Proposed Matching Scheme with Confidence and Prediction Uncertainty in Shared Economy

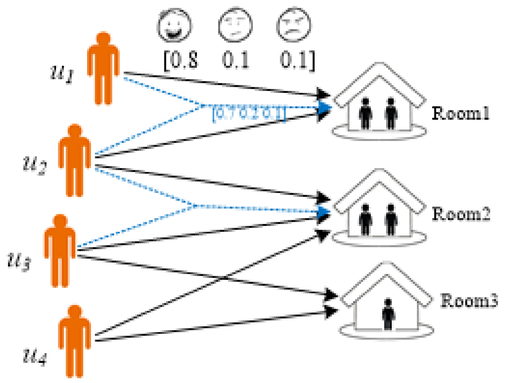
Longhua Guo Advisor: **Jie Wu**

Department of Computer and Information Sciences, Temple University

Introduction

- **Airbnb**: provides collaborative practices for customers and guides them to match with hosts' rooms.
- **Objectives**: the problem seeks to match customers to rooms while maximizing the total satisfaction and considering the uncertainties.
- **In our paper**: we systematically models the matching problem considering the satisfactions with the confidence uncertainty and the prediction uncertainty.

Motivation



Challenges

Data confidence and **prediction bias** influence the inference performance of the satisfaction. When two users stay in a room, the two users' joint satisfaction also deserves particular research because of the roommate effect.

Problem Model

Satisfaction is a tuple of preference between users and rooms, represented by happiness probability P_h, uncertainty probability P_u, and unhappiness probability P_d.

$$Score = \frac{(1+\theta)(P_h - P_d)\theta(1-P_u)}{|P_h - P_d| + \theta(1-P_u)}$$

Objective: to maximize the summation of *Score*.

Constrain: the customer is limited to accommodate to only one room. The accommodation quantity of a room is constrained to 1 or 2.

Solutions

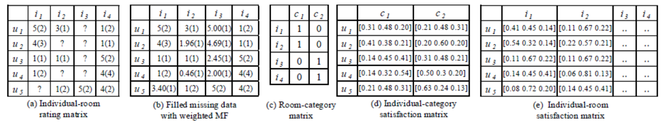
Satisfaction with Confidence Uncertainty

- Given the check-in history records, th satisfaction between users and rooms calculated with the confidence uncertainty.
- The normalized variance of the Be distribution is utilized.

$$\begin{cases} P_u = \frac{12\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)} \\ P_h = \frac{\alpha}{\alpha+\beta}(1-P_u) \\ P_d = \frac{\beta}{\alpha+\beta}(1-P_u) \end{cases}$$

Individual Satisfaction with Prediction Uncertainty

- Infer the user-room satisfaction without check-in history.
- We divide rooms into several categories using information entropy.
- The missing ratings are inferred through a
- weighted matrix factorization algorithm



Pair Satisfaction with Prediction Uncertainty

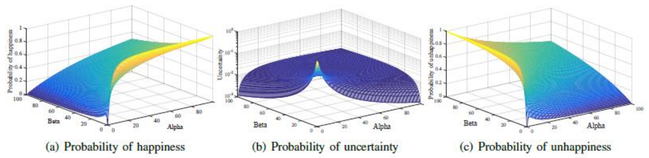
- The pair-room rating records are much sparser than that of the individuals'
- The satisfaction is indicated according to the check-in records of pairs within community.
- The prediction satisfaction is calculated using known pairs' satisfactions and trust level between pairs.

Matching algorithm

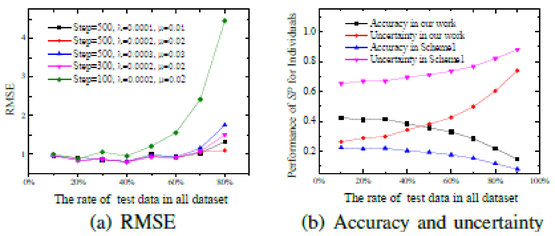
- The matching problem is NP-Hard, based on a reduction from the NP-hard Maximum Weight Independent Set (MWIS) problem

Simulation Result

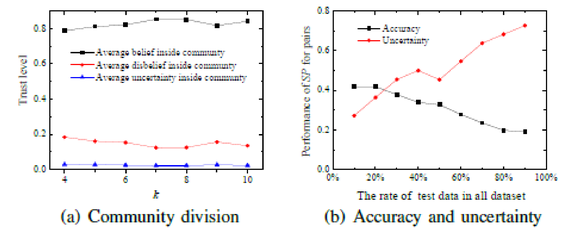
- For the satisfaction with the confidence uncertainty, the figure illustrates the probability distribution of happiness, uncertainty, and unhappiness. With more nights living in the rooms, the uncertainty will decrease.



- We use the Root Mean Square Error (RMSE) metric to evaluate the performance of Individual Satisfaction with Prediction Uncertainty.



- With the increased density of records, the accuracy of Pair Satisfaction with Prediction Uncertainty grows and the uncertainty is reduced.



Conclusion

- The satisfaction between users and rooms is calculated considering **Data confidence** and **prediction bias**.
- An individual's satisfaction with the prediction uncertainty is modeled using a weighted matrix factorization-based algorithm.
- A pair's satisfaction with the prediction uncertainty is modeled based on pairs' similarity in a community.

Reference

Y. Koren, R. Bell, and C. Volinsky, "Matrix factorization techniques for recommender systems," Computer, vol. 42, no. 8, 2009.