On the Links between Nervous System Theories and Artificial Intelligence

Acknowledgments

to The Rector of Óbuda University, Prof. Fodor
to The Senate of this University

to The University of Las Palmas de Gran Canaria

to EUROCAST Conferences (specially to one founder, Prof. Franz Pichler, Linz) and to Workshop Chairman Dr. Ryszard Klempous, Wroclaw)

On the Links between Nervous System Theories and Artificial Intelligence

Formal Neurotheories (Neurocybernetics)

The Three Key Triggering Contributions

Wiener's Cybernetics

Communication and Control in animals and machines
(Wiener, Rosemblueth,Bigellow,**1943**)

Nervous Systems Logical Paradigms

Distributed Computation and Decision
Formal Neural Nets
(Mc Culloch, Pitts, **1943**)

Conceptual Bases of Robotics

The Nature of Explanation
(Craick, **1943**)

Key points in Wiener's Cybernetics (1947)

- Feedback, from the outcome to the input
- Information, not energy in the feedback loop

Origin of the concept of information (Ch.S.Peirce "third quantity")
- Fisher (from the classical statistical theory)
- Wiener (from noise and message in electrical filters)
- Shannon (from problems in coding)

Basis of homeostasis and reactive agents

McCulloch and Pitts Neural Nets

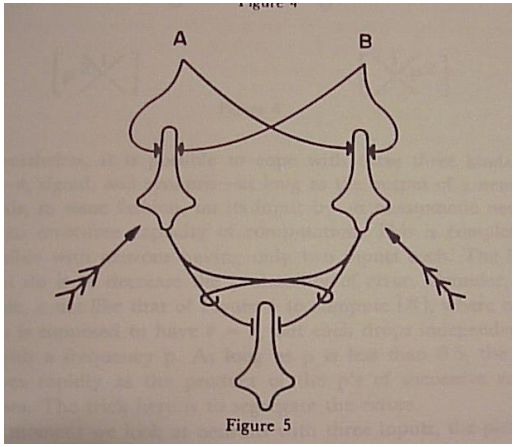
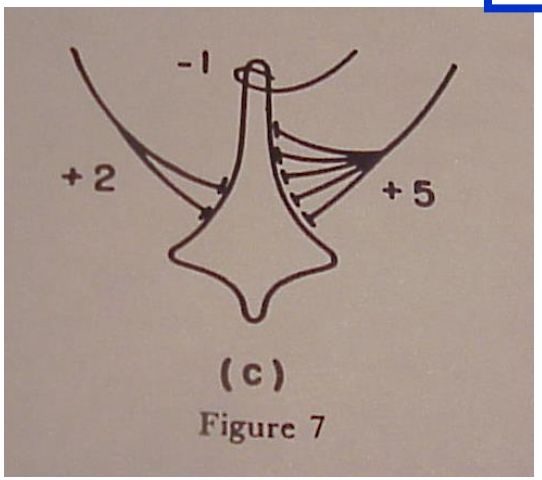


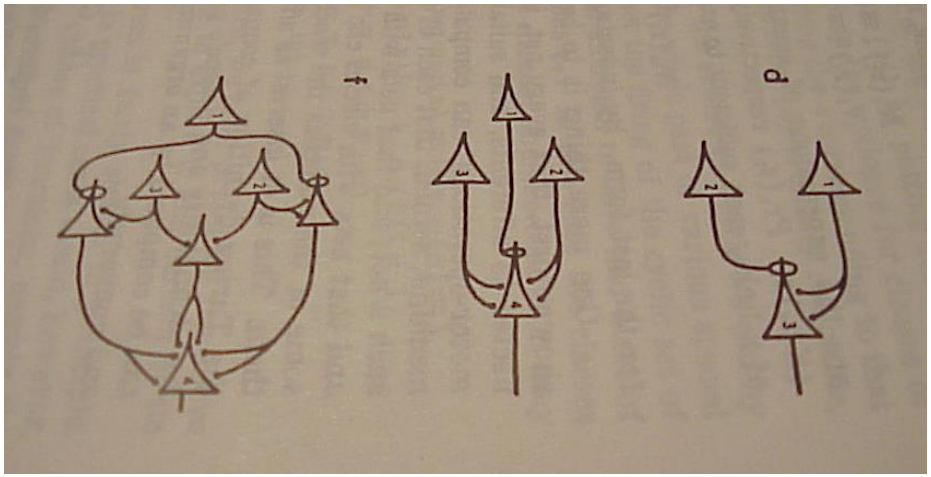
Figure 5

The formal Neuron is a logical unit that embodies the basic properties of excitation, inhibition, threshold and "all or none" inputs and outputs

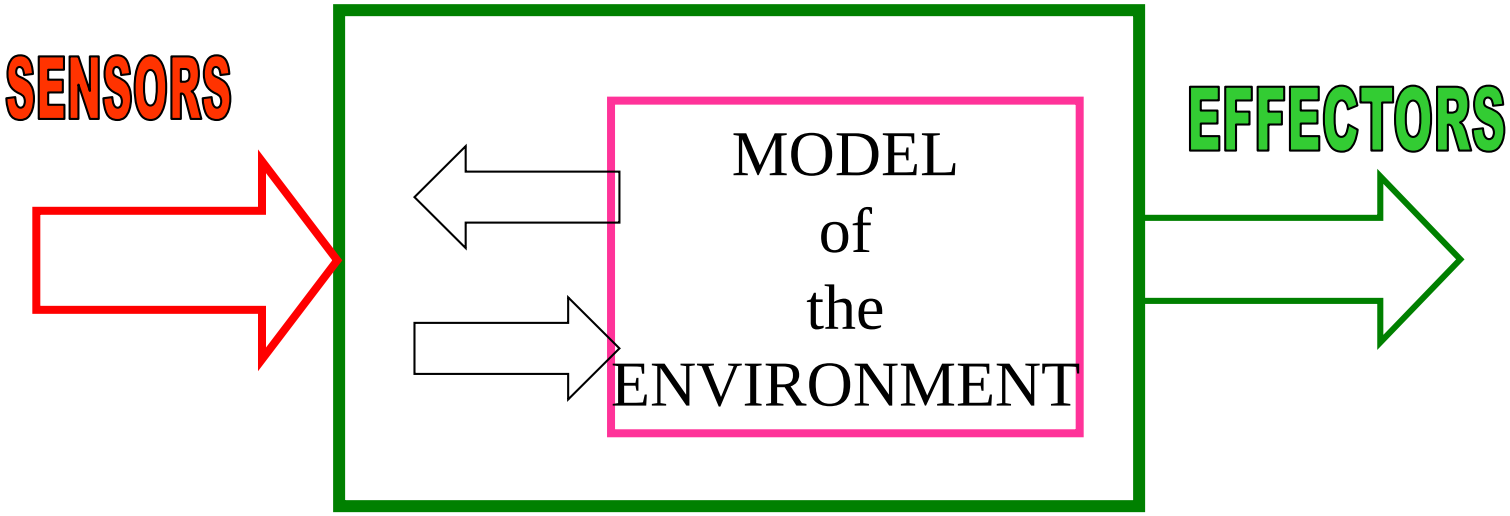
A neural net with loops can compute any number that a Turing Machine with a finite tape can. It is equivalent to what later will be called a "finite automaton" with a modular realization with the simplest units



