# Quantitative Analysis of Purposive Systems:
## Some Spadework at the Foundation of Scientific Psychology

William T. Powers- 1978

Course: Autonomous Machine Learning

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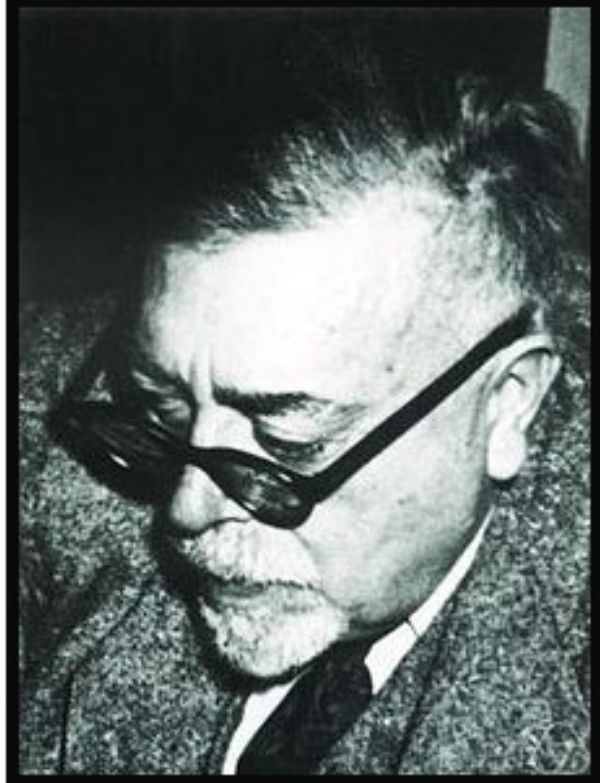
# Contents

# Introduction

- " I believe that the concepts and the methods explored here are the basis for a scientific revolution in psychology and biology, the revolution promised by cybernetics 30 years ago but delayed by difficulties in breaking free of the older point of view.”

  William Powers

# Cybernetics



We have decided to call the entire field of control and communication theory, whether in the machine or the animal, by the name Cybernetics, which we form from the Greek [for] steersman.

(Norbert Wiener)

izquotes.com

# Four Blunders (quantities mistakes)

- These blunders have been directly responsible for the failure of cybernetics and related subjects to provide new directions for psychology.

1. Machine analogy Blunder
2. Objectification Blunder
3. Input Blunder
4. Man-Machine Blunder

# 1. Machine Analogy Blunder

- Thinking of control theory as machine analogy.

- Servomechanisms have always been designed to take over a kind of task that had previously been done by human beings and higher animals and by no other kinds of natural system, that of controlling external variables.

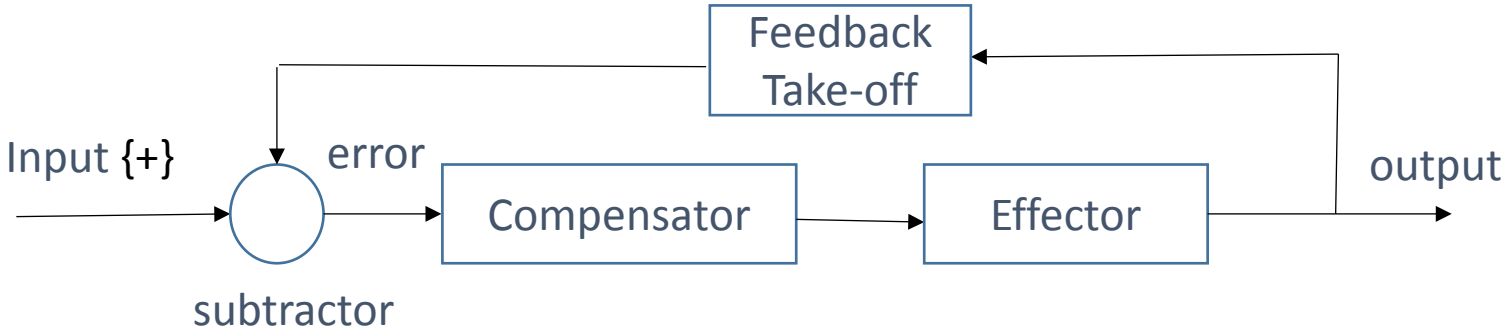
# 2. Objectification Blunder

- Focusing on objective consequences of behavior of no importance to the behaving system itself.

- The only way to make such systems useful is to be sure that the input to the system depends strictly on the environmental effect that the user wants controlled and to protect the input from all other influences.

# 3. Input Blunder

- Misidentifying reference signals as sensory inputs.




- Input: sensory input →reference signal (purpose)
- Output: irrelevant side effects.

# 4. Man-Machine Blunder

- Overlooking purpose properties of human behavior in man-machine experiments.

