Using Context-aware Collaborative Filtering for POI Recommendations in Mobile Guides

Haosheng Huang and Georg Gartner

Vienna University of Technology, Austria

Image from Georg Gartner

1. Motivation

- When visiting a new city, tourists often ask "what to visit next".
  - identify Points of Interest (POIs) from a huge set of choices

- "Experiences" from past users can help current users to solve their problems[1] .
  - More and more GPS trajectories are created.
  - How can we make use of these highly available GPS datasets?

1. Wexelblat A (1999) Footprints: Interaction history for digital objects. PhD thesis, MIT Program in Media Arts & Sciences.

A promising technique

- Collaborative filtering (CF): “Amazon-like recommendation”
  - “People who … also ….” : recommending items that people with similar preferences liked in the past
  - Often employed for movie, product recommendation

- CF in LBS
  - Often using explicit ratings: requiring users’ active involvement → impractical for LBS
  - Providing context-aware CF is still very challenging.

Research goals

- Designing context-aware CF methods
  - to make use of the highly available GPS trajectories
  - for providing contextual “Amazon-like” POI recommendations in mobile guides
- Vision: “in similar context, after visiting POI A, other people similar to you often went to POI B.”

2. Key issues of context-aware CF

- Building contextual user profiles
- Measuring usefulness of other users' "opinions"
- Making recommendations
  - Aggregating "useful opinions"

2.1 Building contextual user profiles

- Extracting visited POIs (stops) from trajectories
  - User profile: a set of visited POIs
- Labeling user profile with "context of the visit"
  - Which context parameters are relevant and thus needed to be modeled?

Identifying relevant context parameters

- A two-stage method
  - Identifying an initial set of candidate context parameters from literature or experts.
  - Refining the initial set according to the collected data
    - ***If tourists in different weather conditions behave differently, "weather" is a relevant parameter.***

2.2 Measuring usefulness of other users' "opinions"

- Measuring usefulness of other users' profiles in making recommendation for the current user in the current context
  - ***Preference-based user similarity***: measured by comparing the POIs they visited

$$SIM_{user}(a,b) = \frac{\sum_{p \in POIS_{a,b}} \frac{1}{F_p}}{\sqrt{\left(\sum_{p \in POIS_a} \frac{1}{F_p}\right) * \left(\sum_{p \in POIS_b} \frac{1}{F_p}\right)}}$$

  - ***Context similarity***: the similarity between other users' context and the current user's context

Context similarity measure

- Statistic-based approach (SBA)
  - ***If visits in a context (situation) are similar to visits in another situation, these two situations can be considered as similar.***
  - Similarity between two situations
    - Measuring the "distance" of visits in these two situations.
    - Transforming the "distance" into similarity

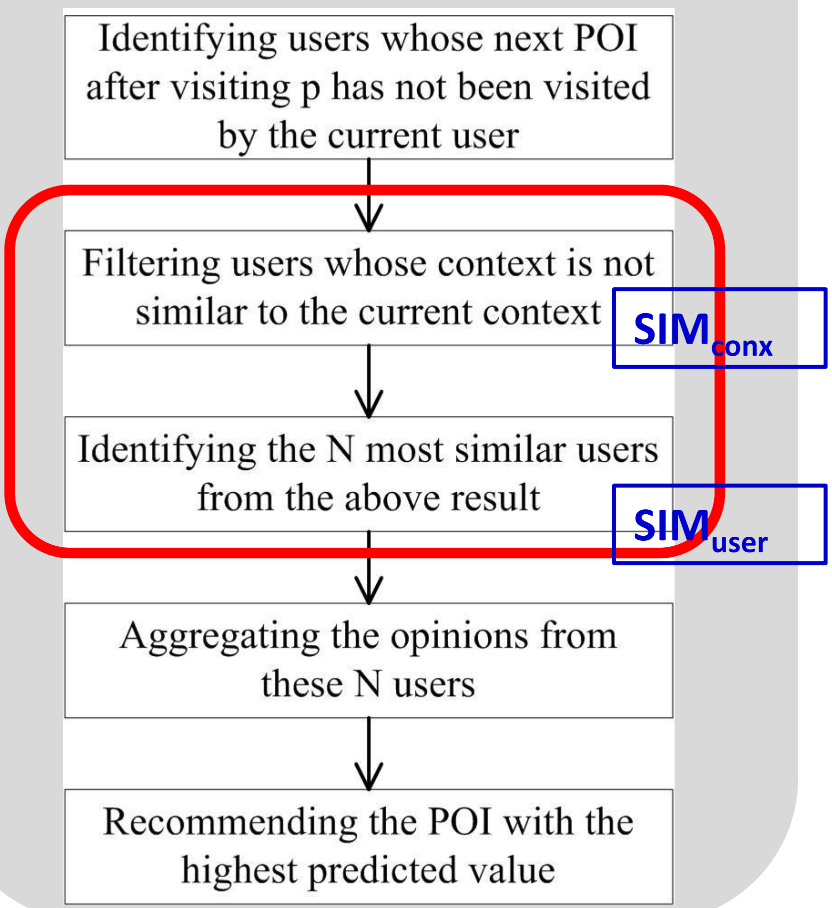
$$Dist(A,B) = \sqrt{\frac{\sum_{p \in \bar{P}} \frac{1}{F_p} * (A_p - B_p)^2}{\sum_{p \in \bar{P}} \frac{1}{F_p}}}$$

