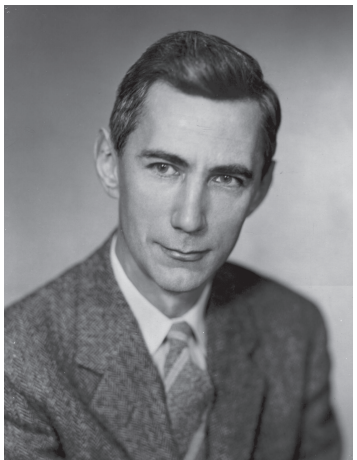
[a] playful genius who invented the bit, separated the medium from the message, and laid the foundations for all digital communications. . . . [He] single-handedly laid down the general rules of modern information theory, creating the mathematical foundations for a technical revolution. Without his clarity of thought and sustained ability to work his way through intractable problems, such advances as e-mail and the World Wide Web would not have been possible.

Something of a loner throughout his working life, he was individually responsible for two of the great breakthroughs in understanding which heralded the convergence of computing and communications. To colleagues in the corridors at the Massachusetts Institute of Technology who used to warn each other about the unsteady advance of Shannon on his unicycle, it may have seemed improbable that he could remain serious for long enough to do any important work. Yet the unicycle was characteristic of his quirky thought processes, and became the topsy-turvy symbol of unorthodox progress towards unexpected theoretical insights.

Anonymous obituary in The Times newspaper on 12 March 2001



Evoking Claude Shannon 1916-2001

1916 – Born and educated in Gaylord, Michigan, USA

1932 – Studied Mathematics (M) and Electrical Engineering (EE), University of Michigan

1936 – Joined the EE Dep. at MIT where he worked with on Vannevar Bush's differential analyzer, an early analog computer.

1938 – In his remarkable master's thesis entitled ***An analysis of relay and switching circuits,*** at Math Dep., he established how Boole's logical symbols can be regarded as a series of on–off switches so that binary arithmetic can be performed by electrical circuits and he developed mathematical techniques for building a network of switches and relays to realize a specific logical function. The work was made independently of the similar earlier theory of Victor Shestakov, which was published in 1941.

1939 – Alfred Noble Prize of the combined American engineering societies.

1940 – PhD thesis ***An algebra for theoretical genetics,*** also at MIT; He was awarded with a fellowship to do research at the Institute for Advanced Study in Princeton, under Hermann Weyl, where he met John von Neumann.

Evoking Claude Shannon 1916-2001

AN ALGEBRA FOR THEORETICAL GENETICS

By

Claude Elwood Shannon

B.S., University of Michigan

1936

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

From The

Massachusetts Institute of Technology

1940

Mathematics Genealogy Project

Claude Elwood Shannon

Biography MathSciNet

Ph.D. Massachusetts Institute of Technology 1940

Dissertation: *An Algebra for Theoretical Genetics*

Advisor: Frank Lauren Hitchcock

Students:
Click here to see the students listed in chronological order.

Name	School	Year	Descendants
Heinrich Ernst	Massachusetts Institute of Technology	1962	
William Hillis	Massachusetts Institute of Technology	1981	
Ivan Sutherland	Massachusetts Institute of Technology	1963	3
William Sutherland	Massachusetts Institute of Technology	1966	

According to our current on-line database, Claude Shannon has 4 students and 7 descendants.
We welcome any additional information.

His results overlapped with some of the early work by J. B. S. Haldane on population genetics, of which he seemed to be unaware. It was published in 1993, when most of his results were obtained independently by others.

rations. The result of random intermating is given by:

Theorem XI. Under random intermating of λ^{hi}_{jk} the nth generation is the population

$$\mu^{hi}_{jk} = [p_0^{n-1}(p_0\lambda^{hi}_{\cdot\cdot} + p_1\lambda^{h\cdot}_{\cdot i}) + (1-p_0^{n-1})\lambda^{h\cdot}_{\cdot\cdot}\lambda^{\cdot i}_{\cdot\cdot}]$$
$$\cdot[p_0^{n-1}(p_0\lambda^{jk}_{\cdot\cdot} + p_1\lambda^{j\cdot}_{\cdot k}) + (1-p_0^{n-1})\lambda^{j\cdot}_{\cdot\cdot}\lambda^{\cdot k}_{\cdot\cdot}] \quad (30)$$

and (assuming $p_0 \neq 1$) approaches asymptotically the population

$$\nu^{hi}_{jk} = \lambda^{h\cdot}_{\cdot\cdot}\lambda^{\cdot i}_{\cdot\cdot}\lambda^{j\cdot}_{\cdot\cdot}\lambda^{\cdot k}_{\cdot\cdot} \quad \text{as } n \to \infty$$

Proof: By definition (8) the first generation is:

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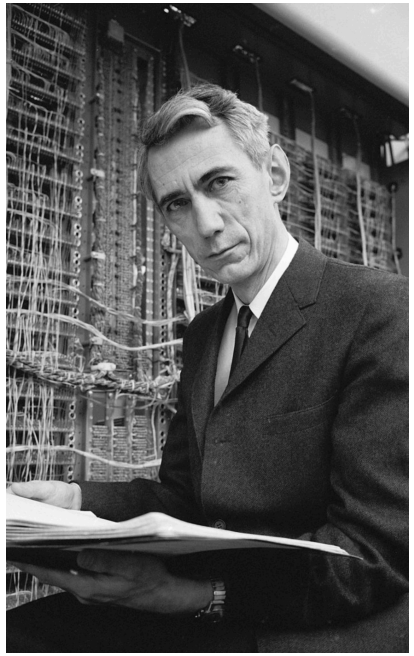
1942 – Already at Bell Labs, where he was a research mathematician for fifteen years, during the World War he worked in fire-control systems for anti-aircraft artillery and in cryptography; in 1943 he met Alan Turing and also developed a mathematical theory of cryptography published, in 1949, as ***A Communication Theory of Secrecy Systems.***

