Can information entropy help to formalize cognition (to evaluate particular models) ?

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One definition of cognition

http://www.eucognition.org/wiki/index.php?title=Definitions_of_Cognition

28.

A cognitive system is an autonomous anti-entropy engine.

David Vernon

Why is it interesting ?

My imagination about cognition:

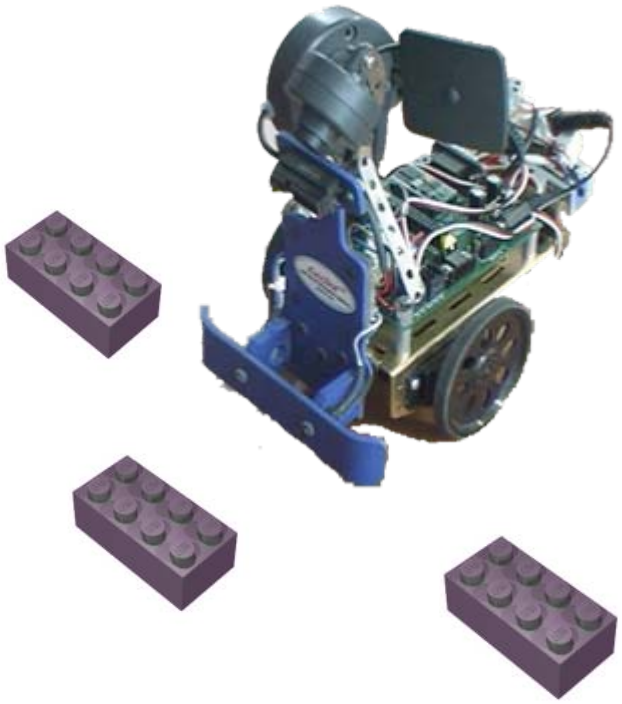
cognitive system should not only act in a reasonable way upon knowledge about its environment, but should be able to improve the knowledge and the activities.

It could be a way how to test indirectly the presence of information processing which cognitive system should manifest, e.g. assimilation, accommodation, anticipation, …

The simplified scheme

Let us concern a robot situated in an environment

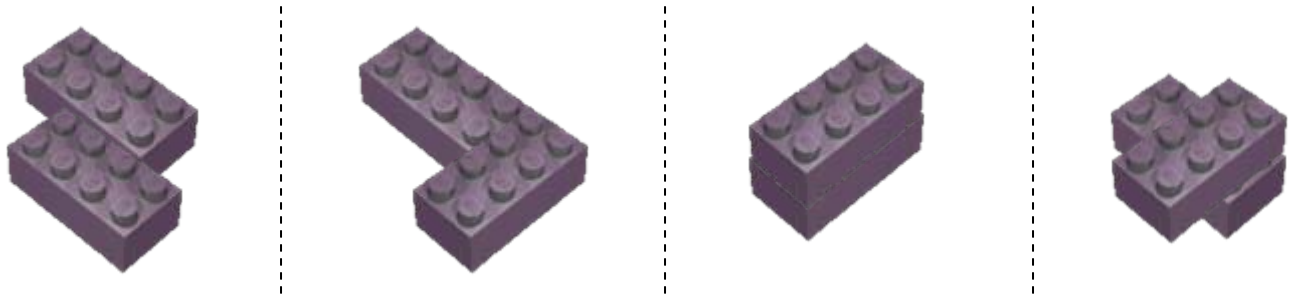
How can we employ information entropy to the situation ?