$$SIM_{conx}(A,B) = e^{-Dist(A,B)}$$

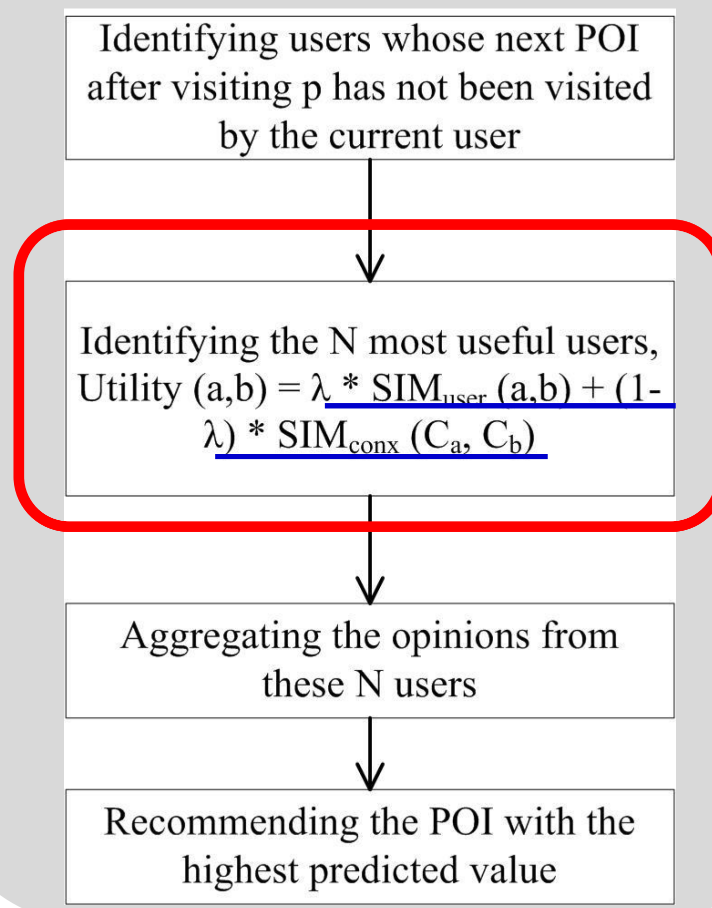
2.3 Making recommendations

- Two ways of combining user similarity and context similarity to identify "useful" users

M1. Contextual pre-filtering (SBA_CP_CaCF)



M2. Contextual modeling (SBA_CM_CaCF)



3. Evaluation

- GPS trajectories collected in Vienna zoo
  - Extracting a set of visited POIs (stops) from each trajectory to build user profiles
  - Only considering trajectories with at least 6 POIs
    - 41 trajectories in total

- Some additional information
  - weather (sunny/rainy), age (>=45, <45), time limit(Y/N), year ticket(Y/N), first visit to the zoo (Y/N), with baby (Y/N)
  - The initial set of context parameters

3.1 Identifying relevant context parameters

- How do tourists' visits differ among different conditions for each candidate context parameter?

