Understanding the Role of Historical Context in a Point of Interest Recommendation System

Paulo Pombinho, Ana Paula Afonso and Maria Beatriz Carmo
Faculdade de Ciências da Universidade de Lisboa,Campo Grande, Lisboa, Portugal
ppombinho@lasige.di.fc.ul.pt, {apa, bc}@di.fc.ul.pt

Keywords: Context-Aware: Mobile Devices: Degree of Interest Function: Evaluation: Information Visualization.

Abstract: The increasingly large quantities of points of interest make choosing between all the available information a painful task for the users. This limitation is aggravated by the reduced screen space of most mobile devices. To minimize these issues, it is fundamental that the information shown to the user is relevant, helping them in making good choices and decisions. We present a two phase evaluation of an adaptive degree of interest function that uses location and temporal contexts combined with the historical context of the previous searches to quantify the relevance of the points of interest shown to the user.

1 INTRODUCTION

Applications designed for the search of points of interest in the vicinity of the users have become very popular, allowing users to make good choices when performing tasks like finding relevant locations in their vicinity. However, despite their undeniable usefulness, the increasingly huge amount of information hinders the users to correctly perceive all that is shown to them (Heimonen, 2002). Furthermore, when coupled with the mobile device's small screen space available, a correct visualization of the information is greatly hampered.

For this reason, it is essential that mobile information visualization applications enforce that what is shown on the screen is truly relevant for the user (Holtzblatt, 2005), and it is fundamental to include recommendations that guide the users in choosing amongst the available information.

Recommender systems have been a popular research topic, and are used in large online stores (Jannach et al, 2012). These systems rely on customers providing ratings and can be divided in two different types: single rating systems, which calculate an overall rating for each product for each user, and multi-criteria systems that rate, not only, an overall relevance, but also additional criteria / attributes (Adomavicius and Kwon, 2007).

However, traditional recommender systems do not take into account richer contexts, such as the type of location or time of day, easily obtained using current mobile devices (Adomavicius et al, 2011).

The adaptation to context dimensions is a key feature to mitigate the limitations in the usability of small screens. According to Reichenbacher (2008), adaptive visualization concerns the adjustment of all components of the visualization process, according to a particular context. This principle is especially important to increase the usability of searching information in mobile devices and to reduce the cognitive load inherent to mobile usage contexts.

In a previous work, we proposed a degree of interest function (DOI) that uses information on the user's preferences and location to estimate the relevance of each POI (Carmo et al, 2008). Despite being considered useful, the user's preferences had to be explicitly stated by them and, consequently, there was a need to specify several attributes and weights, causing the DOI to be deemed confusing (Pombinho et al, 2009).

Using the adaptive principle to solve the limitations of the DOI function and reduce its cognitive load, we proposed an adaptive degree of interest function (ADOI) that avoids the necessity of specifying a large number of attributes, while still maintaining, if not improving, the calculated relevance estimation (Pombinho et al, 2012).

In this paper we evaluate the ADOI function, to understand if it increases the usability of the system, while also improving the relevance calculation.

The next section presents a brief overview of our ADOI function, its distance functions and the adaptive historical context used.

2 ADAPTIVE DOI

One reason why the DOI was considered confusing was the need for the users to specify a large set of attributes for each query and understand and specify the weights for each attribute. To overcome these limitations we proposed an ADOI function that included enhancements to the previous DOI. These modifications aim to avoid the specification of a large number of attributes, while making part of this process automatic and transparent to the user.

We will briefly describe these enhancements, however, they are described in more detail in (Pombinho et al, 2012).

As important as understanding what points of interest exist in the vicinity of the user is to identify which are open by the time the user gets there. As an example, if the user is searching for a gas station, it is not useful to display results that might not be open when the user finally arrives there. For this reason, we have added a new temporal distance function and time attribute to the adaptive DOI function.

To avoid the need, for the user, to specify all the different attributes and weights of the DOI, and reduce the inherent cognitive load, the ADOI uses an historical context that will enhance the queries, by automatically specifying attributes using the information from the user's previous queries.

