"Potential Relationships Between Biological Systems and Computers: Electric Eels and General Systems Theory."

by

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The analogy between the human brain and computing machines has been pointed out by McCulloch in 1949.(1) His analogy deals more with system functioning rather than the operation of biological components of a nervous system. It has occured to me that the understanding of biological signal generators could possibly lay the foundations for quicker advances in the understanding of biological nervous systems. The better understanding of systems such as the brain may lead to concepts useful in designing computers. The detail understanding of the brain is too far away in time to be of practical use in the immediate future. Examination of other biological systems which might be an intermediate step leads to the study of electric eels bade by the Naval Medical Research Institute in 1953.(2)

Voltage Waveforms for Electric Eels.

Typical waveforms for electric eels consist of pulses of about 350 volts peak of about one millisecond duration about three to four milliseconds apart. These bursts of pulses are triggered by a single touch of the eel's head. The function of the electric discharges of the eel is to protect it from enemies and to paralyse animals preparatory to eating them. The polarity is positive at head

2. S. L. Fries, H. W. Shirer, W. J. McCarville, "Discharge Characteristics of a Small Electric Eel." Naval Medical Research Institute, Bethesda, Md. 11 Aug 1953, Memorandum Report 53-13 (ASTIA No. AD-30471)

1. McCulloch, "The Brain as a Computing Machine." Elec. E., pp. 492-497(June 1949)

in respect to the tail.

References on Electric Eels.

C. W. Coates, "Electric Fishes." Elec. E. pp. 47-50(Jan 1950)

History of electric eels, experimental use in science and medicine. Describes a second set of electric organs -- "bundles of Saks" -- which generate pulses 10-15 volts for direction finding purposes. [Note relationship to radar]

M. V. Brown, "The Electric Discharge of the Electric Eel." Elec. E. pp. 145-147(Feb 1950)

Study of the waveforms , voltage, current, and power output of eels. Equivalent circuits and conjectural models of the electric tissue are discussed. Analyses by D. Machmansohn and M. A. Rothernburg indicate phosphocreatine is the immediate source of energy.

C. W. Coates, and R. T. Cox, "A Comparision of Length and Voltage in the Electric Eel, Electrophorus electricus(Linnaeus)" Zoologica, 30, 89-93, 1945.

Contains five earlier references(1940-1945)

R. T. Cox and C. W. Coates and M. V. Brown. Annals N.Y. Acad. Sci. 47: 487, 1946.

Engineering Recommendations

No active research with eels is contemplated as a part of computer research. However it it to the computer engineer's advantage to keep informed onw what research is being done in the search for a satisfactory theory of the elctric cells in the eel.

A direction more valuable for computer engineers is the pursuit of general systems theory as outlined by L. von Bertalanffy(*). Using general systems theory it might be easier to perceive analogies between biological systems and electronic computers. General systems theory is an attempt to find general laws which apply in different fields of science, but with variables representing different phenomena or properties. The development of general systems theory should be of interest to computer engineers for the

* L. Von Bertalanffy, "An Outline of Genreal Systems Theory." Main Currents in Modern Thought, 71, 75, 1955. Reprinted in General Systems, Volume I, 1956, pp. 1-10.

following reasons:

(1) The advancemtnt of the understanding of biological nerve systems having characteristics similar to some types of computers, memory systems, and accounting machines may show by analogy that there are potential components or systems configurations for computers not already known.

(2) The development of more valid laws for biological and social phenomena could extend the domain of biological and social research to various levels such as: small business, large business, government agencies, United Nations, economic committees, etc. This could help any existing system in the political and economic field to adjust to the changing needs of its members, customer, stockholders, clients, or citizens. Thus the computer industry would be in a postion of providing services which help business and other organizations to adapt to the donditions of a complex industrial society.

Conclusions.

This note started as a discussion of the potential utility of electric eel research, leads to the conclusion that a certain amount of general systems theory research may be essential for the stability of a business concern in our complex industrial society. The further pursuit of these points may lead to a better understanding of the critical importance of feedback systems for the stability and prosperity of the United States of America.

Appendix

Further rough notes are in the file conerning series to parallel connections to increase speed of computing; analogies with a biological probelm; feedback loops related to finctioning of human nervous system(hormones, rest, music therapy, psychotrherapy, etc.).

Reference ot Rev. Frithchman's "Gospel of the Univac."

Suggestion for developing the humanitarina aspect of the large scale computer, relation of theory of integration to Stiltjes Integral, Theory of Peace, etc.

SOCIO-ENGINEERING PROBLEMS REPORT NO. 74

Date: 12/14/55 2/24/62 3/31/65 2/10/67

Stage: Memo SEP 74 SEPR 74 Reissue

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