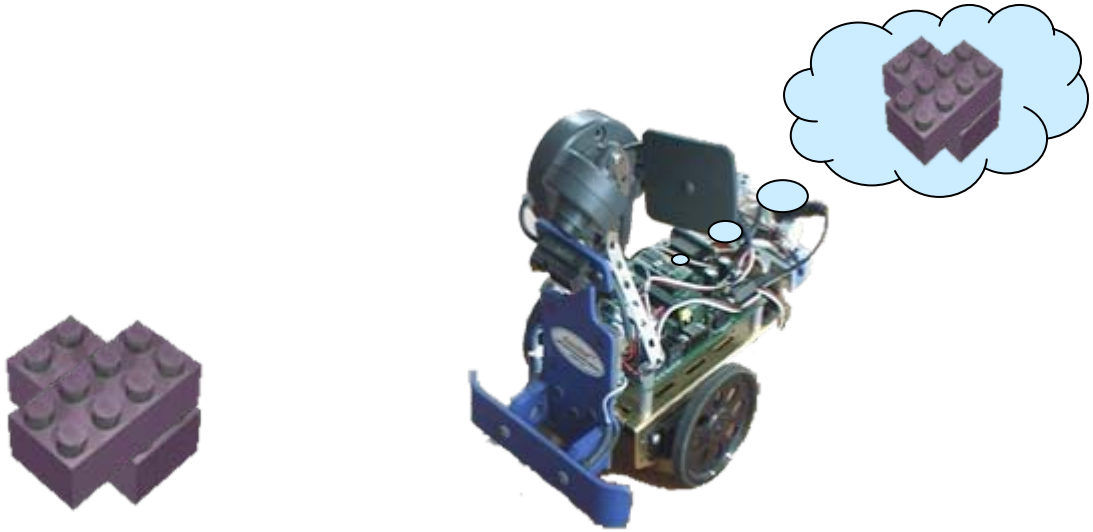
We could concern the robot-environment interaction as transfer of information from the environment to the robot

I

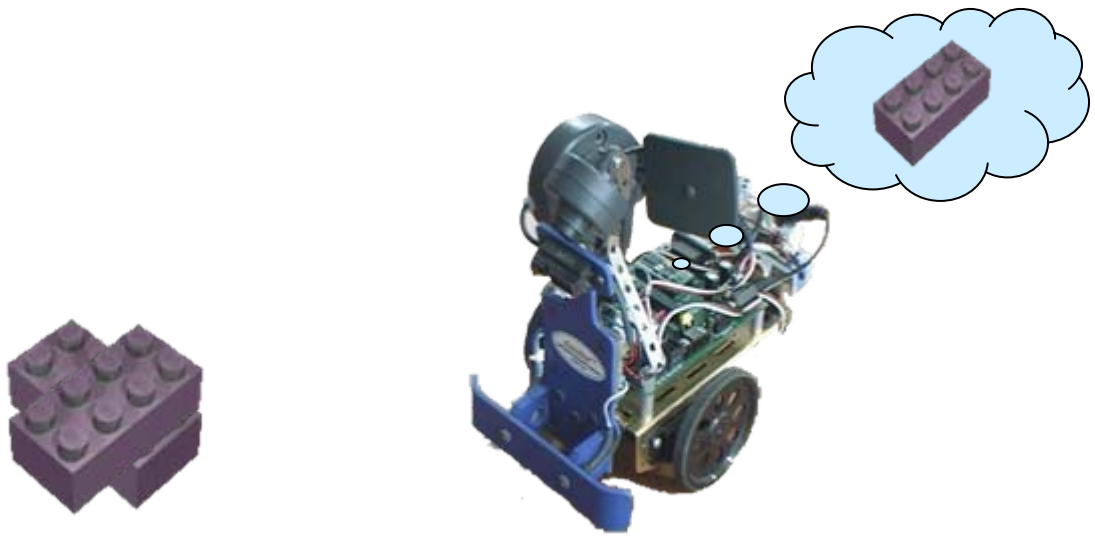
Environment plays a role of information source. Let us concern, that it can have one from N states (each one with same probability)



