STS: Design of Weather-Aware Mobile Recommender Systems in Tourism

Matthias Braunhofer, Mehdi Elahi, Mouzhi Ge, Francesco Ricci, and Thomas Schievenin

Free University of Bozen-Bolzano,
Piazza Domenicani 3, 39100 Bolzano, Italy
{matthias.braunhofer,mehdi.elahi,mouzhi.ge,francesco.ricci}@unibz.it,
toms.19@gmail.com,

Abstract. Context-aware recommender systems (RSs) have been mostly evaluated offline, and very few studies have tried to assess their benefit from the user perspective. Moreover, little research was previously dedicated to integrate the weather context into RSs that could benefit from that information, such as tourism applications. This paper presents a novel context-aware mobile recommender system, named STS, that leverages weather context for providing more relevant recommendations. We have evaluated STS in a live user study and have shown that our approach increases choice satisfaction and perceived recommendation quality.

1 Introduction

Recommender systems help users find interesting products or services [11], and reduce information overload by providing personalized suggestions. The user interface is a major component of a RS, as it is witnessed by the growing presence of this topic in conferences dedicated to intelligent user interfaces, e.g., IUI[1]. Moreover, the item selection problems supported by RSs are typical influenced by several factors. For example, purchasing a tourism product or visiting a place of interest (POI), is the outcome of a complex process that is affected by factors "internal" to the user, such as personal motivations and previous experience, and "external" ones, e.g., advices provided by friends, or the convenience to access the selected destination [12].

In order to deal with these influencing factors a novel line of research on Context-Aware Recommender Systems (CARS) was initiated. CARS generate more relevant suggestions by adapting to the specific contextual situation of the recommendation [1]. For example, the user's location and mood have been used in CARS, and particularly in mobile applications [11].

The most recent research on CARS has focused on model-based techniques that integrate contextual information directly into the rating prediction model, i.e., trying to improve the accuracy of the predicted rating of an item in a

[1] International Conference on Intelligent User Interfaces: http://www.iuiconf.org

particular contextual situation. While these model-based approaches have been largely evaluated in off-line experiments [2, 7], no evaluation was done in live user studies. Furthermore, we note that, in tourism applications, the weather condition that the user will experience at a POI has not been systematically exploited in CARS. The main difficulty in managing this type of contextual data is that it is not linked to the user status, but depends on the item to be recommended – the POI – and dynamically varies in time.

In this paper we try to fill these gaps by presenting a mobile CARS, South Tyrol Suggests (STS), which recommends POIs in South Tyrol (Italy) by taking into account various contextual factors, including the weather conditions at the recommended POIs. We have conducted a live user study to evaluate the goodness of the implemented solution and have shown that it increases choice satisfaction and perceived recommendation quality.

2 Related Work

In this paper we exploit and extend a model-based context-aware rating prediction technique originally introduced in [2] by incorporating new contextual factors describing the weather conditions. Climate and weather conditions are one of the most relevant contextual factors in tourist decision-making. Several studies in tourism domain have shown that weather conditions are a significant factor in tourists' satisfaction, activity participation, and even in perceived safety at touristic place [9]. However, weather conditions have not been adequately exploited in context-aware recommender systems yet.

A mobile platform was chosen as a natural option for implementing our tourist application. In [13] the authors made a comprehensive analysis of the top 300 mobile apps included in the travel category of iTunes app store and categorized them according to the unique information services they provide and their design features. Although several apps provide recommendations using techniques such as collaborative filtering with context awareness, none of them is reported as using weather conditions as a contextual factor.

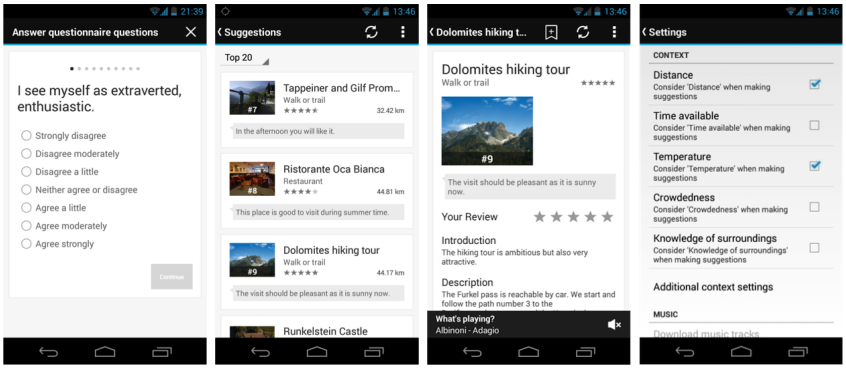
3 STS Design and Application

STS is a mobile context-aware recommender system mainly used for recommending places of interests (POI) in South Tyrol to tourists and local citizens. STS has been implemented as a rich client always-on architecture, i.e., the client has been kept as thin as possible and it works only in a limited way when offline. The Android client comprises a GUI and a presentation logic component; the entire recommendation logic and data layer reside on the server, which makes use of web services or data storages provided by the Regional Association of South Tyrol's Tourism Organizations (LTS[2]), the Municipality of Bolzano[3] and

[2] LTS: http://www.lts.it
[3] Municipality of Bolzano: http://www.comune.bolzano.it

Mondometeo[4] in order to obtain the graphical/textual descriptions as well as weather information for a total of 27,000 POIs.

