

Black Boxes or Rube Goldberg Machines? Neural Networks as Cybernetic Regulators

Cameron Beebe

The SciPhi Initiative, LLC

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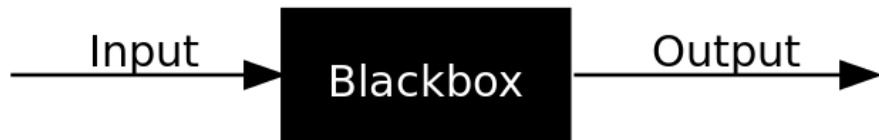
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 - No. Important for explaining to demographic 2.

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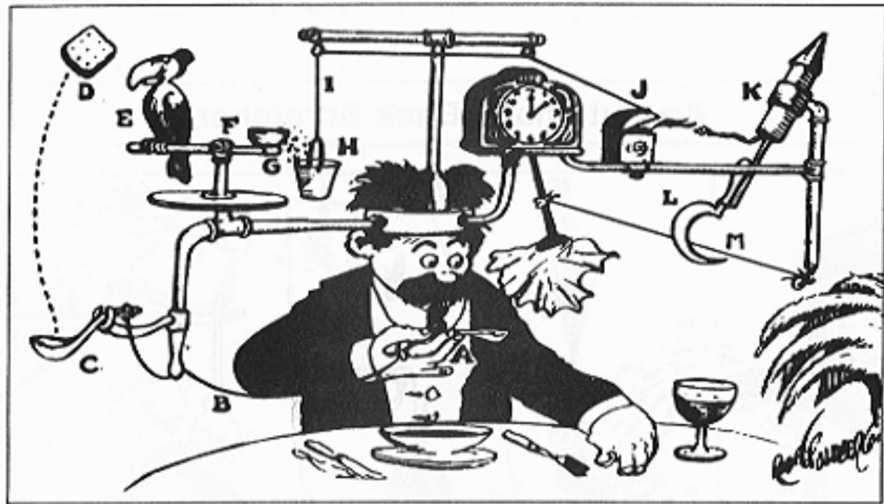
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- Internal mechanisms not known. Number of parameters not known. Parameter values not known.
- Conceptually 'poor' or empty.

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Self-Operating Napkin



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- Conceptually 'rich' in comparison to BBs. This is what we need to communicate to demographic 2.
- Don't need to understand each part/mechanism... but general idea of what *kind* of object we are dealing with.

Pile of Math?



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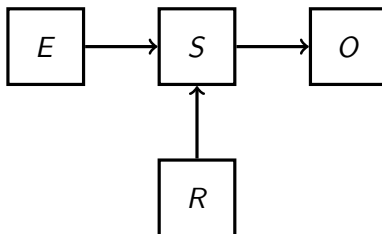
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- High-level explanation: double down on high level analysis of complex system with e.g. math and statistical analyses of ANNs
- Explanation for the people: go back to theoretical and conceptual foundations: cybernetic regulators.

Cybernetic Regulator

A cybernetic regulator is a complex system which controls environmental inputs by appropriate actions, resulting in a state aligning with a regulatory goal.

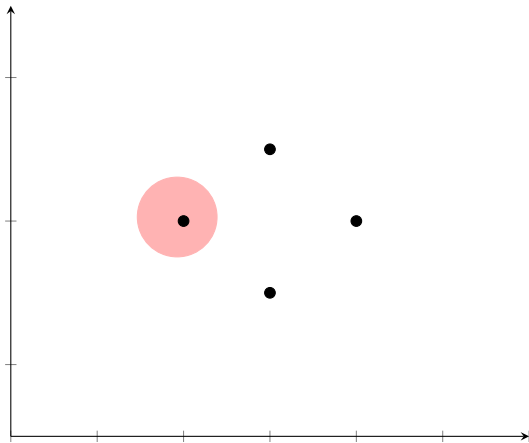


Ashby Regulator (Ashby, 1958)

	R		
E	α	β	γ
	β	α	γ
	γ	α	δ
	δ	ϵ	γ
	γ	δ	ϵ

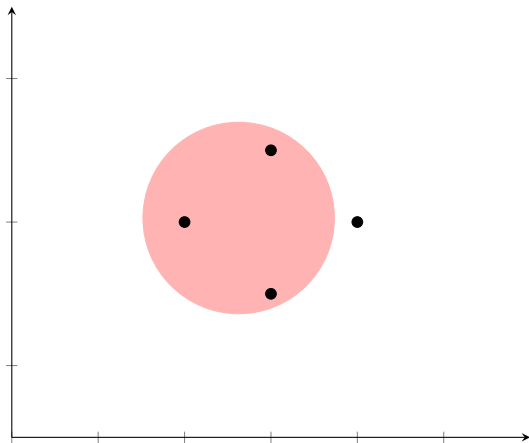
Table: Game in which E goes first. R plays for some outcome (e.g. γ, δ). Broadly, Ashby's Law of Requisite Variety says that "only variety in R can force down the variety due to E ".

Another Game (VC Dimension/Shattering)



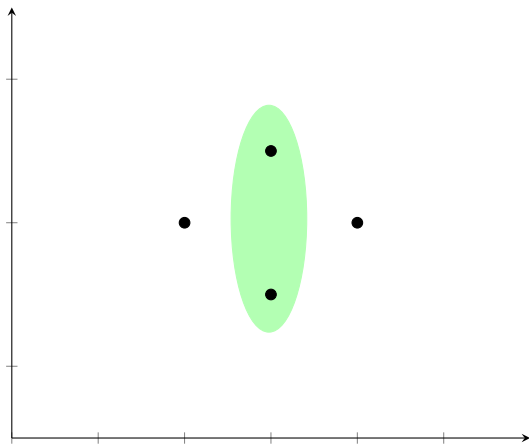
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Another View: VC Dimension/Shattering



$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

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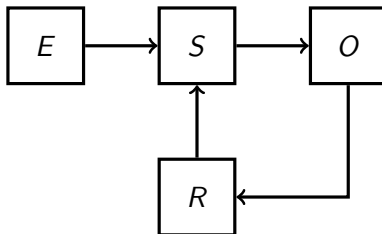
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- ANNs are Error-Controlled Regulators.

Error-Controlled Regulator



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Cashing Out

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- Won't do well on Test data. (Overfitting)
- Techniques to make the regulator imperfect—but more robust. Forgetting, Dropout...
- Developing Intuitions about the kinds of objects ANN models are: Cybernetic Regulators, complex systems like RGMs.

Thanks!

Ashby, W. R. (1958). *An Introduction to Cybernetics*. Chapman and Hall.