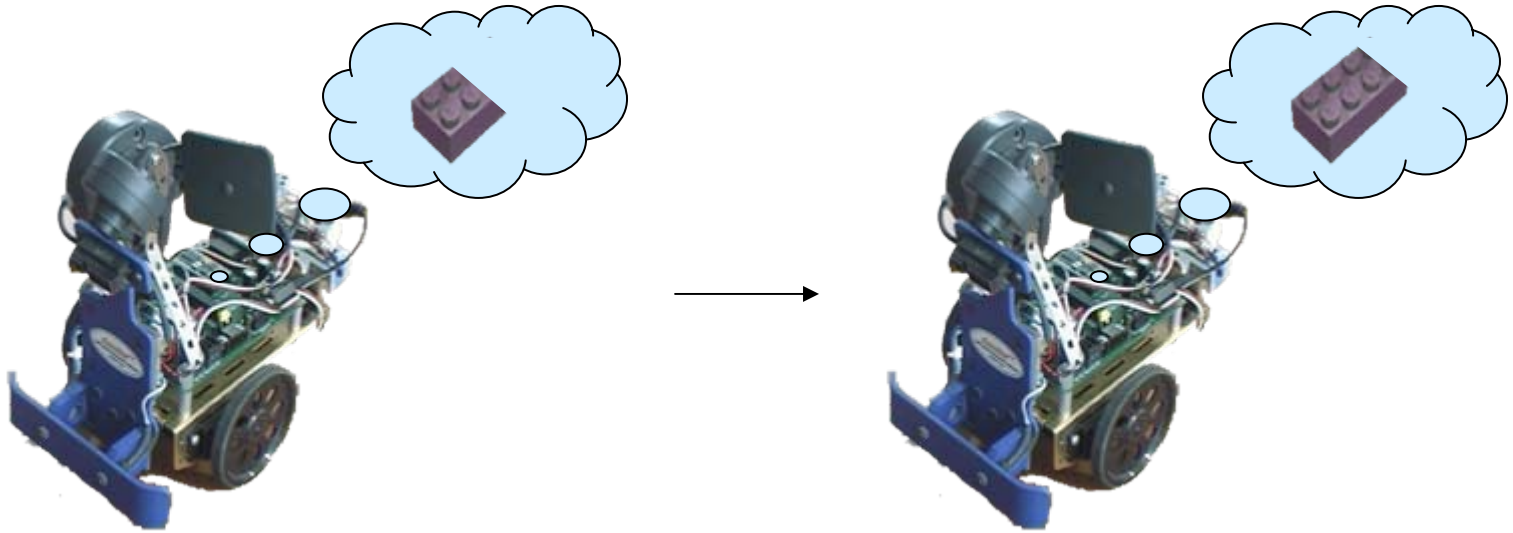
Robot plays a role of information destination. Let us concern that its task has something to do with revelation (or just approximation) of the particular state of the environment.

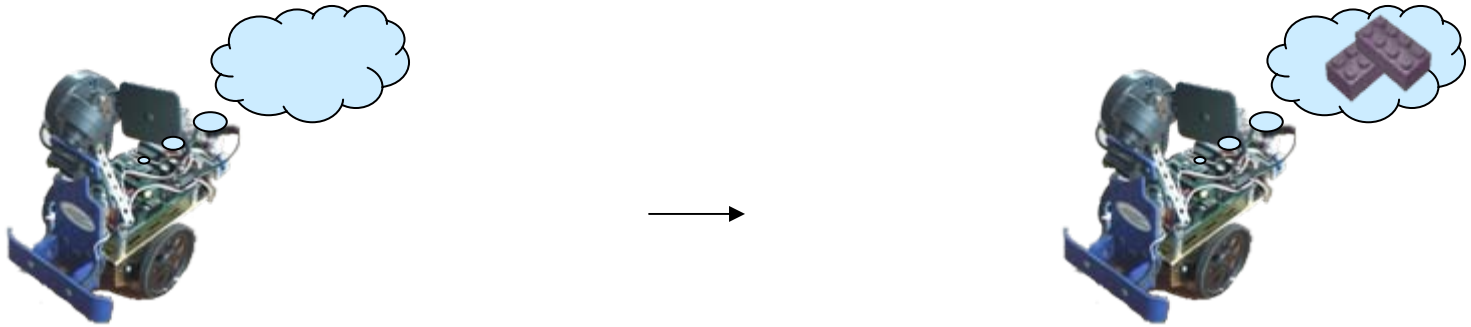


Within this scheme, we are looking for a measure how much of useful information has been transferred from environment to the robot