	The number of visited POIs	Length of visit (km)	Duration of visit (hour)
Age (>=45, <45)	**p=0.18 (15.45 vs. 13.23)**	**p=0.19 (4.56 vs. 3.09)**	**p=0.16 (2.88 vs. 2.01)**
First Visit (Yes, No)	p=0.52 (14.46 vs. 13.56)	p=0.26 (4.19 vs. 3.18)	p=0.30 (2.58 vs. 2.08)
Annual Ticket (Yes, No)	p=0.63 (13.50 vs. 14.77)	p=0.79 (3.66 vs. 3.41)	p=0.28 (2.62 vs. 2.05)
Companion (Yes, No)	p=0.93 (13.88 vs. 14.00)	p=0.71 (3.39 vs. 3.89)	p=0.74 (2.30 vs. 2.03)
Time Limit (Yes, No)	p=0.29 (13.00 vs. 14:32)	p=0.31 (2.98 vs. 3.74)	p=0.60 (2.10 vs. 2.32)
Weather (Sunny, rainy)	**p=0.01 (15.07 vs. 11.64)**	**p=0.04 (4.01 vs. 2.52)**	**p=0.01 (2.62 vs. 1.52)**

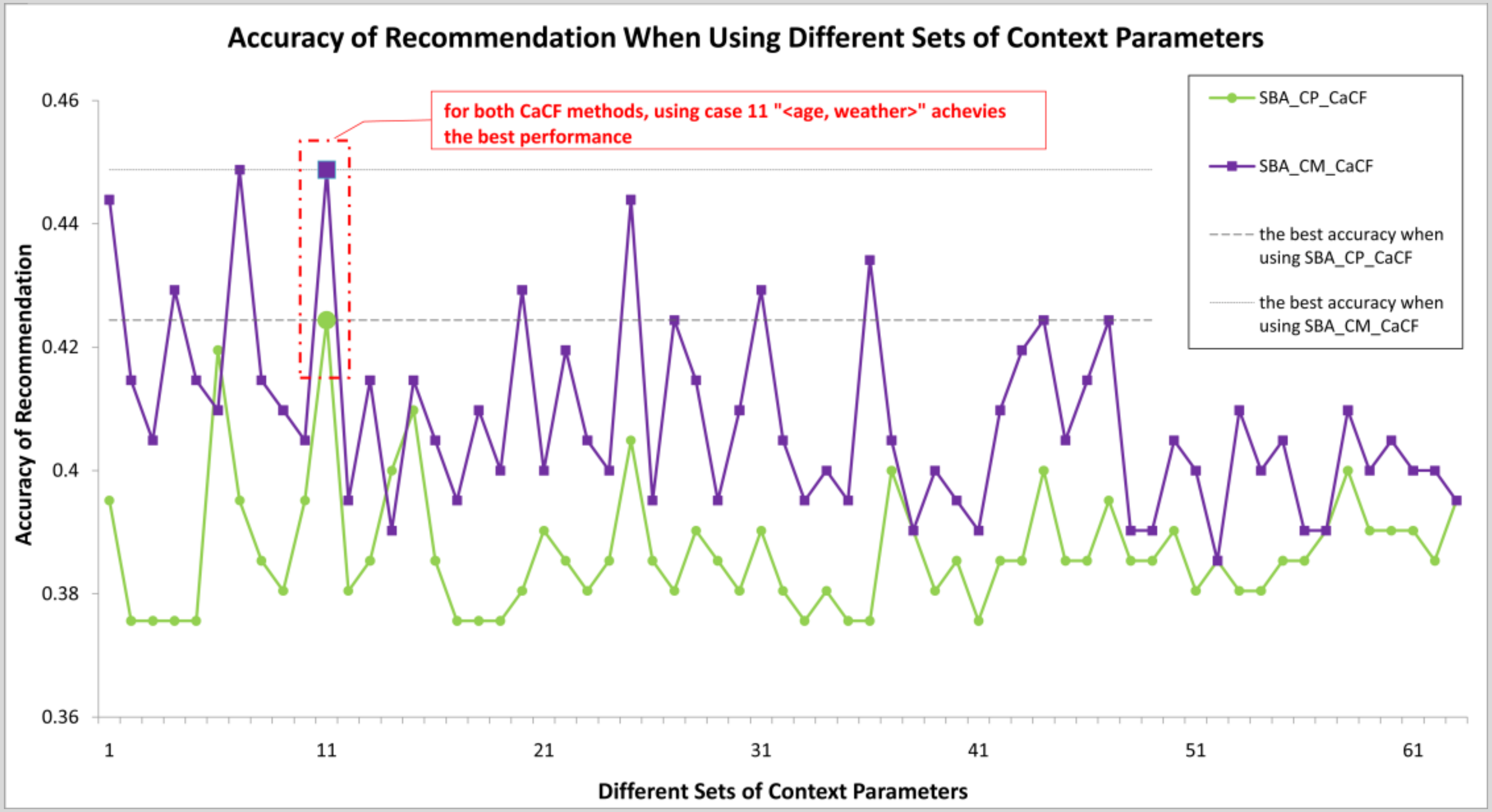
- The final set of context parameters:
  - **<age, weather>**

3.2 Experimental evaluation

- Leave-one-out evaluation
  - Using 40 of the 41 trajectories (visitors) to predict for the remaining one.

