

11-5-2010

The Limits of Control, or How I Learned to Stop Worrying and Love Regulation (Discussion)

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Recommended Citation

Hughes, Joshua, "The Limits of Control, or How I Learned to Stop Worrying and Love Regulation (Discussion)" (2010). *Systems Science Friday Noon Seminar Series*. 22.
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THE LIMITS OF CONTROL
or how I learned to stop worrying
and love regulation

(DISCUSSION)

Systems Science Seminar
November 5, 2010

CONTROL

Achieving and/or maintaining a desired state (or set of states) of a **system** in an **environment** subject to some **criteria**.

“Regulation achieves a *goal* against a set of disturbances.”¹

Two main points in control/regulation

“only variety can destroy variety”¹

“every good regulator of a system must be a model of that system”²

¹ Ashby, W. Ross (1958). “Requisite Variety and Its Implications for the Control of Complex Systems,” *Cybernetica*, **1**, 83.

² Conant, R.C., Ashby, W.R. (1970). “Every good regulator of a system must be a model of that system,” *International Journal of Systems Science*, **1**(2), 89-97.

Ashby's formulation of REGULATION

pay-off (outcome) table

		responses	
		r_1	r_2
disturbances	d_1	z_{11}	z_{12}
	d_2	z_{21}	z_{22}

Ashby's formulation of REGULATION

pay-off (outcome) table

		responses	
		r_1	r_2
disturbances	d_1	good	bad
	d_2	good	bad

Ashby's formulation of REGULATION

pay-off (outcome) table

		responses	
		r_1	r_2
disturbances	d_1	good	bad
	d_2	bad	good

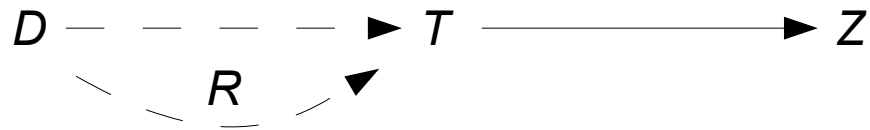
Ashby's formulation of REGULATION

pay-off (outcome) table

		R		
		r_1	r_2	
D	d_1	z_{11}	z_{12}	← T
	d_2	z_{21}	z_{22}	

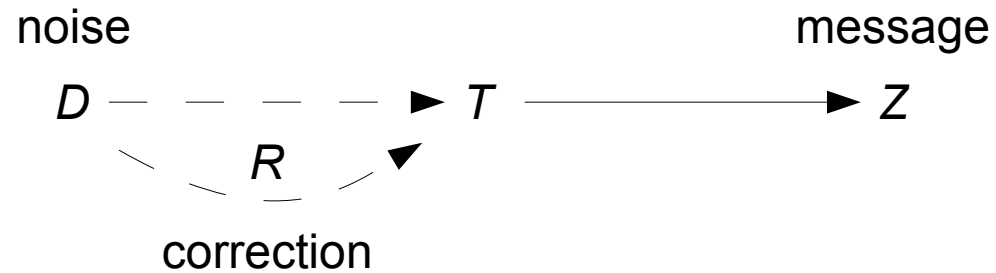
The “goal” of R is get the desired Z (a subset of T) given any D .

Ashby's *alternate* formulation of REGULATION



The “goal” of R is get the desired Z (a subset of T) given any D .

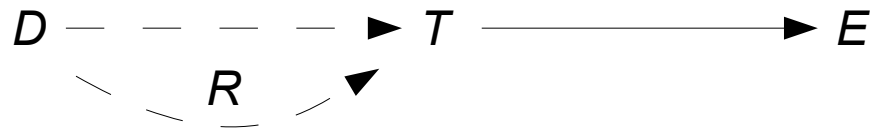
Ashby's *alternate* formulation of REGULATION



The “goal” of R is to correct for D so the message Z is received.

Ashby's *alternate* formulation of REGULATION

outcomes Z = variety in essential variables E



The “goal” of R is maintain E within a specified range.

Ashby's LAW OF REQUISITE VARIETY

introduce entropy $H(x)$ as a measure of variety

{gbcggc}

has a variety of 3 letters

{bcaaCaBa}

has a variety of 5 shapes or 3 letters

typical to measure entropy in bits

Ashby's
LAW OF REQUISITE VARIETY

$$H(E) \geq H(D) + H_d(R) - H(R)$$

$H_d(R) = 0$ when R is a determinate function of D

$$H(E) \geq H(D) - H(R)$$

the variety in the essential variables
will be greater than or equal to
the variety in the disturbances
minus
the variety in the regulators

Conant and Ashby's GOOD REGULATOR

**“Every good regulator of a system
must be a model of that system.”**

$H_d(R) \rightarrow 0$ as R gets better (more determinate)
for $H_d(R) = 0$ we need a perfect model

{*bcaaCaBa*}

Ashby's
LAW OF REQUISITE VARIETY
sustainability example

$E = \{people\ live\ well,\ nature\ is\ not\ run\ down\}$

$$H(E) \geq H(D) - H(R)$$

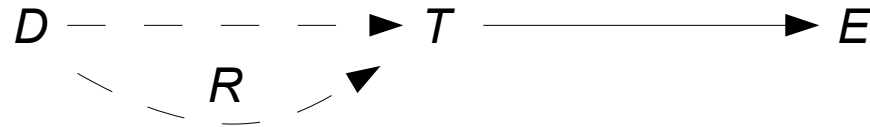
options

- 1) *do nothing* – essential variables are controlled by disturbances
- 2) *lower standards* – allow more variety in E
- 3) *increase regulation* – new laws, renewable resources
- 4) *discover disturbance patterns* – learning structure (constraints) of disturbances reduces variety in D and *can* lead to the creation of better models

CONTROL PROBLEMS

other examples

$$H(E) \geq H(D) - H(R)$$



What are the essential variables?

What are the disturbances?

What are the possible regulators?

How well can we model the system?

SOCIAL SYSTEM CONTROL PROBLEMS

other examples

traffic controls

(speed bumps, crosswalks, signals)

taxes, tax breaks, tariffs, subsidies

federal regulation

(health care, housing, financial system)

war on drugs

others?