A Multilayer ERGM framework for weighted networks

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Exponential random graph models (ERGMs) represent a flexible way to analyse the connectivity structure of social networks through the choice of network statistics. However, the use of ERGMs has been mostly limited to binary networks encoding presence or absence of edges between nodes. In fact, weighted random graphs are often dichotomised using a threshold with consequent loss of information due to the arbitrary choice of cutoff values. The extension of ERGMs to weighted networks is therefore a crucial yet challenging task. Recent generalisations of the ERGM framework to weighted networks include the Geometric- and Poisson-reference ERGMs for valued networks proposed by Krivitsky (2012) and Generalised ERGMs introduced by Desmarais and Cranmer (2012). In this work, we propose a multilayer modelling approach for weighted networks in order to simplify specification, tractability of the model, and substantial improvement in interpretability. The weighted network is considered as the outcome of random graph dissolution process across nested layers. The network statistics developed for binary ERGM framework can be readily used or adapted to the multilayer modelling framework, therefore maintaining their interpretation. A Bayesian inferential approach is considered and the estimation is carried out using advanced computational approaches for doubly intractable problems. We demonstrate this new modelling approach by analysing real network datasets using the statnet suite (Handcock et al., 2003) and the Bergm package for R (Caimo and Friel, 2014).