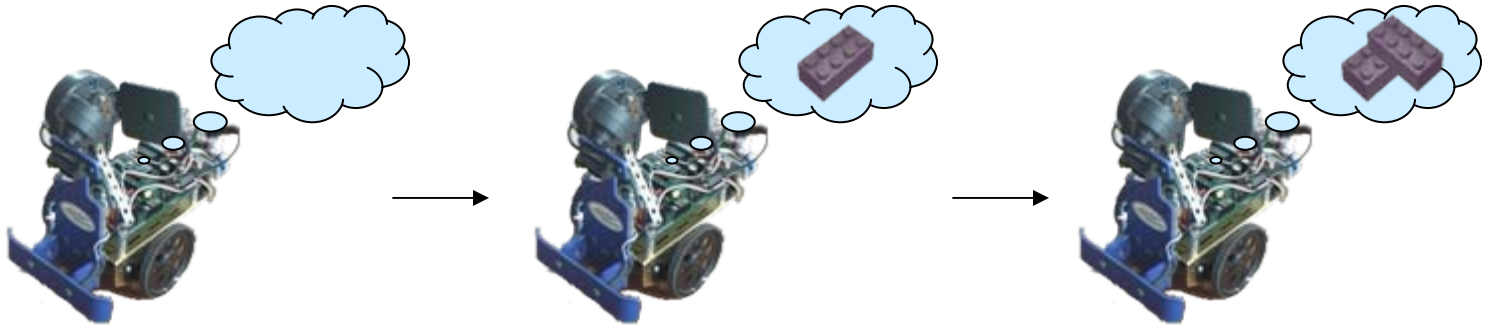


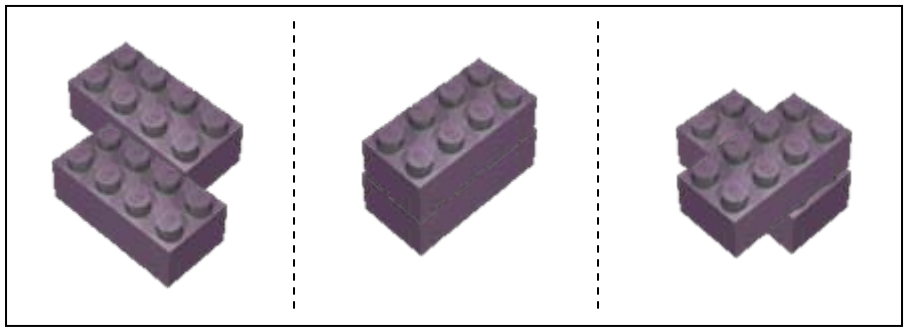
By transfer of (useful) information to robot, its knowledge about environment becomes less and less uncertain (= more and more complete = more and more ordered)

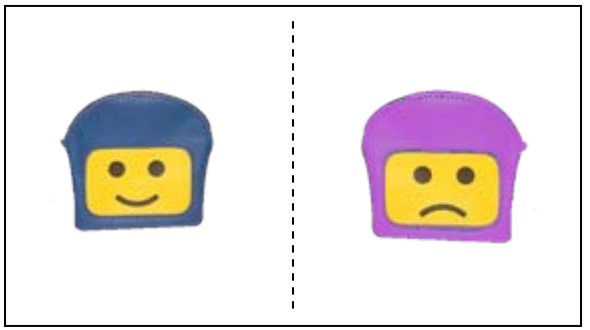




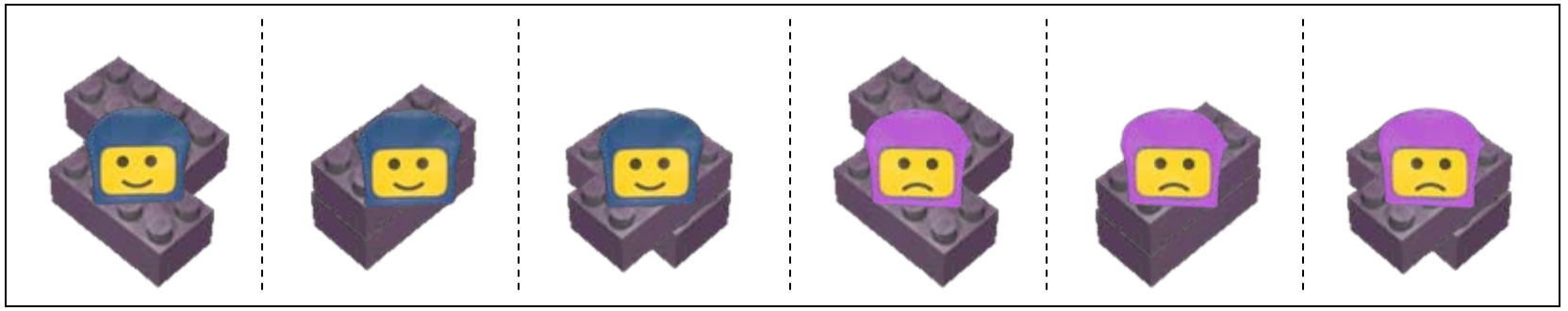
The measure has to reflect to the fact that transfer of partial information is equal to the transfer of the whole







