Cross-view link prediction with attribute vectors and its information criterion

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Various types of data such as texts, images, and sounds, become easily obtainable these days. These different types of data are referred to as "views", and there have been many approaches to find unobserved correspondences of data across views.

In general, multi-view data may have attribute vectors along with a complicated link structure. One main example is images and their multiple tags, which can be seen as two-view data with graph-structured links. Their attributes can be obtained by utilizing generally well-known image features and word features such as SIFT (Lowe, 1999) and GLoVe (Pennington et al., 2014). By learning underlying associations between links and attributes, unobserved links are expected to be inferred through attribute vectors.

To formulate the relationship between attributes and links, we propose a novel probabilistic model:

$$w_{ij}^{(de)} \mid \boldsymbol{x}_i^{(d)}, \boldsymbol{x}_j^{(e)} \overset{\text{i.i.d.}}{\sim} \mathrm{Po}(\mu(\boldsymbol{x}_i^{(d)}, \boldsymbol{x}_j^{(e)}; \boldsymbol{\theta})),$$

where $\boldsymbol{x}_i^{(d)} \in \mathbb{R}^{p_d}$ represents the attribute of i-th data in view-d, $w_{ij}^{(de)} \geq 0$ represents the link weight between $\boldsymbol{x}_i^{(d)}$ and $\boldsymbol{x}_j^{(e)}$, and $\mathrm{Po}(\cdot)$ represents Poisson distribution. Mean function $\mu(\boldsymbol{x}_i^{(d)}, \boldsymbol{x}_j^{(e)}; \boldsymbol{\theta}) \geq 0$ takes large value if $\boldsymbol{x}_i^{(d)}$ and $\boldsymbol{x}_j^{(e)}$ are close in the common low-dimensional space parametrized by $\boldsymbol{\theta}$. With a suitable estimator of $\boldsymbol{\theta}$, the function $\mu(\boldsymbol{x}_i^{(d)}, \boldsymbol{x}_j^{(e)}; \boldsymbol{\theta})$ might reflect the probability that $\boldsymbol{x}_i^{(d)}, \boldsymbol{x}_j^{(e)}$ are linked.

In this presentation, at first, we define an estimator of $\boldsymbol{\theta}$ based on the likelihood $L(\boldsymbol{\theta}) := \mathbb{P}(\{w_{ij}^{(de)}\} \mid \{\boldsymbol{x}_i^{(d)}\}, \boldsymbol{\theta})$ along with proposing an iterative algorithm. Next, we prove that the estimator is statistically consistent under some conditions. At last, we derive an information criterion which can be used for choosing suitable parameter space.

This study can be seen as a probabilistic formulation of Cross-Domain Matching Correlation Analysis (Shimodaira 2016; CDMCA), which finds unified low-dimensional linear transformation of multi-view attributes so that linked attributes get close.

References

[1] Shimodaira, H. (2016). Cross-validation of matching correlation analysis by resampling matching weights. *Neural Networks*, **75**, 126-140.