(c)
Figure 7



The roots of Connectivism



Simplified Craick's Construtivist Model

Basis of Symbolic Agent A.I. and Robotics

1943-1953

The Josiah Macy's Foundation Conferences

Ten Conferences on *Circular, Causal and Feedback Mechanisms in Biological and Social Systems*

Some of the attendants

W.S. McCulloch (Chairman), J. von Neumann, N. Wiener, A. Rosemblueth, J. Bigellow, C. Shannon, W. Pitts, W. Ross-Ashby, W. Grey-Walter, R. Lorente de Nó, L. Kubie, D.McKay, L. Pauling, K.S. Lashley, H. von Foerster

The Josiah Macy Foundation Conferences 1943-1953

- **Antecedent: meeting in 1942 of engineers, physiologists and matematicians, where "Behaviour, Purpose and Teleology" by Wiener, Rosemblueth and Bigellow was presented**

Some of the many concepts and subjects treated:

*** Regulation, homeostasis and goal directed activity**

*** Transmision of signals and communication**

*** Neural nets and automata theory**

*** Closed loops in the central nervous system**

*** "Circular causality" in economics and the polling of public opinion**

*** Conflic between motives in psychiatry (heterarchy of values)**

*** Reverberating and content addressable memories**

*** Learning as changes in transition probabilities**

Reference: C. Pias, editor: Cybernetics, The Macy's Conferences 1946-195 Transactions. Diaphanes. Zurich-Berlin (2003)

1948

ACTUALITÉS SCIENTIFIQUES ET INDUSTRIELLES

1053

CYBERNETICS

OR

CONTROL AND COMMUNICATION IN THE ANIMAL AND THE MACHINE

BY

NORBERT WIENER

Professor of Mathematics at the Massachusetts Institute of Technology
Guest Investigator at the Instituto Nacional de Cardiología de México.

PARIS
HERMANN & Cie, ÉDITEURS
6, Rue de la Sorbonne, 6

THE TECHNOLOGY PRESS
Cambridge, Mass.

JOHN WILEY & Sons. Inc.
440 Fourth Av., New York

1948

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Groups and Statistical Mechanics 57

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Time Series, Information, and Communication 74

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Feed-Back and Oscillation 113

CHAPTER V.
Computing Machines and the Nervous System 137

CHAPTER VI.
Gestalt and Universals 156

CHAPTER VII.
Cybernetics and Psychopathology 168

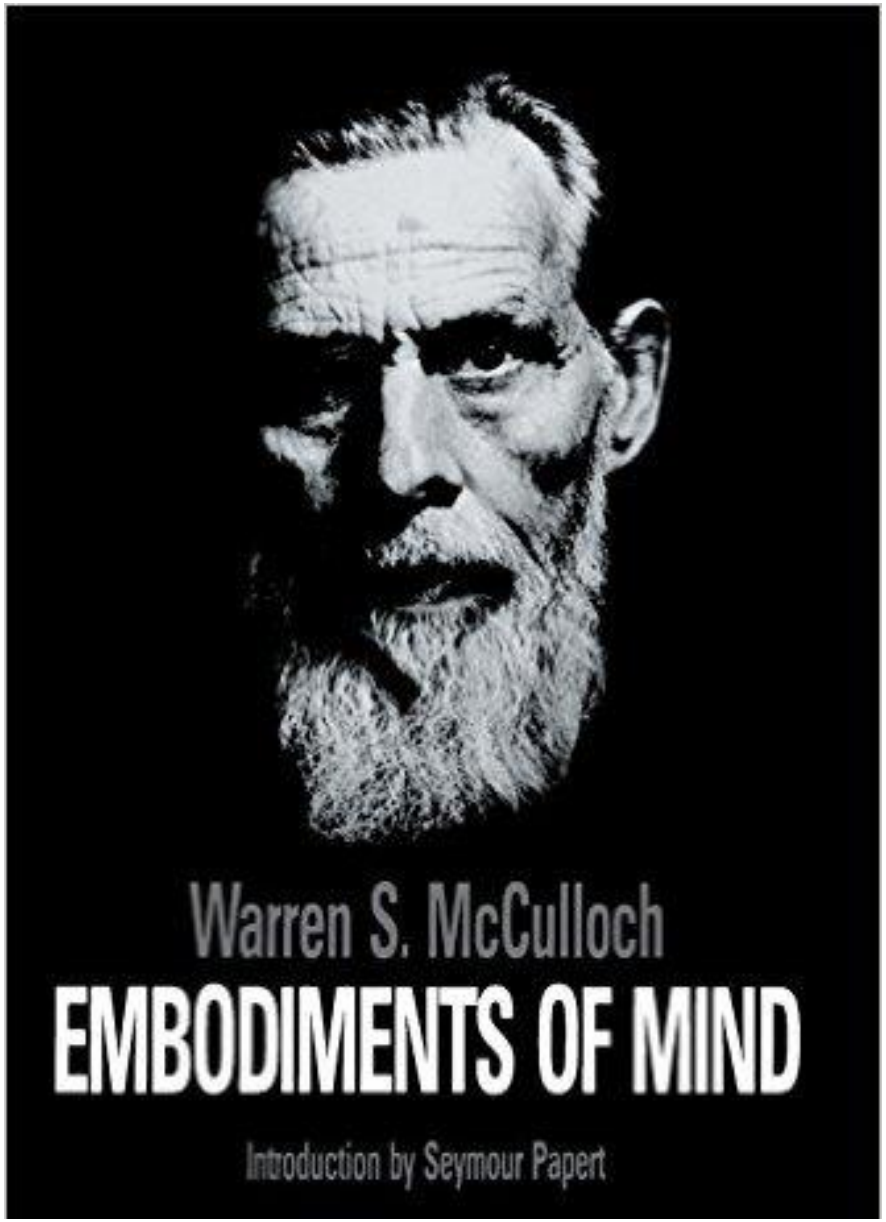
CHAPTER VIII.
Information, Language, and Society 181