When used for the first time, STS presents a registration screen where the user can specify a username, date of birth and gender. Next, the user is asked to answer the Ten-Item Personality Inventory questionnaire [6] so that the system can assess their Big Five personality characteristics: conscientiousness, agreeableness, extroversion, emotional stability and openness (an example of collecting extroversion is shown in Figure 1a). Using the given date of birth, gender and the assessed personality as input, the system, which implements an active learning component [5], identifies and prompts the user to rate a series of POIs whose ratings are expected to best improve the accuracy of the subsequent recommendations.



(a) (b) (c) (d)

Fig. 1: User interfaces of the STS application

Afterwards, the system provides recommendations as illustrated in Figure 1b. By default, this window provides the tourist with a list of 20 POIs that are considered appropriate for the current user and context. In case one of the items is interesting to the user, the user can view its details by clicking on it. In the detailed view, as shown in Figure 1c, STS provides various information about the item, such as photo, name, description, category and more importantly explanation of the recommendation based on the most influential contextual condition. For example, the sunny weather can be considered as a good motivation for the visit. Besides, users can also bookmark them, view the POIs on a map and write reviews for them.

Regarding the contextual factors, some contextual conditions are automatically acquired such as the weather conditions at each POI, while other factors such as time available or mood can be specified by the user (Figure 1d). Each of these contextual factors can be set or unset by the user, causing them to

[4] Mondometeo: http://www.mondometeo.org

be considered or ignored when generating recommendations. More information about the used contextual factors and their associated contextual conditions are shown in Table 1.

Table 1: Contextual factors used in the STS application

Contextual factors	Associated contextual conditions
Weather	Sunny, cloudy, rainy, thunderstorm, clear sky, snowing
Season	Spring, summer, autumn, winter
Budget	Price for quality, budget traveller, high spender
Daytime	Morning, afternoon, night
Companion	With friends/colleagues, with children, alone, with girlfriend/boyfriend, with family
Mood	Happy, sad, active, lazy
Weekday	Working day, weekend
Travel goal	Business, health care, scenic/landscape, hedonistic/fun, religion, visiting friends, education, activity/sport, social event
Transport	A car, a bicycle, public transport, no transportation means
Surrounding Knowledge	New to area, returning visitor, citizen of the area
Crowdedness	Crowded, not crowded, empty
Time available	Half day, one day, more than one day
Temperature	Burning, hot, warm, cool, cold, freezing
Distance	Far away, near by

The recommendation algorithm of STS computes a rating prediction for all tourist items from the database. In order to generate recommendations in real-time, STS' underlying recommendation algorithm follows a model-based approach from [2], that is, the learning phase is performed offline every five minutes. After the model is learned, recommendations can be generated in constant time. More details about our deployed recommendation algorithm can be found in [3].

4 Evaluation and Discussions

In order to evaluate STS, we conducted a user study with 54 participants, whose ages were between 18-35. Users were randomly assigned to two groups, one used a variant of the system that does use the weather factor (STS) and the other tried a variant (STS-S) that has exactly the same interface but the rating prediction and recommendation model is not using the weather factor. The users were asked to look for attractions or events in South Tyrol. The concrete task procedure is as follows: firstly the participants need to consider the contextual conditions that are relevant to them and specify them in the system settings (but they were invited not to modify the settings related to the weather factor). They were then asked to browse the attractions and events sections and check whether they could find something interesting for them. Also, they were instructed to browse the system recommendations, select one that they believed could fit their preferences and bookmark it. Finally, users needed to fill out a survey and evaluate the system they have experienced, with regard to their perceived recommendation quality and choice satisfaction, whose measurements are adopted from [8].

Additionally we provided a post-study section especially on the weather factor. That means after the users had selected a recommended POI, they had the opportunity to double check the weather conditions at the selected POI by accessing the Mondometeo website. If they considered their initial choices not appropriate anymore after having assessed the weather conditions at the selected POI, users were able to eventually change their selected POI and bookmark another one. Based on the user's evaluation, we have compared STS and STS-S, and derived some indications for designing future context-aware recommender systems, especially in the tourism domain.