Therefore by revelation of a particular state of a part which could has N states followed by revelation of a particular state of a part which could manifest M states is the same as a single-shot revelation of a particular state of their composition (which could have N.M states)



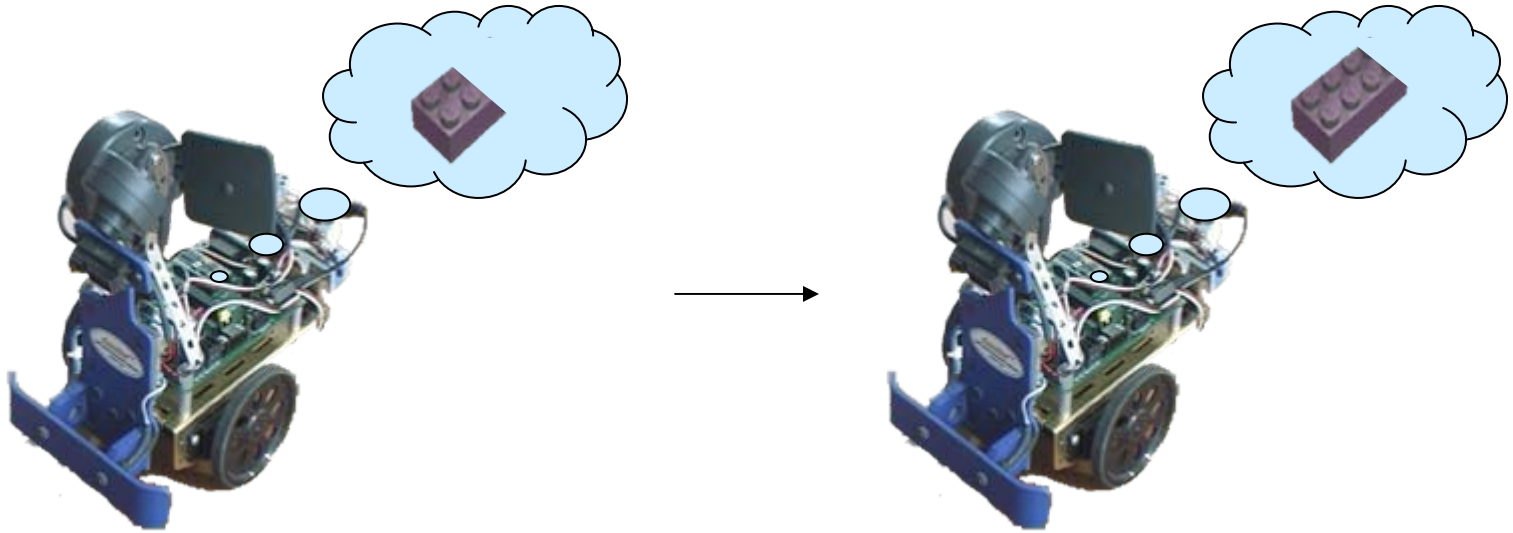
So when we denote the measure as H, we need to hold:

$$H(N) + H(M) = H(N.M)$$

Thus $H(N) = \log N$

which is Shanon's information entropy

As the robot knowledge about environment becomes less and less uncertain, information entropy is decreasing. Thus it is correct to claim that cognitive system is anti-entropic