Neurocybernetic Problems introduced (and, in many aspects, still open) in the Macy's Conferences (1955's)

* Regulation, homeostasis and goal directed activity
* Nervous System Multiple Coding and Transmision of signals and communication
* Neural nets and automata theory
* Closed loops in the central nervous system
* "Neuralcircular causality" and its counterparts in economics and in the polling of public opinion
* Conflict between motives in psychiatry (heterarchy of values)
* Reverberating and content addressable memories
* Learning as changes in transition probabilities

At the Research Laboratory of Electronics (From 1952) in Warren McCulloch environment

- Lettvin, Maturana, McCulloch and Pitts “What the Frog’s Eye tells the Frog’s Brain” (1959) Epistemological Neurophisiology
- “Two Remarks on the Visual System of the Frog” (1960) (Lettvin)
- “ Towards a Probabilistic Logic” (1959) (Winograd, Cowan)
- Reliable computation with unreliable components
- “What is a number…”
- Search for a theory of brain function based on abductive logic
- Modes of decision of the vertebrates (The reticular formation)(Kilmer)
- “Circularities in Nets and Functional Matrices” “Triadic Relations”
- Models of dynamic memory and towards a theory of intensional relations (Da Fonseca)



The MIT Press 1965

Later Classical Neurocybernetics Problems

***Reliable computation in nets (From McCulloch, von Newman)**

***Adaptive Systems and Learning (From Ashby, von Foerster, Caianiello)**

***McCulloch's Programs**
I Logical Synthesis: Neuronal Counterparts of Logical Machines
II Computer Methaphors in the Synthesis of Nervous Structures and Activities (Reticular Formation Paradigm)

Neurocybernetics-Artificial Intelligence
Marvin Minsky's AI MIT Laboratory

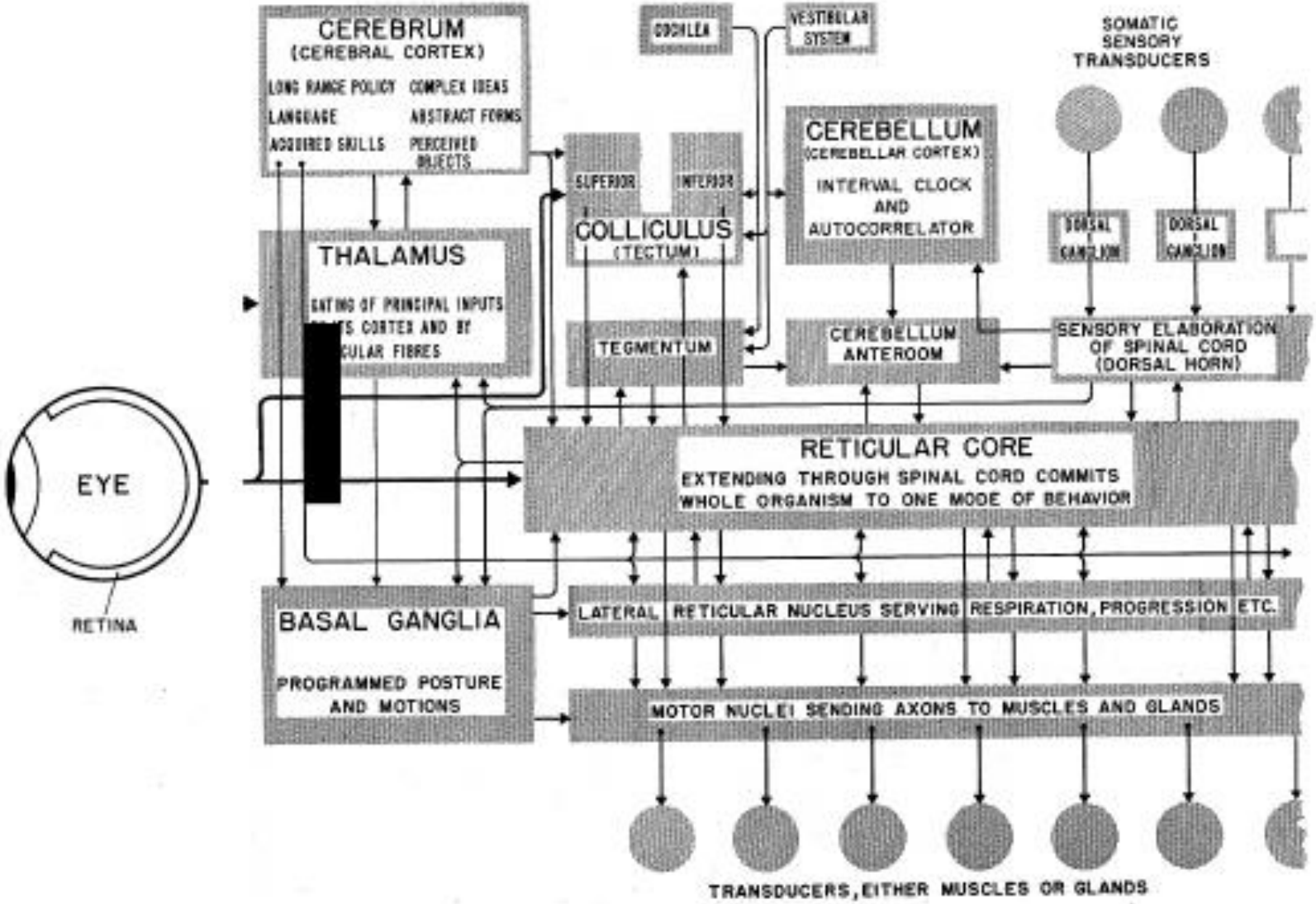


Fig. 7-1. Block diagram of generalized vertebrate nervous system.

