People trust different sets of social connections for different types of recommendations. Can we model this heterogeneous trust to improve collaborative filtering algorithms?

**Data**

- **Yelp**
  - 5614 users, 27688 (7598-S, 20900-R) businesses, 247551 reviews (sparsity-0.16%), 45634 edges (1712 zero degree nodes, maximum degree - 568), 88 attributes

- **Epinions**
  - 6874 users, 14142 (4307-E, 10105-M) products, 74246 (57059-M, 17187-E) reviews (sparsity-0.07%), 43733 edges (917 zero indegree nodes, 641 zero outdegree nodes maximum degree - 314)

**Idea**

Modeling Heterogeneous Trust

**Cosine Trust**

Similar connections are more trusted

\[ S'_{ij} = \begin{cases} \frac{\sum R_i R_j C_{ij}}{\sum R_i C_o \sum R_j C_o} & \text{if } T_{ij} \neq 0 \\ 0 & \text{if } T_{ij} = 0 \end{cases} \]

- **Recommendation Power**

  Two step random walk on weighted bipartite graph of users and products

  \[ S_{ij} = \begin{cases} \frac{1}{R_i} \sum_{R_j} C_{ij} & \text{if } T_{ij} \neq 0 \\ 0 & \text{if } T_{ij} = 0 \end{cases} \]

  \( R_b \) - Sum of all ratings received by b, \( R_i \) - Sum of all ratings given by i

**Global Trust**

Social network analysis to estimate trust using centrality measures of nodes - PageRank, Closeness Centrality

\[ \hat{R}_{a,b} = \frac{\sum R_{a,t} T_t}{\sum T_t} \]

**Latent+Trust**

Use SGD to learn trust strengths and latent factors for prediction

\[
\min_{P,Q} \sum_{R_{a,b} > 0} (R_{a,b} - \alpha p_a q_b \quad - (1 - \alpha) \left( \sum_{\|T_a\|=1} S_{a,b} R_{a,b} \right)^2 + \beta \left( \|P\|^2 + \|Q\|^2 \right)
\]

\( P_{u \times K} \) and \( Q_{K \times b} \) - latent factors of users and products, \( p_u \) - u'th row of P and \( q_b \) - b'th column of Q

**Latent+Heterogeneous Trust**

Use SGD to learn heterogeneous trust strengths and latent factors for prediction

\[
\min_{P,Q} \sum_{R_{a,b} > 0} (R_{a,b} - \alpha p_a q_b \quad - (1 - \alpha) \left( \sum_{\|T_a\|=1} S_{a,b} R_{a,b} C_{b,l} \right)^2 + \beta \left( \|P\|^2 + \|Q\|^2 \right)
\]

\( S'_{a,b} \) - trust strength for category l, \( C_{b,l} \) - whether product b belongs to category l

**Results**

- **Figure 1**: Yelp and Epinions Rating Distribution
- **Figure 2**: Recommendation Power using Bipartite Graph
- **Figure 3**: Heterogeneous trust learnt for movies and electronics
- **Figure 4**: Hybrid Trust Models on Epinions