Consistent Estimation of Curved Exponential-Family Random Graph Models with Local Dependence and Growing Neighborhoods

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Statistical inference for discrete exponential-family random graph models given a single observation of a large random graph is in general problematic. We show that statistical inference is sensible as long as the model is endowed with additional structure. We consider a simple and common form of additional structure: multilevel structure in the form of neighborhoods. Multilevel structure is observed in multilevel networks and is generated by either multilevel sampling designs or stochastic processes governing random graphs. We derive non-asymptotic concentration and consistency results concerning maximum likelihood estimators of linear and curved exponential-family random graph models with weak and strong dependence within and between neighborhoods, where the neighborhoods and the natural parameter vectors of neighborhoods may grow with the number of neighborhoods. These consistency results are the first consistency results concerning a wide range of linear and curved exponential families under correct and incorrect model specifications and demonstrate that statistical inference is meaningful as long as models are endowed with additional structure. We discuss a local approach to computing maximum likelihood estimators that can be applied to large random graphs. Simulation results and an application are presented.