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Ideal Flow Network for Recommender Systems

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Abstract

Recommender Systems automate the process of providing personal and high quality recommendations. Ideal Flow Network (IFN) is one of the most natural techniques to create a product graph for Recommender Systems. Nodes represent the items and the links represent the relationship between items. IFN itself is a strongly connected network where the flows in each node are conserved. The total inflow would be exactly the same as the total outflow in each node of an IFN.

IFN can be approached through random walk on a strongly connected network where random trajectories are applied to form the flow. While the flow in each link and each node would goes into infinity as we continue to add random trajectories on the network, the relative flow would converge into asymptotic values of integer numbers, which are called the ideal flow. The convergence of the relative flow would also automatically become *premagic*, where total inflow is exactly the same as the total outflow for each node. Thus, ideal flow can be viewed as asymptotic relative flow on a strongly connected network. Applying a few random trajectories will not build a premagic property. The premagic property would only happen at the asymptotic values, which can be obtained by taking the limit of the numbers of random trajectories into infinity.

Items in an itemset transaction are set as node of the random walk trajectory (i.e. a node sequence) where each node is one unique item. The relationship between items in a transaction indicates the items "go together" or "purchased together". All items in the transaction goes together on each other. The product graph of an itemset would be a complete graph. During the training of the recommender system, we transform each transaction trajectory t into a complete graph $\mathbf{G}_t$. In System Layer, the complete graph of each transaction $\mathbf{G}_t$ were overlaid into a system IFN $\mathbf{F}^S$. Thus, the system IFN $\mathbf{F}^S$ is an aggregation of all transactions.

To predict the recommendation items, when the current customer were purchasing itemset L, the Recommender System would give suggestion of the next purchase items P. The prediction of the next purchase items is based on the most likely purchased items from the system IFN $\mathbf{F}^S$. The result of prediction would be $P[n_j] = f(n_i, n_j)$ where $n_i \in L, n_j \notin L$ and $n_i n_j \in \mathbf{F}$. We can then sort the prediction P based on the flow and set a threshold to reduce the items.