

Coherent Systems

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Abstract

This paper notes that one problem in the study of 'natural' intelligent systems is that there is no really satisfactory way to separate out 'intelligent systems' from 'non-intelligent systems'. Some examples are put forward of systems which are normally defined as 'non-intelligent' but whose status is uncertain, and some brief comparisons are made between the functional characteristics of these systems and the functional characteristics of AI systems.

1 Introduction

Part of the task of cognitive science is to figure out how naturally-evolving 'intelligent systems' function. But a question that needs to be asked (regularly) is: when is a system an intelligent system and when is it not an intelligent system? The easy answer - a system is an intelligent system only if it is also an animal - may not be true. It is certainly not definitionally true. [5]

A safer (although more vague) answer to the question might be: a system is an intelligent system only if it can produce 'coherent' behaviour; i.e. if it can perform some task which takes intelligence when performed by humans. But if we settle for an answer like this, we have to come to terms with the fact that there are some systems in the natural world which are 'coherent', but not 'animal'.

2 Examples

A good example is the *free-market economy* or *economic* sub-system: such a system is naturally evolving (i.e. it emerges spontaneously given certain economic preconditions); it does something which involves a great deal of intelligence in humans (i.e. it organises an efficient distribution of resources) and it is certainly not an animal. Unlike animal coherent systems, this type of system is understood quite well. Economic theory tells us that the system 'works' due to the way in which interaction between individual buying and selling behaviours tends to cause local price changes which combine to guarantee optimal patterns of distribution.

Another good example is *epigenesis*. Epigenesis can be viewed as a 'system' which has the effect of unrolling phenotype from genotype; i.e. a system which serves to bring about the emergence of a life-form given some specific genetic coding. It too has all the required properties: it is naturally-evolving, it produces behaviour which is well beyond the abilities of humans [3], and it is not, itself, an animal. Genetic theory tells us that the functioning of the system is best understood in terms of cell construction; which itself can be understood in terms of the local consequences of chemical processes and interactions triggered by the DNA code.

We can find further examples of the type of system we are considering if we look at systems of organisation in *insect colonies*. These are also naturally-evolving; they have the effect of implementing rational, seemingly 'purposive' global behaviours on the part of the colony and they do not correspond to any single animal body (although sociobiologists in the past have speculated that they should be identified as 'superorganisms' [6]). Sociobiological theory tells us that colony 'behaviours' are built up out of locally-oriented interactions between individual insects, and are not attributable to any single decision-making unit within the system.

Finally, we might consider weather systems. These systems are clearly naturally-evolving and non-animal but perhaps do not seem particularly 'coherent'. However the maintenance of a systematic and highly complex pattern of weather events (crucial within the functioning of the ecological systems) is a task which WOULD take a certain degree of intelligence if performed by humans, so we should not rule them out. Meteorological theory tells us that weather systems are organisations of local interactions between (for example) thermal updraughts, air-body motion, and lapse-rate states.

3 Generalizations

Interestingly, the idea that we can view economic, genetic, sociobiological and meteorological systems as 'coherently behaving' systems, would seem to be generally accepted. Economists view free-market competition as doing the job of a 'central intelligence' [4], geneticists view epigenesis as doing the job of 'pulling out information' [3], sociobiologists view insect colonies as 'behaving organisms'

[6], while meteorologists talk about the behaviour of the weather using a wide variety of anthropomorphisms.

But the noteworthy thing is this: there is a quite consistent functional isomorphism (albeit at a high level of abstraction) between all the systems mentioned above. They produce utterly different types of organised behaviour, but always via the same functional set-up.

In it, global behaviours are 'built up' out of the consequences of interactions between simple local behaviours but always - it seems - the two layers of behaviour are quite separate and self-contained. That is to say, behaviours at the 'interactional layer' have a logic, motivation and style quite distinct from the logic, motivation and style of behaviours at the 'global layer'. For instance, the bargaining behaviour shown by an individual buyer or seller in a free-market economic system is clearly distinct from the global distributive behaviour of the system as a whole. Similarly, the behaviour of individual enzymes and proteins inside a cell structure is distinct from the overall phenotype-generating behaviour demonstrated by the 'epigenetic' system.

It has not been possible to look at a wide variety of non-animal coherent systems here. However, the implication that ALL non-animal coherent systems share, at some level of abstraction, the same specific functional configuration is clearly quite strong. What we need to know is whether the isomorphism extends over the whole class of coherent systems (i.e. even over human intelligence systems), or just over the sub-class of non-animal coherent systems.

4 Implications

The mere possibility that it *might* extend over the whole class is good enough reason for re-examining AI systems in terms of the degree to which they embody the identified functional configuration. Unfortunately, this task is not possible here; however, some initial comments can be made.

The principle feature in the functional configuration of coherent systems is 'interaction'. However, it seems to be the case that most AI systems in which interaction plays an important role either emphasise 'interaction between computational processes' or alternatively, 'computation emerging out of interaction between activity patterns' [2]. In the former type of system, the behavioural output of each process is usually involved directly in the behaviour of the whole system and is not therefore, 'self-contained' in any real sense. In the latter type of system, interaction usually involves interplay within patterns of excitation (i.e. resonance) and does not therefore involve local processes or behaviours.

The AI systems which seem to come closest to embodying the functional configuration in question, are in fact, bottom-up vision systems in which low-level processes 'debate' with co-processes regarding how to interpret some specific region of an image. [1]

5 Concluding remarks

Intuition tells us that there is a big difference between intelligent systems and other types of coherent systems, such as the ones I have looked at above. However, occasionally intuition can be misleading and it is usually a good idea to probe at the foundations upon which our intuitions are based.

Our intuition about animal coherent systems being fundamentally different from non-animal coherent systems would seem to be based on

- the fact that animal coherent systems are associated with a type of hardware fundamentally different from the 'hardware' associated with non-animal types of coherent system, and
- the fact that animal coherent systems appear to manifest behaviour which is significantly more flexible than non-animal systems.

We should note however, that the possibility of there being abstract isomorphisms between flexible systems occupying neuron-based hardware, and less flexible systems occupying very different hardware is acceptable enough when those less flexible systems are computer models of intelligence. So there may be no substantial reason to reject it when the less flexible systems are in fact non-animal coherent systems.

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7 References

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