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Dynamic Information and the Meaning of Biological Signs

The communication between cooperating and adversary organisms is central to the understanding of biological ecosystems. Commonly, this communication is formalized in terms of Claude E. Shannon's *Mathematical Theory of Communication* [4]. In this theory, information is represented as a measurable quantity arising from statistics on the underlying vocabulary. There have been several works addressing the application of Shannon information to biological systems [1,3,5].

Here, I argue that Shannon information encompasses significant shortcomings, which limit the applicability to communication in the life sciences. Since Shannon information is a purely statistical quantity, it treats only syntactic aspects of the communication process. In contrast, the levels of semantics, pragmatics, and dynamics [1] are not under consideration. Clearly, a message has always an impact on living systems, because it leads to a certain adaptive response. Yet this active response is part of the pragmatic-dynamic level and integral part of biological communication.

In this talk, I present an alternative concept of information [2]. The so-called *Dynamic Information* rates incoming signals with a relative importance depending on the internal state of an agent [1,2]. The bigger the induced change in the agent's behavior, the bigger are relative importance and the resulting dynamic information.

First, I introduce the mathematical framework modeling elementary biological communication by means of dynamical systems with input and output. In this approach, agents are represented by nonlinear coupled systems of ODEs with input terms. Next, the concept of dynamic information is developed as a bridge between the theory of dynamical systems and Shannons's theory of communication. Finally, I apply the developed framework to task allocation in ant colonies.

References

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