Paper for Symposium 1: Anticipation, Incursion.

The Natural Metaphysics of Computing Anticipatory Systems

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Abstract

Much of the work to date on anticipatory systems concerns the comparison of present and future states but time is not essential to Robert Rosen's original notion of a system both predictive of and reactive to itself. We sought to show at CASYS'07 that prediction is an attribute of predication. Not only is predication more general than prediction in time but it is more comprehensive of Rosen. His words are '*A system containing a predictive model of itself and/or its environment'.* There are three distinct aspects. There is the model of itself, there is the model of the environment and there is the model of itself and the environment.

Dubois and others (including we ourselves) have investigated further to distinguish the two types of predication. The copula with the prediction and the reaction attributed to the system itself is interpreted as strong anticipation: the object as a proper model is interpreted as weak anticipation. Although not made explicit by Rosen this follows because a system cannot be a proper model of itself. The 'model of itself' limb in his definition is therefore not modelling but is metaphysics. A model gives only partial predication whereas the metaphysical is full and complete.

This distinction in computing anticipatory systems has significance for a fundamental problem of philosophy in theoretical and practical aspects of computer science. The current Wikipedia entry for anticipation in the Rosen context concentrates on the issue of the need for an internal model in natural evolutionary cognitive systems. A more general and practical context for that issue might be on what representation of the real world should underpin information systems. Models in databases like the relational SQL or object-oriented operate as anticipatory systems for information retrieval.

These are applications where more attention needs to be paid to the role of the environment in Rosen's definition. A model of a system and its environment may not raise too many problems for weak anticipation but for strong anticipation the system and its environment need to be integral. This may be only classic holistic systems theory but it is metaphysics not modelling. For a model cannot represent strong anticipation, only a model of strong anticipation. This suggests for the applications in Artificial Intelligence the 'internal model' needs to be replaced by metaphysics.

Because of the continual interaction with a changing environment, the non-stationary has to be incorporated with the stationary. With the usual mathematical modelling tools, a set

represents stationary objects. Non-stationary dynamics is provided by functions between sets but functions and sets are not integrated. To include natural living systems, where the interaction with the environment is literally vital, Rosen later proposed (as an early student of Sammy Eilenberg one of its founders) the use of category theory where both objects and mappings between them are interchangeable, each being representable by the same notion of the arrow. It also provides for recursion between the highest arrow, the topos (that is the metaphysics of the world), systems (categories including the environment), and models. A formal natural relationship between any of these is a unique adjointness from a left preordered exactness to a right partial ordered co-exactness. Anticipation is the structural ordering in each case and may be stationary or non-stationary.

Thus in general iff the operation of an environment C on a subobject A has a solution subobject B then A implies B in the environment of C. This can be represented as the adjunction $C \times A \rightarrow B \dashv C \rightarrow B^A$.

This adjunction is the natural metaphysical ordering which constitutes anticipation. Thus causation (left adjoint) and Heyting inference (right adjoint) are both stationary forms of the predicate of anticipatory systems. These dominate the two applications of AI and databases considered above. In AI the left adjoint is a relevance connection in context and the corresponding right adjoint is cognition. For data warehousing, data mining, the semantic web, etc, a query in context is left adjoint and the resultant retrieval right adjoint.