From Sutro et al. " Development of Visual, Contact and Decision Subsystems for a Mars Rover" MIT, Cambridge Mass, 1967

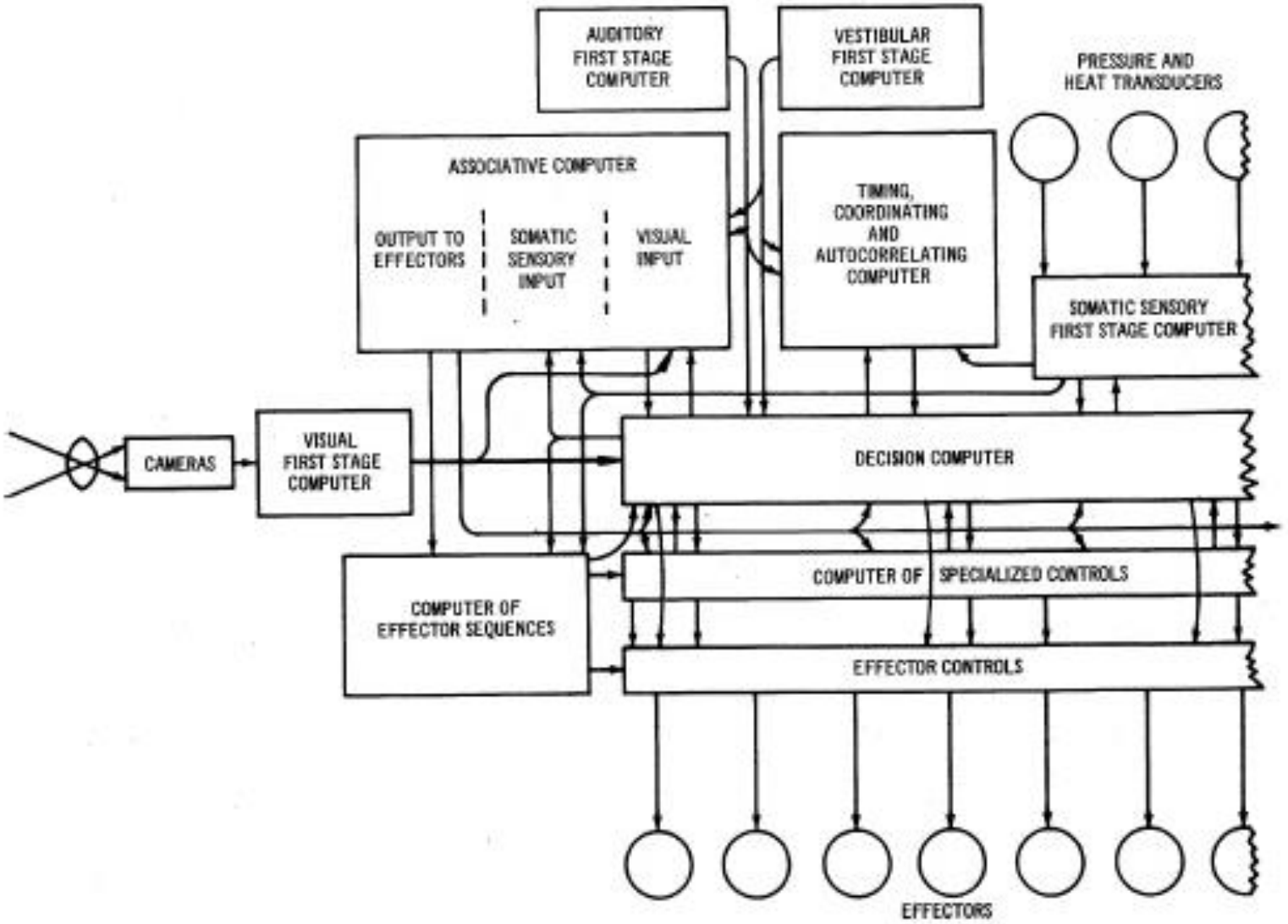
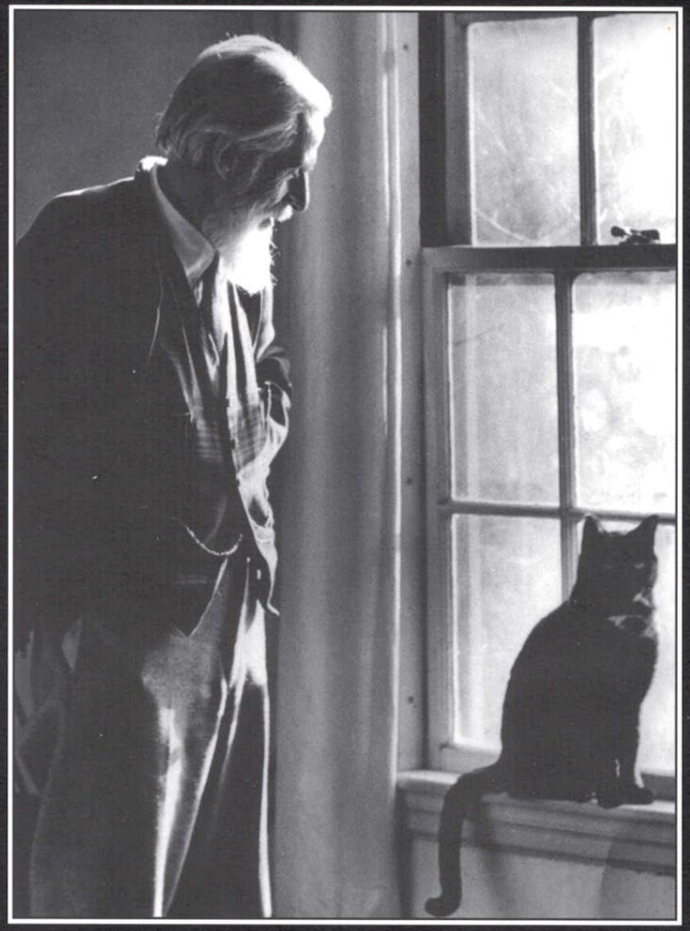


Fig. 7–2. Block diagram employing functional engineering nomenclature.