Classification of Cognitive Systems by entropy

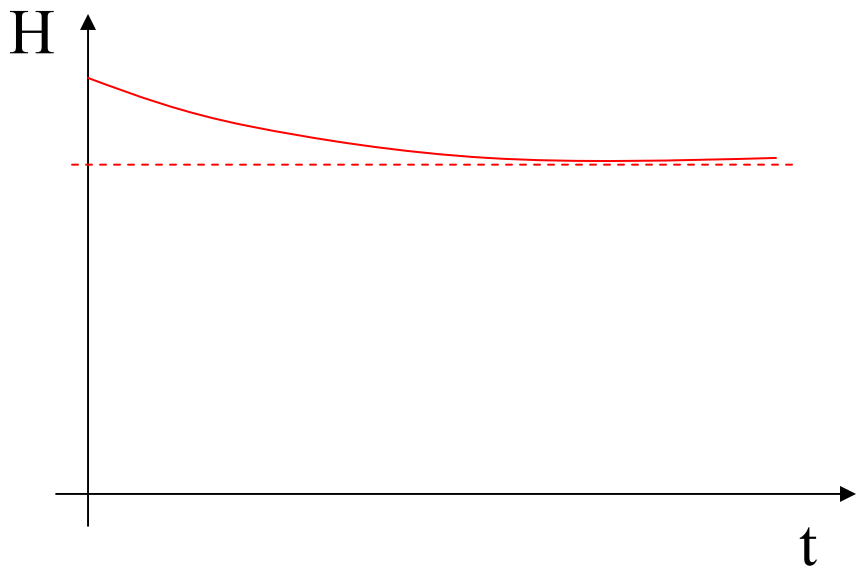
Now let us to use character of entropy evolution during course of a system to classify several types.

Type I

- entropy is constant
- system is not cognitive (?)
- example: robot with fixed reactions to external stimuli

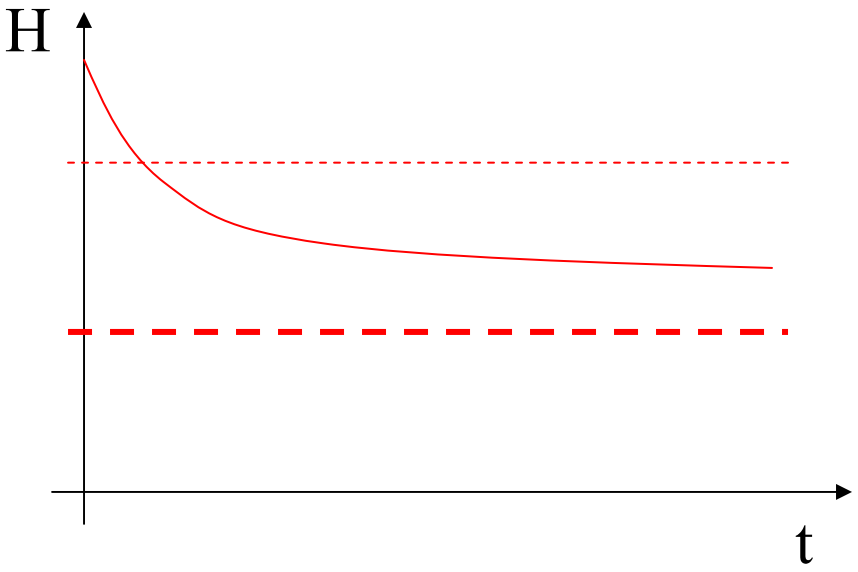
Type II

- entropy is decreasing to a limit given by its fixed nature
- is the system cognitive at all ? (little bit)
- example: robot which is able to calibrate constants employed within fixed reactions



