ETN-Gen: Generating Temporal networks through Egocentric Temporal Neighbours

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1 Introduction

Temporal networks represent a useful tool to organize and describe real world scenarios in many fields, such as biology, communications, physical interactions and mobility and simulate complex dynamics. However, many available temporal networks, in particular those representing social interactions, are not big enough to simulate real world dynamics. Moreover, synthetic networks can be useful to preserve sensible data. For this reason, the generation of realistic synthetic temporal networks represents an important problem. Many algorithms for static network generation have been proposed in the last decades. However, it is not easy to extend static generative models to dynamical models, due to the complexity introduced by the temporal dimension.

We propose an algorithm able to generate temporal graphs with high temporal resolution, that are both topologically and dynamically similar to an input temporal graph. In particular, we propose a generative algorithm based on Egocentric Temporal Neighborhood (ETN)[1], i.e. small temporal subnetworks. The technique is based on a binary signature, making the generation process fast and scalable in both number of nodes and number of temporal snapshots. In the training process a distribution of ETNs is build from an original real network, then in the generative process, the distribution of ETNs is used to generate synthetic sequential snapshot starting from a static graph seed.

2 Temporal graph generation

The idea is to first characterize an original real-world network in terms of its temporal substructures, *Egocentric Temporal Neighbours (ETN)* [1], with a node egocentric point of view. These are defined on a series of a small number k of temporal layers. We build a dictionary that associates the structures of length $k-1$ to the possible last layers. We then use this dictionary to generate a new network, starting from a first seed and progressively building the consecutive temporal layers. Each layer is built following the egocentric perspective for each node, and conflicts among different nodes perspectives are globally solved.

3 Dynamical and topological results

The effectiveness of the method, denoted as *Egocentric Temporal Neighbour Generator (ETN-gen)*, can be assessed on different temporal networks. Here we report the results obtained for the *High School 11* [2] network collected by SocioPatterns. We compared our generator with three competitors STM [3] (red), Dymond [4] (yellow) and TagGen [5] (green). To test the topology of the generated graph, we compare the generated and the original graph according to ten different topological measures. We use the Kolmogorov-Smirnov test, which computes the distance between distributions, so smaller results correspond to more similar networks. Figure 1 shows the results.

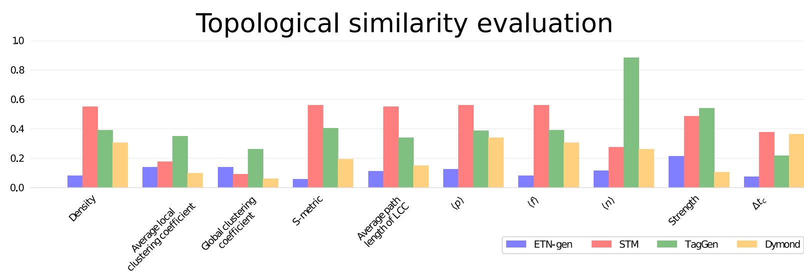

Fig. 1: **Topological similarity**.

Figure 2 shows the number of interaction at each time steps (the black line shows the original one). ETN-gen captures both the day/night periodicity and also the order of magnitude of the original temporal graph. Both Dymond and STM are not able to capture neither the magnitude nor the periodicity. On the other hand, TagGen is able to capture the periodicity but it is not able to reproduce the number of interactions (in Figure 2 the results of TagGen have been cut to better show the number of interaction from other methods). To evaluate the dynamical similarity, we simulate random walk starting

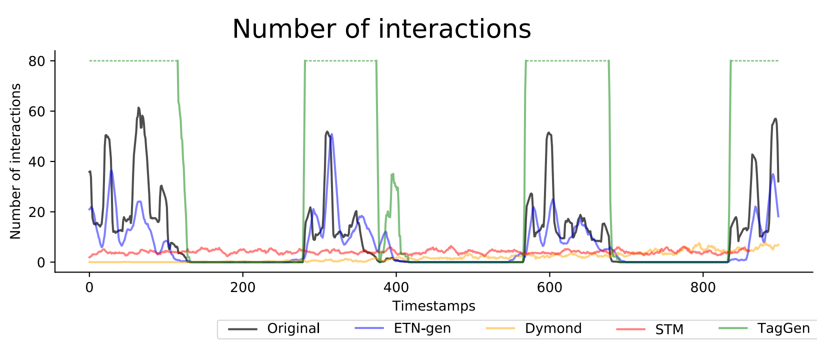

Fig. 2: **Number of interactions**.

from a random initial node and we compute Coverage and Mean First Passage Time (MFPT), we report in figure 3 the Kolmogorov-Smirnov test which compares original and generated graphs. We also show an horizontal black dashed line, representing the Kolmogorov-Smirnov test applied to simulations within the original graph, that we consider as a lower bound. We also simulated an SIR model with recovery probability $\mu = 0.055$ and contagion probability $\lambda = 0.013$ and we compute the R_0. We compare the distributions of R_0 using the Kolmogorov-Smirnov test (figure 3)

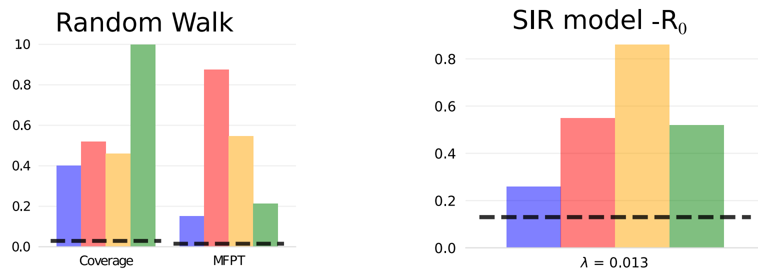

Fig. 3: **Dynamical similarity**.

4 Conclusion

We present ETN-gen, a novel strategy to generate temporal networks, focusing on the egocentricity of a node. Our method is able to capture high temporal resolution and is able to reproduce topological and dynamical properties better than other existing techniques. Not only our algorithm obtains the best score in 10 out of 13 tests, but it is also able to capture the intrinsic periodicity of number of interactions in day and nights.

References

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