From Sutro et al. (same reference)

BRAIN PROCESSES, THEORIES AND MODELS

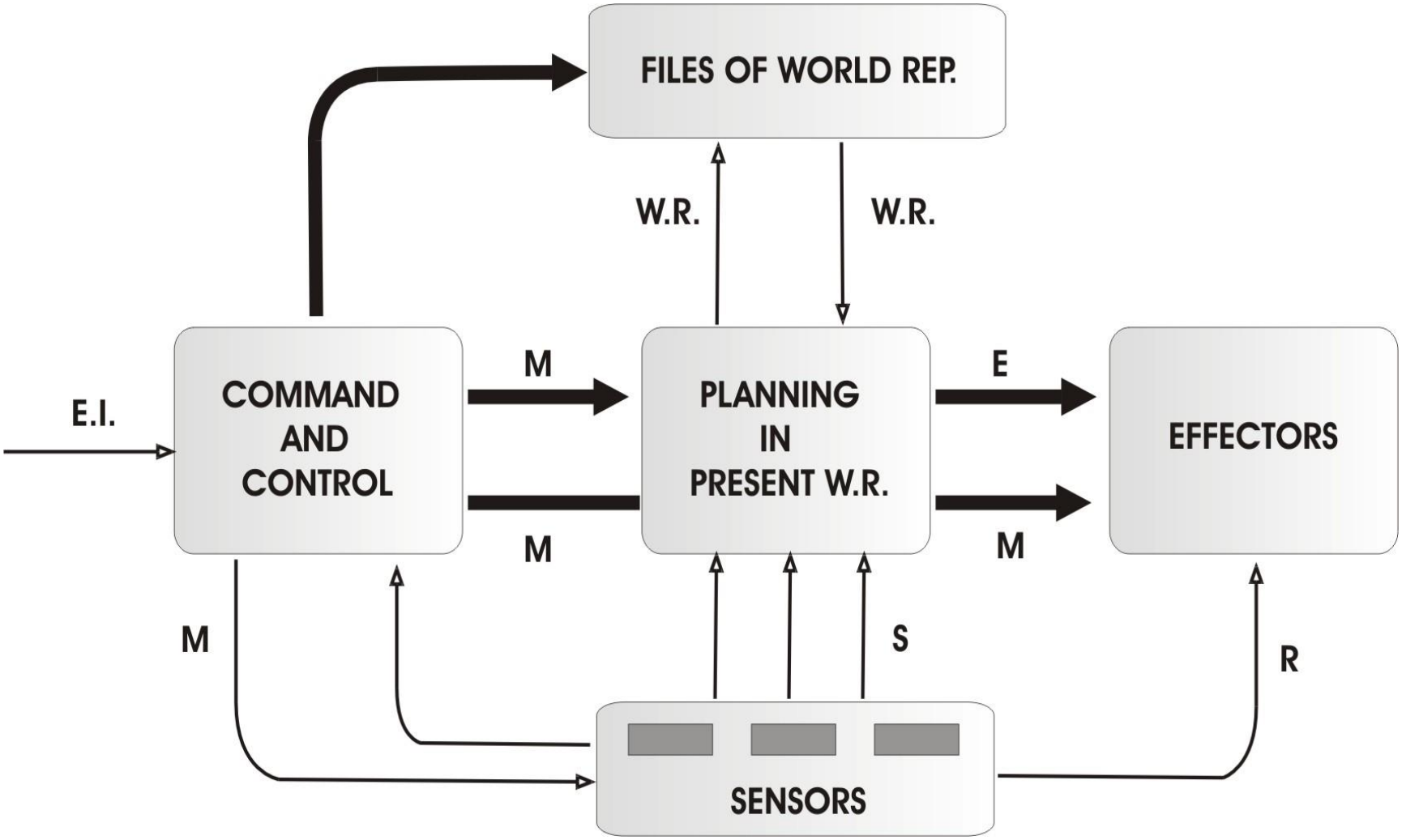
An International Conference in Honor of W. S. McCulloch
25 Years after His Death



edited by

Roberto Moreno-Díaz and José Mira-Mira

McCulloch, 25 years in Memoriam, Nov. 1995


FILES OF WORLD REP.
W.R.
W.R.
E.I.
COMMAND AND CONTROL
M
PLANNING IN PRESENT W.R.
E
EFFECTORS
M
M
M
S
R
SENSORS

LAS PALMAS INTERNATIONAL CONFERENCE WIENER'S CYBERNETICS: 50 YEARS OF EVOLUTION.

Casa de Colón, Las Palmas de Gran Canaria, Canary Islands, Spain
FEBRUARY 8-11, 1999.

Organized by:

Universidad de Las Palmas de Gran Canaria.
Instituto Universitario de Ciencias y Tecnologías Cibernéticas.

Johannes Kepler Universität Linz.
Institut für Systemwissenschaften.

Universita di Napoli.
Dept. di Matematica e Applicazioni "Renato Cacciopoli"

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Scope: The general aim is to revisit the contents of Wiener's book and to explore the evolution of the subjects of the different chapters of the book:

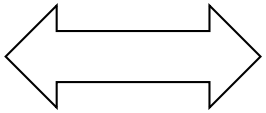
- Newtonian and Bergsonian Time,
- Groups and Statistical Mechanics,
- Time Series,
- Information and Communication,
- Feed-Back and Oscillation,
- Computing Machines and the Nervous System,
- Gestalt and Universals,
- Cybernetics and Psychopatology, Information,
- Language and Society.

Of specific interest is to explore the relation of Wiener's approach to current key topics such as Neuroscience, Artificial Intelligence, Robotics, Artificial Life, Genetic Algorithms, Fuzzy Logic, Complexity Theory and others.