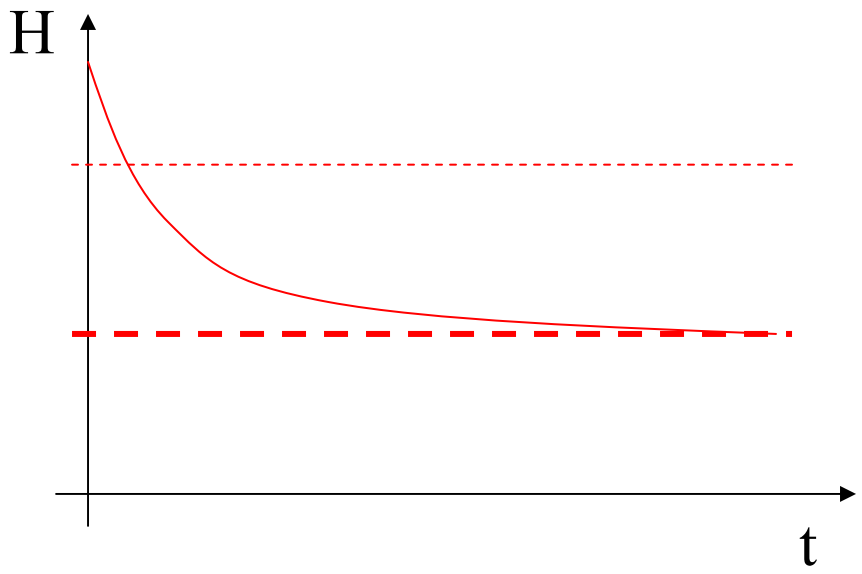
Type III

- entropy is decreasing to limit given by an application domain which the system was created for, but does not reach a limit given by its sensors
- system is cognitive
- example: robot with ability to learn something using a particular model, e.g. robot which mimics human manipulation with objects



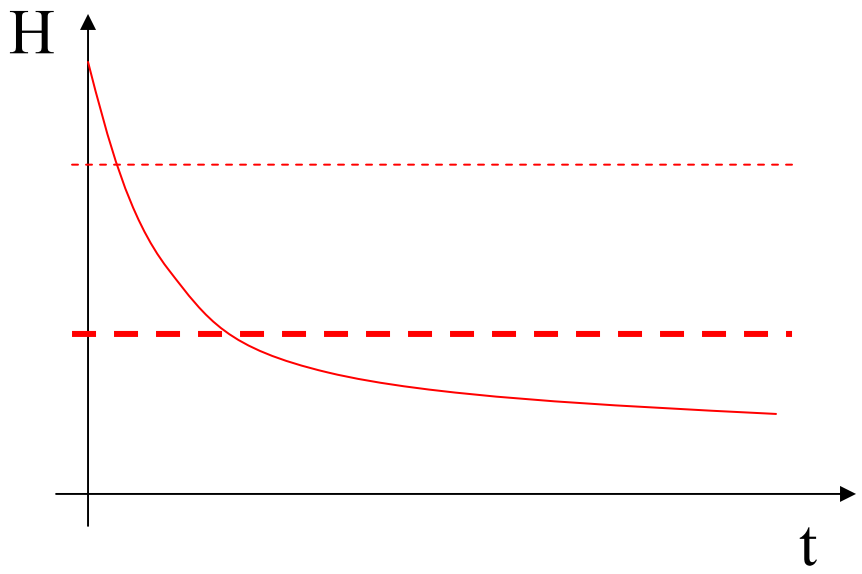
Type IV

- entropy is decreasing to a limit given just by ability of sensors
- system is cognitive & great
- example: sci-fi robot (so far)



Type V

- entropy is decreasing beyond the limit given by sensors
- system is equal to man
- example: man who creates a measuring device to extends his perception



Advantages of this approach

In this way we can express state of useful information in robot. By copying of information in robot memory, or by acquiring irrelevant data, the knowledge about environment is not improved and its entropy is not decreasing.

Problems of this approach

To solve different probability of environment states is easy. Let us p_i are probability of state i, $\sum_{i=1}^{n} p_i = 1$

Then $H(p_1,...,p_n) + H(q_1,...,q_m) = H(p_1.q_1,p_1.q_2,...,p_n.q_m)$

Thus $H = \sum_{i=1}^{n} p_i \log (1/p_i) = - \sum_{i=1}^{n} p_i \log p_i$

Problem1: acquisition of phantom information (in fact entropy could be also increased)

Problem 2: dynamic environment

Yet another definition of cognition

Cognition is capability of a system to decrease information entropy of its knowledge about its environment

Thank you !

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