- Predictive accuracy
  - If the predicted POI is actually visited by the user, the recommendation process is considered as successful.

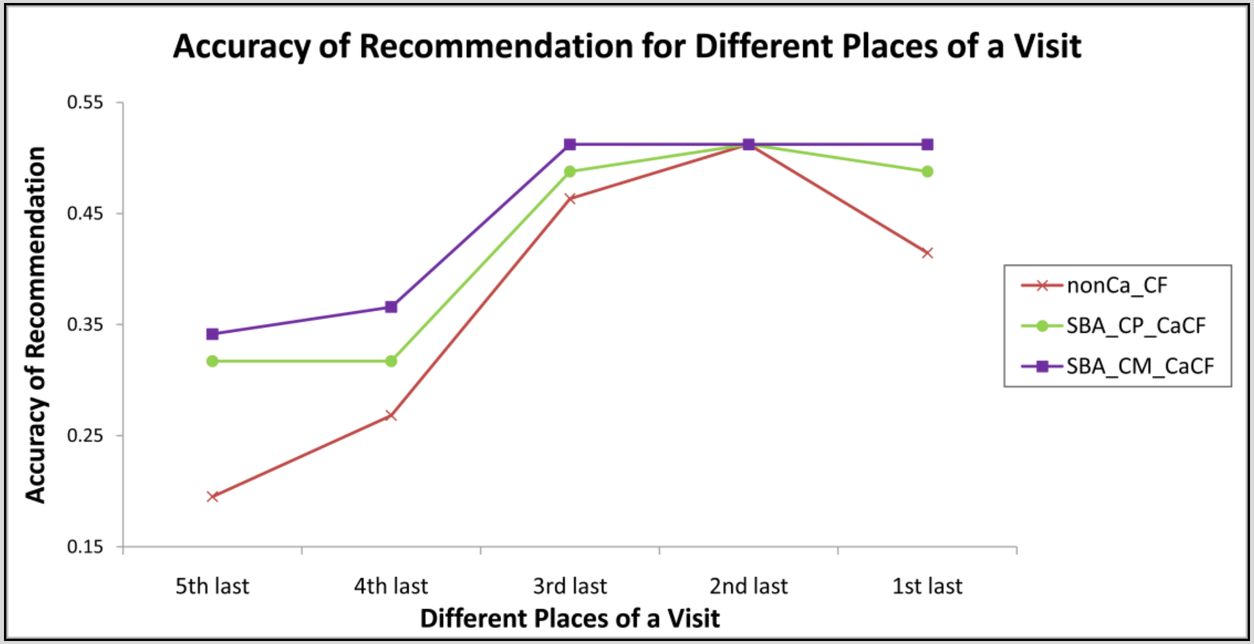
Results (1): How do the performances of the CaCF methods change when using different sets of context parameters?



… choosing a suitable set of relevant context parameters is very important and may affect the recommendation performance.

…Using the proposed set of context parameters performs the best: ***the two-stage method is feasible and useful for identifying relevant context parameters***.

Results (2): How do the CaCF methods perform differently when making recommendations for different places of a visit?



… a upward trend for the accuracy of all CaCF methods and the nonCa_CF when the positions of the predicted POI increase.

…the performance of contextual modeling approach is at least as good as the performance of contextual pre-filtering approach.

… the CaCF methods perform considerably better than the non-contextual CF method: ***including context information in a CF for mobile guides can improve the recommendation performance*.**

4. Conclusions

- Two context-aware CF methods are designed to mine GPS trajectories to provide users with contextual "Amazon-like" POI recommendations.

- The evaluation shows that
  - The two-stage method can help to identify relevant context parameters.
  - **Including context information into CF can provide users with more appropriate recommendations.**

5. Work in progress

- Evaluated with different kinds of data
  - Data from Vienna zoo, city center, city-wide
- Exploring more complex CaCF methods
  - Considering different types of context information

Thank you!
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Comments?

Haosheng Huang

Georg Gartner

Research Group Cartography
Vienna University of Technology
http://cartography.tuwien.ac.at
haosheng.huang@tuwien.ac.at
georg.gartner@tuwien.ac.at