Key objective of todays “Computational Neurotheories”

- **Obtaining Computable Models and Theories of nervous activity, from membrane phenomena to perceptual, cognitive, behavioural and social processes**

Equivalence?

Neurocybernetics  Computational Neurotheories

LEVELS AND FORMAL TOOLS IN NEUROCYBERNETICS

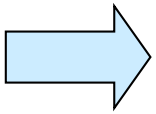
	Level	Formal Approaches
COMPUTING AS TOOLS	Neurotransmitters,membrane phenomena, action potentials	Biochemistry, Biophysics
	Biophysics of neural codes and multiple codes	Biophysics, Signal Processing
	Sensorial codes, decoding in motor and glandular effectors, coding in the Retina	Space-time System Theory
COMPUTING AS METHAPHORS	Neural nets, input output interaction and coordination.Brain subsystems	Algorithmic (Logic,Symbolic) Connectivistic A.I.
	Central neural code, cooperative processes, perception of universals, social-like behaviour	Symbolic, Methods and Techniques of Cognitive A.I.

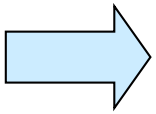
Three Focousing of A.I. links to Neurocybernetics

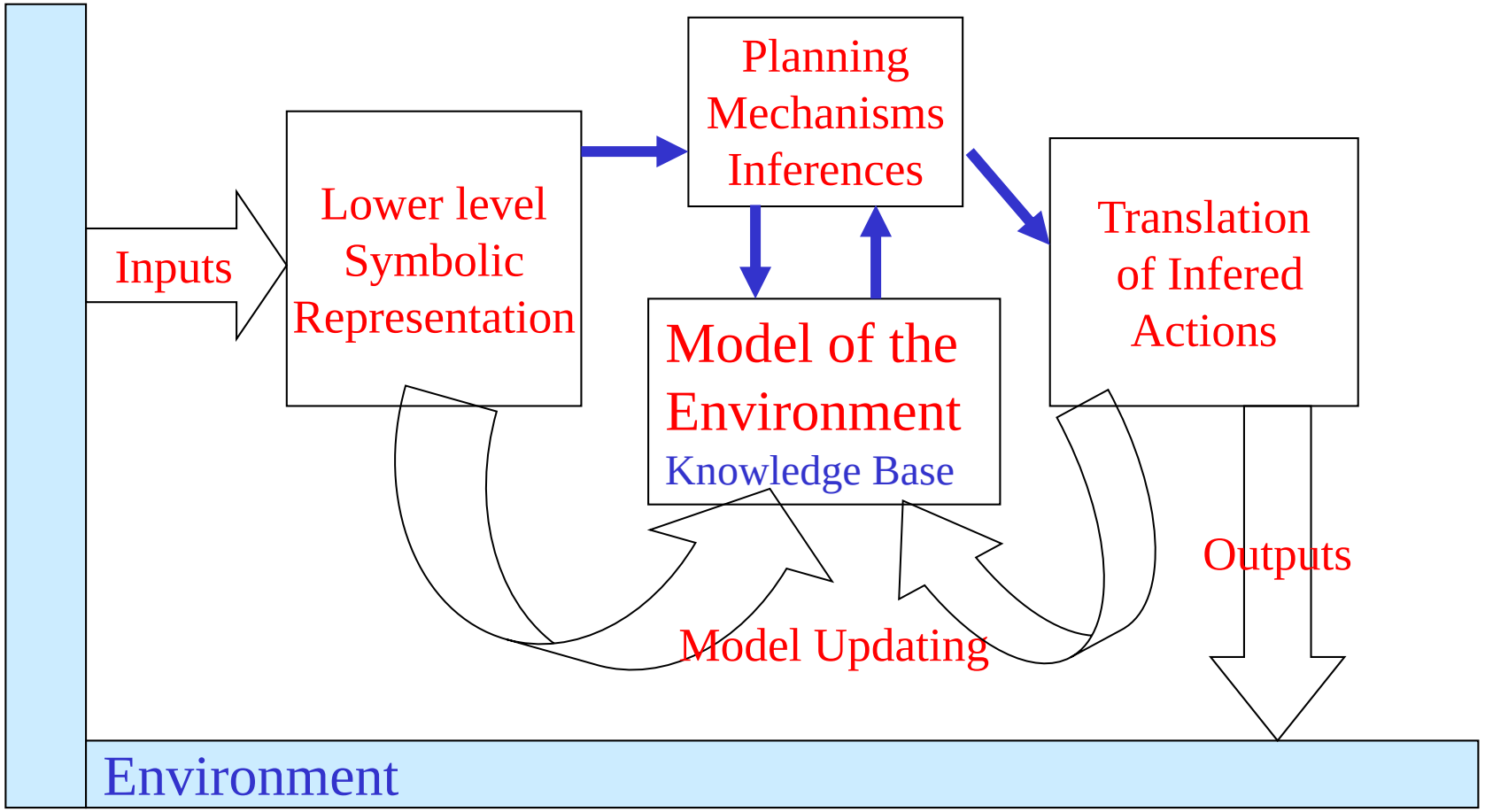
Symbolic A.I.

