

MAX-PLANCK-INSTITUT FÜR PHYSIK KOMPLEXER SYSTEME

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Report on the Habilitation Dissertation of Dr. David Hartman, Charles University Prague

Dear Colleagues,

It is my great pleasure to write this report on the Habilitation Thesis of Dr. David Hartman. The candidate has produced an impressive amount of original research work which has given strong impact on his field of research.

The thesis summarizes research work performed by the candidate in the field of complex systems analysis in terms of dynamical networks in recent years. The author has structured the large amount of material which was published in 19 original scientific publications in a well thought manner, representing both the immense progress in mathematical theory as well as the practical issues when dealing with empirical field data. Among his publications is an article in *Nature Communications* with more than 200 citations, and two more articles with more than 100 citations (google scholar, as of March 4, 2023). This proves the high visibility of his work in the scientific community. Altogether, this thesis is a highly instructive document which proves the scientific maturity of Dr. Hartman. I therefore recommend to accept this thesis as a habilitation thesis in the strongest way.

Dr. Hartman subdivides his work into 4 different sub-topics. However, in my summary, I coarse-grain this into just two: The identification of network structure from observed data, and mathematical progress in the understanding of network properties and design. In both fields, his work is innovative, relevant, and of general interest.

Given a set of simultaneously recorded time series, a network is build by considering each data source as a node. Network inference then means to decide which nodes are linked, which is expressed by the adjacency matrix of the network. Dr. Hartman employed, tested, and improved a lot of the available methodology on the identification of such links by data analysis. Particular emphasis is put on causal inference, i.e., the issue of which data source is a potential driver of another data source. This is statistically challenging, e.g., when being compared to simple cross-correlation analysis, and Dr. Hartman has achieved relevant progress.

Having established such an adjacency matrix, another relevant aspect of network structure inference consists in whether it is possible and useful to decompose a given network into sub-networks. One goal in this context is dimensionality reduction, and Dr. Hartman compares different methods such as Principal Component Analysis. A very relevant sub-class of networks are those with a small world property, i.e., those with a rather small average shortest path length and a large normalized clustering coefficient. Just to mention one of Dr. Hartman's great achievements here, I want to point out his observation of a bias towards small world properties by improper statistical analysis, so that many networks have been erroneously attributed to be small world which are in reality not.

Dr. Hartman's mathematical work concerns symmetries in networks and the estimation of uncertainty in network design. The latter is handled by him by replacing fixed values (obtained from statistical inference) by intervals of confidence and then introducing methods to perform computations on these intervals. To be frank, these works are at the limit of my own expertise, but I can confirm the high relevance and originality of these papers. They have been well received by the scientific community.

I also studied the analysis performed with the Trunitin system. The reported overlap with existing publications is solely due to the fact that Dr. Hartmann's thesis is based on his own published scientific articles which appeared in high level international journals. There is not the slightest indication of any type of scientific misconduct.

In summary, I consider the presented thesis as an excellent document of high level scientific productivity and I recommend to accept it as a habilitation thesis without the slightest reservation.

With best regards

A rectangular box with a black border, completely filled with a solid grey color, used to redact the signature of Holger Kantz.

Holger Kantz