CS520 Web Programming

Recommendation Systems

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Recommendation Systems

- *Predict* items a user may be interested in based on information about the user and the items
- An effective way to help people cope with information overload
- Examples: Amazon, Netflix, Tivo, …

So How Can We Do It?

- The content based approach
- The user feedback based approach

Collaborative Filtering

- Rate items based on the ratings of other users *who have similar taste as you*

Problem Definitions

- Prediction
  - Given: a user and `k` items
  - Return: predicted rating for each item
- Recommendation
  - Given: a user
  - Return: `k` items from the database with the highest predicted rating

Basic Assumptions

- Items are evaluated by users explicitly or implicitly
  - Ratings, reviews
  - Purchases, browsing behaviors
  - …
- We may map explicit and implicit evaluations to a rating scale, e.g. 1-5.

Heuristic

- People who agreed in the past are likely to agree in the future

Problem Formulation

- User-Item Matrix

Item	Ken	Lee	Meg	Nan
1	1	4	2	2
2	5	2	4	4
3			3	
4	2	5		5
5	4	1		1
6	??	2	5	

So what would be Ken's rating for Item 6??

Solving the Problem

- Intuition: Ken's rating for Item 6 is likely to be high
  - Ken's ratings are similar to Meg's
  - Ken's ratings are opposite of Lee's
- Develop the algorithm
  1. Quantify rating similarity
  2. Calculate the predicted rating

Similarity Measure

- Pearson Correlation Coefficient
  - A measure of linear correlation of two random variables

Pearson Correlation Coefficient

- Let `x` and `y` be two users, and $r_{x,j}$ be the rating of item `i` by user `x`

$$w_{x,y} = \frac{\operatorname{cov}(x,y)}{\sigma_x \sigma_u}$$

$$= \frac{\sum_i (r_{x,i} - \bar{r}_x)(r_{y,i} - \bar{r}_y)}{\sqrt{\sum_i (r_{x,i} - \bar{r}_x)^2}\sqrt{\sum_i (r_{y,i} - \bar{r}_y)^2}}$$

So what is $w_{ken,lee}$?? what's the range of $w_{i,j}$?

Predict the Rating

- The predicted rating $p_{x,i}$ should be a function of
  - The past ratings of user `x`
  - The ratings of other users for item `i`, weighted by their similarity to user `x`

Predicted Rating

- `p`$_{x,i}$ is the predicted rating of item `i` by user `x`

$$p_{x,i} = \bar{r}_x + \frac{\sum_u (r_{u,i} - \bar{r}_u) \times w_{x,u}}{\sum_u |w_{x,u}|}$$

So what is $p_{ken,6}$??

Variations and Optimizations

- Similarity measure
- Significance weighting
- Item rating variance
- Neighborhood selection
- Combine neighborhood ratings

Other Similarity Measures ...

- Spearman Correlation
  - Uses ranks instead of raw rating scores
- Cosine similarity
- Mean squared difference
- Entropy-based
- ...

... Other Similarity Measures

Cosine similarity: $\cos(\mathbf{X}, \mathbf{Y}) = \frac{\mathbf{X} \bullet \mathbf{Y}}{|\mathbf{X}||\mathbf{Y}|} = \frac{\sum x_i y_i}{\sqrt{\sum x_i^2}\sqrt{\sum y_i^2}}$

Mean squared difference: $msd(\mathbf{X}, \mathbf{Y}) = \frac{\sum (x_i - y_i)^2}{N}$

Entropy-based association: $h(X, Y) = -\sum p_{i,j} \ln p_{i,j}$

Significance Weighting

- Weight users in additional to the similarity measure

$$w = \begin{cases} 1 & n \geq 50 \\ n/50 & n < 50 \end{cases}$$

where `n` is the number of items rated by both users.

Item Rating Variance

- Some items are more telling about tastes than others
  - E.g. "Sleepless in Seattle" is more telling about taste than "Titanic"
  - Give more weight to items with high variance in ratings

Neighborhood Selection

- Select a subset of users for better performance and *accuracy*
  - Correlation threshold
  - Best `n` neighbors

Combine Neighborhood Ratings

- Deviation from mean
- Weighted average
- Weighted average of z-scores

Mean absolute deviation: $s = \frac{1}{n}\sum_{i=1}^{n}\left|r_i - \overline{r}\right|$

Standardized measurement (*z-score*): $z_i = \frac{r_i - \overline{r}}{s}$

Algorithm Quality Metrics

- Coverage – percentage of items for which the system can produce a prediction
- Accuracy
  - Statistical metrics
    - Mean Absolute Error (MAE)
  - Decision-support metrics
- Efficiency
  - Throughput – number of recommendations per second

And The Winners Are

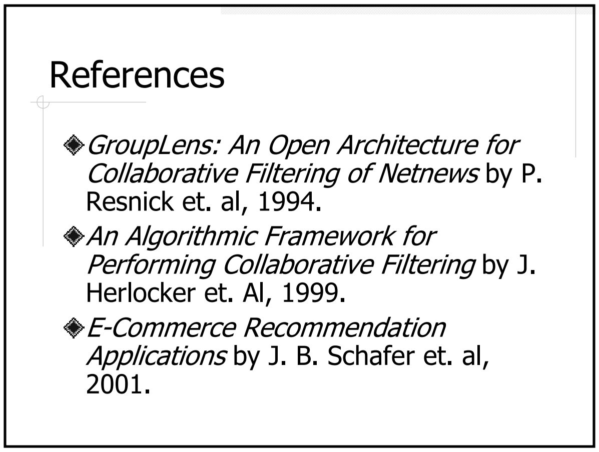
- Similarity measure
  - Pearson Correlation
  - Spearman Correlation
- Significance weighting
- Neighborhood selection
  - Best `n` neighbors with `n≈20`
- Combine neighborhood ratings
  - Deviation from mean

Other Recommendation Algorithms

- Combine collaborative and content-based filtering
- Item-item collaborative filtering
- Bayesian networks
- ...

Some Libraries

- Apache Mahout – http://lucene.apache.org/mahout/
- COFE – http://eecs.oregonstate.edu/iis/CoFE/
- And more – http://en.wikipedia.org/wiki/Collaborative_filtering#Software_libraries



References

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