Situated A.I

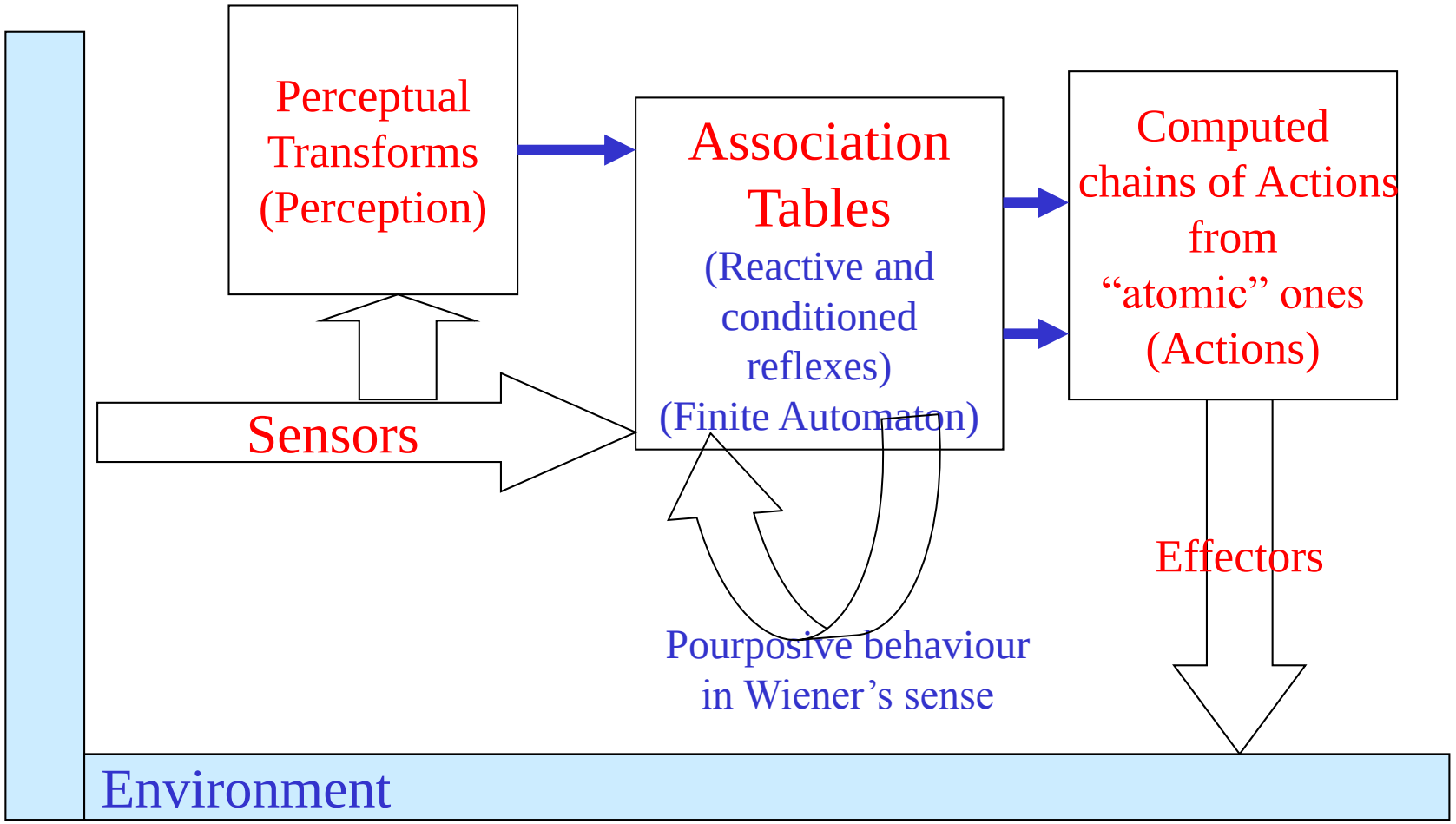
Connectivistic A.I.

Situated and Connectionist A.I  Computational Intelligence.

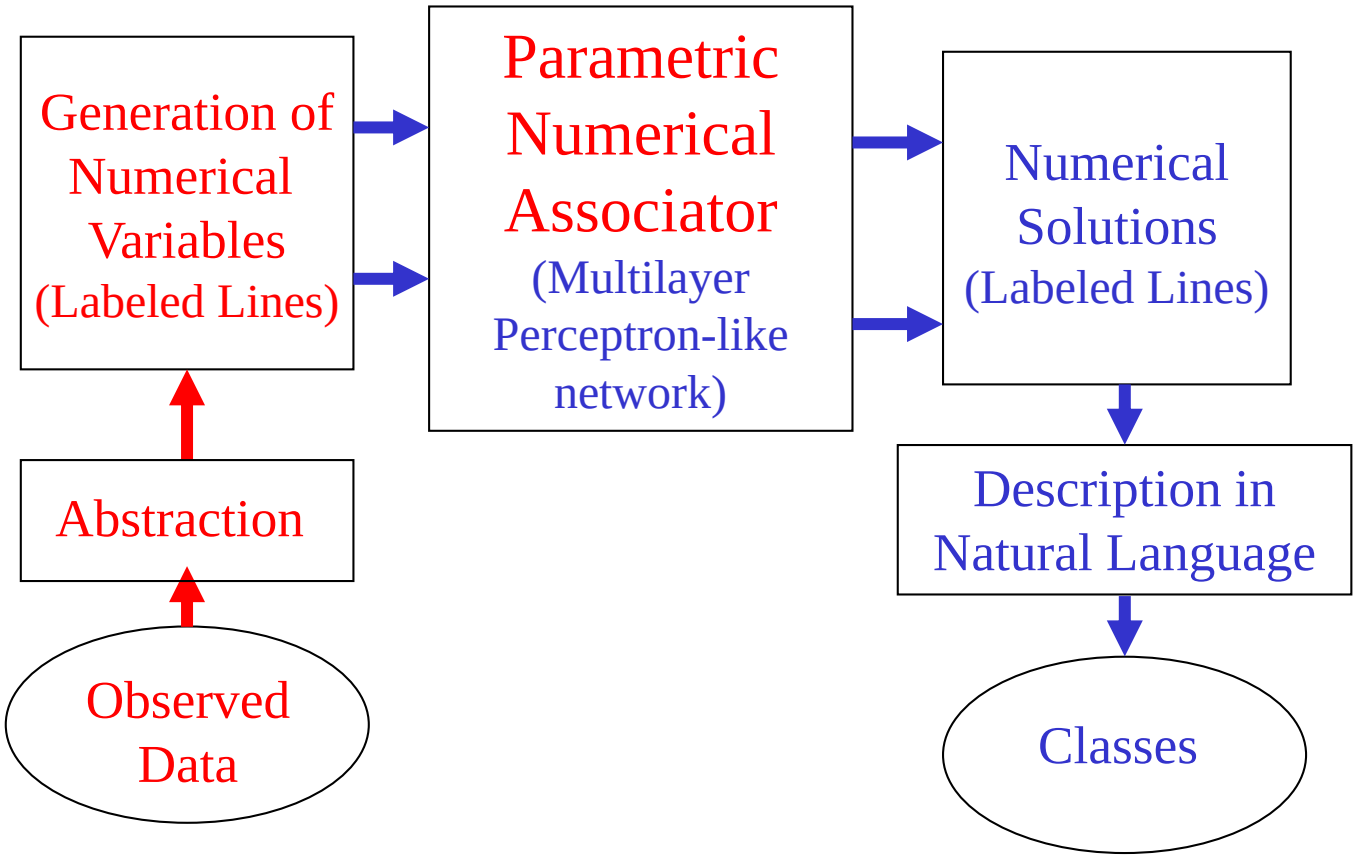
(Symbolic A.I.  GOFAIR)



Updated view of Craik's proposal (Symbolic Agent A.I.)