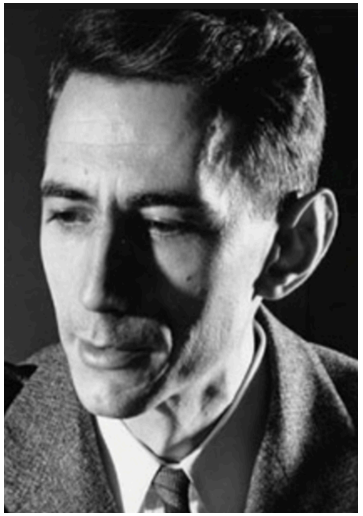


1948 – Shannon published his most important work, ***A mathematical theory of communication,*** that was explained in the book, co-authored by W. Weaver, ***The mathematical theory of communication,*** developing the concept of entropy to measure uncertainty in a message and laying the basis of the mathematical theory of information.

1958 – Appointed Donner Professor of Science at MIT, until his retirement in 1978, having been awarded of several prizes, including the National Medal of Science (1966), the Kyoto Prize (1983) and the National Inventors Hall of Fame (2004).

2016 – Bell Labs' Web exhibit at
https://www.bell-labs.com/claude-shannon/

Evoking Claude Shannon
1916-2001



So wide were its repercussions that the theory was described as one of humanity's proudest and rarest creations, a general scientific theory that could profoundly and rapidly alter humanity's view of the world. Few other works of the twentieth century have had a greater impact; he altered most profoundly all aspects of communication theory and practice. *Ioan James (2014)*

The Bell System Technical Journal

Vol. XXVII *July, 1948* *No. 3*

A Mathematical Theory of Communication

By C. E. SHANNON

Introduction

THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist[1] and Hartley[2] on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design.

If the number of messages in the set is finite then this number or any monotonic function of this number can be regarded as a measure of the information produced when one message is chosen from the set, all choices being equally likely. As was pointed out by Hartley the most natural choice is the logarithmic function. Although this definition must be generalized considerably when we consider the influence of the statistics of the message and when we have a continuous range of messages, we will in all cases use an essentially logarithmic measure.

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Evoking
Claude Shannon
1916-2001

ANO XX — N.º 74-75 **GAZETA DE MATEMÁTICA** MARÇO/JUNHO — 1959

EDITOR: *Gazeta de Matemática, Lda.* ADMINISTRADOR: *A. Sá da Costa*

REDACTORES: *J. Gaspar Teixeira, J. Morgado e J. da Silva Paulo*

Composto na Tipografia Matemática, Lda. — Rua Diário de Notícias, 134 - 1.º - Esq. — Telef. 29449 — LISBOA 2

A definição de entropia em cálculo das probabilidades

por **J. J. Dionísio**

O propósito deste artigo é expor como se introduz no Cálculo das Probabilidades o conceito de entropia. Colocar-nos-emos naturalmente no caso mais simples das distribuições discretas e a isso se limitarão as nossas considerações. Seguiremos para o efeito a primeira das memórias de A. I. KHINCHIN editadas pela casa Dover de Nova York sob o título *Mathematical Foundations of Information Theory*, editadas também em Berlim (Deutscher Verlag der Wissenschaften) acompanhadas de trabalhos de outros autores, sob a epígrafe *Arbeiten zur Informationstheorie.*

Assim se esclarece, nas suas linhas gerais, a conexão entre a relação (17) de BOLTZMAN e a definição (2) da função entropia.

Contudo, foi a moderna teoria das telecomunicações e do controle automático que levou o cientista americano C. E. SHANON a introduzir a definição geral de entropia (*A mathematical theory of communication*, Bell System Techn. J., 27, 1948), criando-se assim um novo ramo do Cálculo das Probabilidades que se encontra em pleno desenvolvimento: a teoria da informação.

Princípios fundamentais dos computadores digitais automáticos

por **A. César de Freitas**

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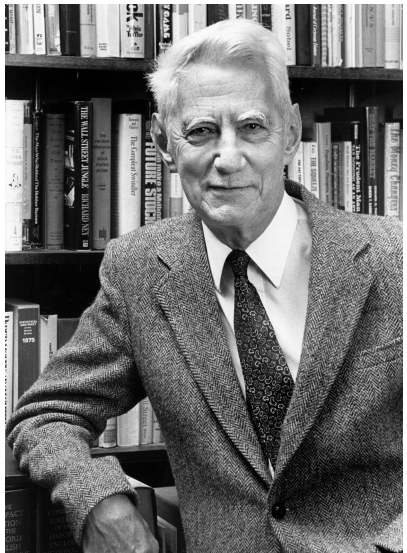
The growth of both communication and computing devices has been explosive in the last century. It was about a hundred years ago that the telephone and phonograph were invented, and these were followed by radio, motion pictures and television. We now have vacuum tubes, transistors, integrated circuits, satellite communication and microwave cable. We have even talked to astronauts on the moon. Our life style has been totally changed by advances in communication. On the computing side we started the twentieth century with slide rules and adding machines. These were followed in quantum jumps by Bush analog computers, Stibitz and Aiken relay computers, Eckert and Mauchly vacuum tube machines ..., transistor computers and, finally, the incredibly compact integrated circuit and chip computers. At each step the computers became faster, cheaper and more powerful. These hardware revolutions were matched by equally impressive developments in programming.

Shannon (1983)



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