We have found that users indeed fill out the personality questionnaire, which subsequently leads to a higher number of user ratings acquired by the active learning component compared to a baseline AL approach that does not exploit that information [5]. Another result, which is more interesting for this paper, is that including the weather factor increases choice satisfaction. Our analysis indicates that almost 60% of the users who have used STS-S changed their selection after the assessment of the weather conditions, while only 30% of the STS users changed their selection (this difference is statistically significant – chi-square test). Moreover, including the weather factor can significantly increase choice satisfaction (t-test probability $p = 0.01$). In particular we found that STS users liked significantly more their selected item ($p = 0.02$) and were more excited with it ($p = 0.03$).

We also found that using the weather factor in the rating prediction model can result in a higher perceived recommendation quality. Users believe that POIs suggested by STS were considerably more relevant than those suggested by STS-S ($p = 0.04$), and STS users didn't like the suggested POIs significantly less than STS-S users ($p = 0.001$).

Moreover, STS was evaluated by using the SUS (System Usability Scale) questionnaire [4], which was handed out to all experimental subjects. SUS score for STS is 78.8 and for STS-S is 77; both of them are significantly above the average SUS score of 68.

In conclusion, STS scored very well in the perceived recommendation quality and users' choice satisfaction. As [10] stated, tourism is certainly a primary application area for mobile apps. Device portability makes it easy for the tourists to access information in the different touristic places and helps them to find relevant attractions and services, or support them in the exploration of certain area. Our results confirm that the mobile platform can be effectively used for designing and implementing context-aware recommender systems, especially in tourism domain.

5 Conclusion

In this paper, we have presented a novel mobile context-aware recommender system named STS, which recommends POIs using a set of contextual factors such as the weather conditions at the POIs. We have described the design and implementation of STS. In order to evaluate the application, we have conducted

a user study by measuring user choice satisfaction and perceived recommendation quality. We have found that STS is of high utility and our results indicate that including the weather factor in tourism recommender systems can yield a higher choice satisfaction and perceived recommendation quality. We believe that this benefit is not limited to mobile applications and we conjecture that even in a PC-based application, which could be used before the travel, receiving weather-dependent recommendations would increase the user's acceptance of the recommendations. In the future we would like to improve the user interface and procedure for collecting users' feedback. Secondly, beyond the weather factor, we will conduct further experiments to better assess which contextual factors more significantly affect the RS performance.

References

1. G. Adomavicius, B. Mobasher, F. Ricci, and A. Tuzhilin. Context-aware recommender systems. *AI magazine*, 32(3):67–80, 2011.
2. L. Baltrunas, B. Ludwig, and F. Ricci. Matrix factorization techniques for context aware recommendation. In *Proceedings of the fifth ACM conference on Recommender systems*, pages 301–304. ACM, 2011.
3. M. Braunhofer, M. Elahi, F. Ricci, and T. Schievenin. Context-aware points of interest suggestion with dynamic weather data management. In *21st Conference on Information and Communication Technologies in Tourism (ENTER)*. Springer, 2014.
4. J. Brooke. Sus-a quick and dirty usability scale. *Usability evaluation in industry*, 189:194, 1996.
5. M. Elahi, M. Braunhofer, F. Ricci, and M. Tkalcic. Personality-based active learning for collaborative filtering recommender systems. In *AI*IA 2013: Advances in Artificial Intelligence: XIIIth International Conference of the Italian Association for Artificial Intelligence, Turin, Italy*. Springer, 2013.
6. S. D. Gosling, P. J. Rentfrow, and W. B. Swann Jr. A very brief measure of the big-five personality domains. *Journal of Research in personality*, 37(6):504–528, 2003.
7. A. Karatzoglou, L. Baltrunas, K. Church, and M. Böhmer. Climbing the app wall: Enabling mobile app discovery through context-aware recommendations. In *Proceedings of the 21st ACM international conference on Information and knowledge management*, pages 2527–2530. ACM, 2012.
8. B. P. Knijnenburg, M. C. Willemsen, Z. Gantner, H. Soncu, and C. Newell. Explaining the user experience of recommender systems. *User Modeling and User-Adapted Interaction*, 22(4-5):441–504, 2012.
9. N. Kozak, M. Uysal, and I. Birkan. An analysis of cities based on tourism supply and climatic conditions in turkey. *Tourism Geographies*, 10(1):81–97, 2008.
10. F. Ricci. Mobile recommender systems. *Information Technology & Tourism*, 12(3):205–231, 2010.
11. F. Ricci, L. Rokach, B. Shapira, and P. B. Kantor. *Recommender systems handbook*. Springer, 2011.
12. J. Swarbrooke and S. Horner. *Consumer behaviour in tourism*. Routledge, 2007.
13. D. Wang and Z. Xiang. The new landscape of travel: A comprehensive analysis of smartphone apps. In *Information and Communication Technologies in Tourism 2012*, pages 308–319. Springer, 2012.