Architecture of a Situated I.A.System (Reactive Agent)



Typical Connectivistic A.I. Application
Architecture of an Artificial Neural Net

Computing Cognitive A.I.

Neurocybernetics

Theory of Computation
Representation of Goals,
Believes, Purposes
Principle of rationality (Leibniz)

Mind and Feelingns
Natural Language
Coherent Description of
Cognitive Processes

Knowledge Level

Data Structures
Algorithms
Formal Languages
Comand an Control

Perception. Codes in Cortex
Role of brain regions
(i:e: cerebellum)
Reticular Formation

Symbolic Level

Hardware and Signals
Paralel Architectures
Artificial Neural Nets

Anatomy and Physiology
Of Neurons and Nets
Morphology and Fuction in
the Nervous System

Physical Level

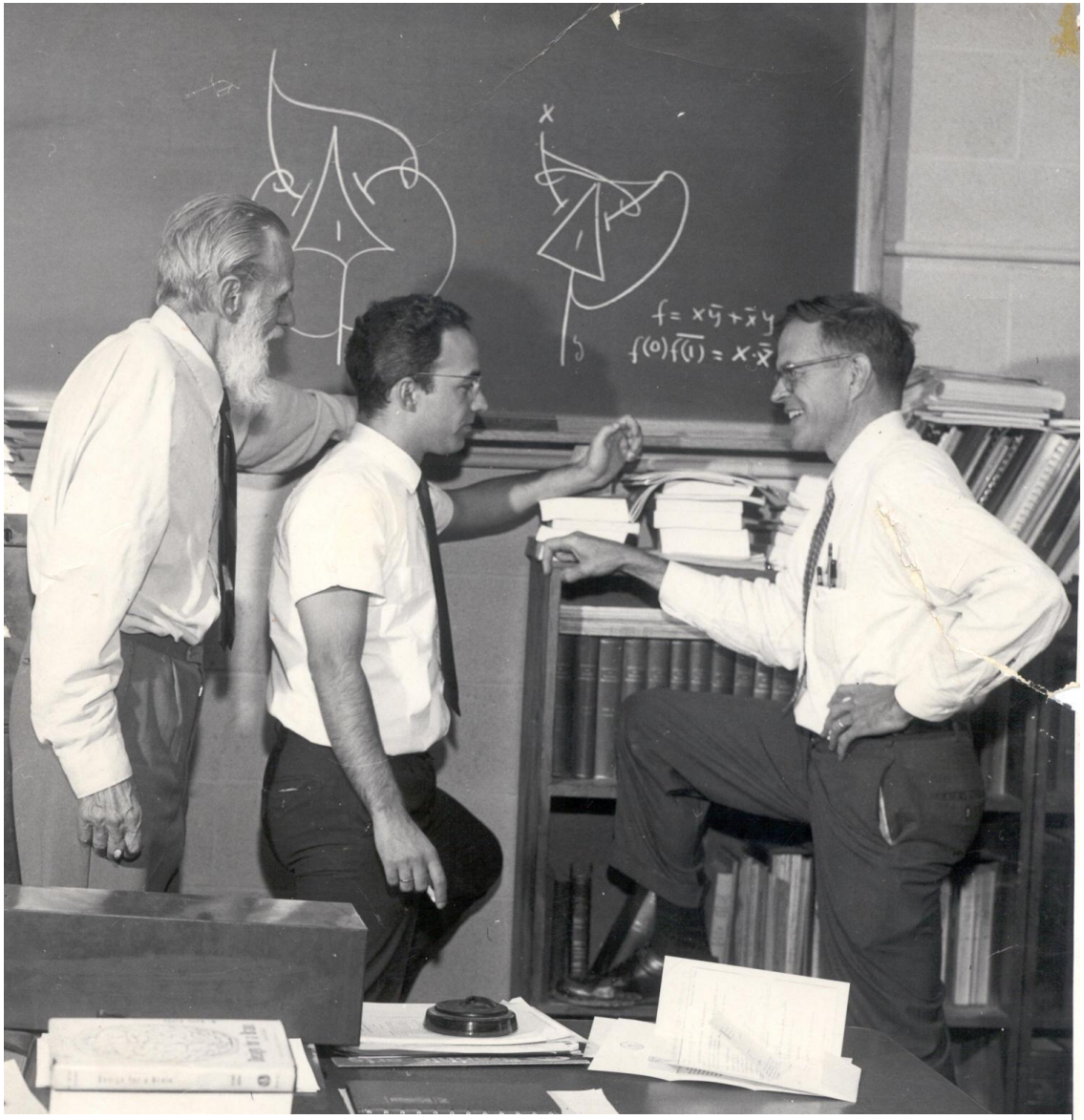
Reduction

Emergency?

Linking Computing Science and Neurocybernetics.

Some open areas of methaphors in the interaction of Neurocybernetics and Computing at the Symbolic Level

- Logic of Intentions and the Theory of Triadic Relations
- Visual World Representation (World of Illusions) and Coding in Visual Cortex
- Computing Models of Chains Perception-Action
- Multisensorial integrated representation of data
- Reliability and Multifunctionality of computing units and subsystems (Cerebral Dynamics)
- The Problem of Command and Control (homunculus)



McCulloch, Moreno-Díaz, Sutro,. RLE, MIT, 1965

MCCulloch : “I want to know what is a number that humans may know it; and humans, that they may know a number”

Rufus Jones : “Friend, thee will be busy as long as thee lives”