- Only the subject has a means of directly affect the state of the display; hence the display will be made to match the subject's inner reference.

# The Quasi-static Approach

- The validity of the quasi-static approach as well as it usefulness depend on the frequency domain of interest.
- The interested frequency domain lies between a pure steady state and the “corner frequency” where the quasi-static analysis begins to break down.
- The classical mechanistic cause- effect model will become a subset of the present analysis.

# The Quasi-static Analysis

- Consider a behaving system(system) in relationship to an environment.
- It has one sensory input affected by the an input quantity ($q_i$) and one output that affects an output quantity ($q_o$)
- The output quantity will be related to many other external quantities, but the only one of interest here is ($q_i$), the input quantity.

# The Quasi-static Analysis

- The system equation

$q_o = f(q_i)$ *(1)* $f(q_i)$, *f is a general algebraic function.*

- The environment equation

$q_i = g(q_o) + h(q_d)$ *(2)*

- The environment equation contains two terms, which together determine completely the state of the input quantity.

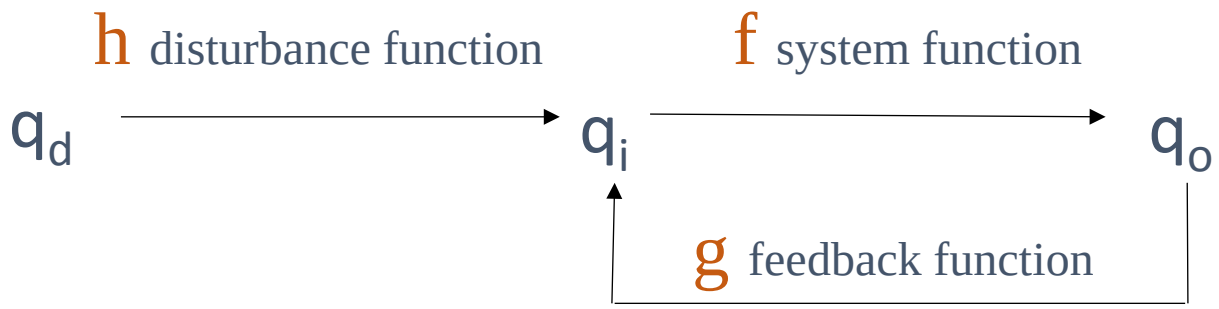
1) Come from the output of the system via $q_o$ ,

*$g(q_o)$, g is general algebraic function describing the physical connection from* $q_o$ *to* $q_i$ *(feedback path).*

2) An equivalent disturbing $q_d$ . *All other possible influences on the input quantity that are independent of* $q_o$.

# The Quasi-static Analysis

- Relationship among variables and functions in quasi-static analysis




- $q_d$ : disturbance quantity
- $q_i$ : input quantity
- $q_o$ : output quantity

# The Quasi-static Analysis

- To find a general simultaneous solution valid for all quasi-static cases, we shall rearrange equations *1* and *2*. By using Taylor series
- $q_o = f(q_i^*) + (q_i - q_i^*)\,[\,A+B\,(q_i - q_i^*) + C\,(q_i - q_i^*)^2 + \ldots]$

  *A,B,C are the Taylor series coefficients and is symbolized as U*

  $q_i^*$ *is a special value.*

  $q_o = f(q_i^*) + U(q_i - q_i^*)$ *3*

In a parallel manner the environment equation

$q_i = g(q_o^*) + V(q_o - q_o^*) + h(q_d)$ *4*

# The Quasi-static Analysis

- From equations *3* and *4* and when $h(q_d)= 0$ , $q_i = q_i^*$ then
- $q_i^* = g(q_o^*)$ and $q_o^* = f(q_i^*)$
- Substitution into equations *3* and *4*

$$q_o - q_o^* = U(q_i - q_i^*) \qquad 5$$

$$q_i - q_i^* = V(q_o - q_o^*) + h(q_d) \qquad 6$$

- Substitution into equations *5* and *6* then $V(q_o - q_o^*)= g(q_o)- g(q_o^*)$

$$g(q_o)= q_i^* + ( UV/ 1\text{-}UV)\, h(q_d) \qquad 7 \quad \text{where } UV \neq 1$$

- Substitution into equations *5* and *6*

$$q_i = q_i^* + h(q_d)/ ( 1- UV) \qquad 8 \quad \text{where } UV \neq 1$$

# The Quasi-static Analysis

- $q_o - q_o^* = U(q_i - q_i^*)$
- $q_i - q_i^* = V(q_o - q_o^*) + h(q_d)$

- *UV* is called the ***loop gain*** in morphologically similar equations of control theory.

- These equations remain completely general, applying to any system-environment relationship of the basic from the assumed, when the assumption of the dynamic stability is observed to hold true.

# Thank you