

Reply letter

12 September, 2018

Dear Professor Procaccia,

On behalf of Prof. Jürgen Kurths, we would like to resubmit our review paper entitled “Complex network approaches to nonlinear time series analysis”.

Our replies to the comments by the referee are as follows:

We sincerely thank the referee for his/her comments regarding to our manuscript. We have amended the manuscript considering all these remarks.

First, we would like to emphasize the motivation of our manuscript to focus on nonlinear time series analysis by means of various network approaches that have originated from complex network theory. The time series network approaches reviewed throughout the present paper are based on dynamical systems theory, which present themselves as state-of-the-art contributions to traditional nonlinear time series analysis [1]. To some degree, the topics we have presented in the manuscript are examples of successful applications of complex network theory to tackle nonlinear time series either from numerical models or experimental measurements. We have clarified this point in the introduction section of the revision.

Second, for more general problems related to the analysis of (dynamical) data from different sources, data mining tools have been proposed in the research field of computer science and for tackling engineering problems [2], but have shown little interactions with methods in nonlinear dynamics historically. We noticed that tools originating from the two different fields do indeed share similar aims, such as identifying and quantifying hidden structures or patterns of the underlying dynamical system. However, to the best of our knowledge, the discussion of nonlinear time series analysis tools in terms of data mining techniques and vice versa has only started very recently. Further bringing together nonlinear time series analysis, complex networks and data mining approaches will be one of the most interesting topics for future work related to the specific field covered by our review paper, as we now discuss in the conclusion section of the revised manuscript.

Third, as commented by the referee, there is an emerging trend to combine complex network approaches with data mining tools, which provide many novel insights in the context of hidden pattern discoveries in large data sets [3]. For instance, the classification task of data mining provides a richer representation of functional networks from rather large data sets (e.g., in the context of climate variability or human brain dynamics) by choosing feature vectors of lower dimension. Furthermore, there have been a few successful applications of data mining tools for complex network analysis from synthetic and experimental data, in particular, in the context of disease classification [4] [5] [6]. In that respect, the review of [3] is presenting a first attempt to bridge the two communities of complex network research and data mining. However, to our understanding a direct relationship of the endeavors reported in that report with nonlinear time series analysis problems (the scope of our present review paper) has not yet been explicitly put forward and, thus, our review is complementary to the mentioned review [3].

Following these general observations on the interactions between the different topically relevant fields of research, we have carefully checked the methods and applications that have been reviewed in [3] and the references therein. According to this, we have found little indications for previous significant interactions and methodological exchange between the two fields of nonlinear time series analysis and data mining, partially due to disjoint research communities. One example is that none of the topics of

complex network approaches (including the three main approaches of recurrence networks, visibility graphs and transition networks as discussed in our manuscript) for nonlinear time series analysis has been discussed or cross-referenced in the recent review report [3] that has been mentioned by the referee. This indeed shows that the cross-fertilization between complex network research, data mining, and nonlinear time series analysis is pretty immature to date, which calls for further investigation and underlines that both review reports are complementary to each other.

Accordingly, the focus of the present report is *not* to discuss time series mining algorithms, since this would expand the topics largely beyond the scope of a single review paper.

In summary, we think that there are clear differences between the present manuscript on network approaches for nonlinear time series analysis on the one hand, and data mining tools on the other hand [3], which have been clarified in both the introduction and conclusion sections of the revision.

We thank the referee again for his/her fruitful comments, which very much helped us to improve the presentation of our manuscript.

Yours sincerely,

Yong Zou, Reik V. Donner, Norbert Marwan, Jonathan F. Donges, and Jürgen Kurths

Reference:

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