Abstract

Application of information theory methods to study the social behavior of zebrafish

Virág Horváth

Detecting causal relationships in complex dynamical systems is a central problem of multiple different disciplines that work with these systems. Multiple methods have been developed, such as Granger causality (Granger 1969) and convergent cross mapping (Sugihara et al. 2012), that are used for identifying causality in stochastic and deterministic nonlinear systems.

The aim of this thesis is to discuss some information theory concepts, methods and their uses in a particular biological experimental setting in order to explore what we can learn about the behavior of zebrafish pairs from their swimming patterns. After discussing some basic theoretical aspects of these methods, we test them first on computer simulated data and finally on experimental data.

From the location of time delay mutual information peak between the fish in each pair we have learned what direction we need to shift one of the time series so that they share the most information with each other. After calculating transfer entropy the results suggested that in most cases the relationship could be characterized as following behavior, meaning that one partner of the pair follows the motion of the other. Next we looked at Granger causality, we used F-test to see possible Granger causation. There was only three cases where the possibility of causation, in one of the directions, could be present based on the first couple of lags, but even in those cases the F-values drop too low quickly for us to confidently reject the null hypothesis that fish 1 does not Granger cause fish 2. When using convergent cross mapping we were looking for an increase in the cross mapping correlation coefficient as the library length increases. In four experiments an increase can be seen in at least one of the directions. In two of these we see the cross mapping skill increases in both cross mapping directions which would indicate a bidirectional coupling.