For each pair (*attribute type, attribute value*) we store a count of how many times it was queried. Whenever the user makes a query, the attributes specified and their values are updated in the internal database. This historical log allows a summary of the interest of the user to be assembled over time. For instance, if the user always goes to Italian restaurants, it is possible to use this information to automatically specify the "type of restaurant" attribute without further action from the user.

The user preferences and the type of searches made by them are, however, not always the same according to the location and temporal contexts. For this reason, we allow users to define geographical areas that are relevant for them (for example, a work or a home area). When the user performs a query, the logs are recorded in the appropriate geographical area / time of day section. Whenever a new query is made, the attributes are automatically adapted to the user's current location and temporal contexts.

3 USER EVALUATION

Since the proposed ADOI relies on an historical context that represents each user's implicit preferences, obtained from previous interactions with the system, we need this information to correctly perform an evaluation of the functions.

The best approach would be to have a significant number of users trying the application prototype during several months, slowly building the historical context to match their interests. However, due to consequent need of a very large number of available trial mobile devices and also due to time constraints, this approach was not deemed practical.

Another approach would be to deploy an application, and have a large number of users performing the evaluation on their own mobile devices. However, for it to be feasible, we would need POI data for an extensive area with information about the POI attributes which, again, was not possible.

For this reasons, to obtain, the user's general interests, we conducted a preliminary evaluation.

3.1 Phase One

In our study we had 13 participants, six male and seven female, with ages ranging between 21 and 62.

Since the goal of this phase was to obtain the user's interests, it consisted of a questionnaire that evaluated three different scenarios and also the general preferences. To avoid biasing the evaluation, the users were not briefed about the true purpose of the study; instead they were only informed that it was a survey about restaurants.

Despite having, as a goal, obtaining information for the second phase of the evaluation, some relevant data was obtained.

Regarding the general preferences of the users, it was interesting to find that "Type" and "Price" were by far considered the most important. On the contrary, the existence of a "Seafront" and the "Classification" were considered less important.

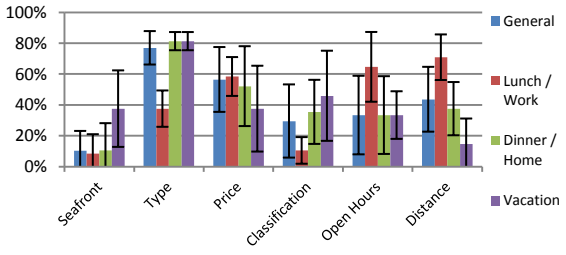

Figure 1: Average classification and standard deviation for each attribute / scenario

Enforcing our idea that different contexts create different needs, we had 62% of the users state that they had different preferences in the three scenarios and, for most the closer scenario was the search near home at dinner. Finally, when we consider all the answers for the different scenarios, we can conclude

that there are some attributes that have significant differences between them (Figure 1).

Although, as stated, our main goal in this phase was to obtain data to allow the second phase of the evaluation, the results obtained, despite covering a reduced number of users, do reveal a strong tendency for different interests in different contexts.

3.2 Phase Two - Hypothesis

The main objective of this evaluation phase was to understand if the proposed concepts were easily comprehended by the users and if they achieved a relevance calculation that, when compared to the actual interest of the users in specific POI, had closer results than the standard DOI.

From our understanding, and the previous analysis of the first phase of the evaluation, we considered five hypotheses:

H1 – The Exploratory DOI will be considered more useful in scenarios where the user wants to choose a different POI from those already known.

H2 – Both types of users (with and without preference differences) will prefer the Adaptive DOI, finding it easier to use.

H3 –The temporal distance will be more used than the geographical distance.

H4 – The Standard DOI will have similar results to the Adaptive DOI for users with no different preferences for different scenarios.

H5 – The Adaptive DOI will obtain closer results (both in the order and value) to the true preferences of the users who have different preferences for different scenarios.

3.3 Phase Two - Procedure and Tasks

Since the participants in the second phase were the same from the first, and to minimize biasing from one phase to the other, we had a time lapse of over a month. Furthermore, using information obtained from the first phase, we instantiated, for each user, the Historical database with values resembling the users interest for each scenario.

This evaluation phase consisted of five tasks:

First task – In the initial task, users were presented, for each three different scenarios (used in the first phase), with a list of POI and their attributes. They were then asked to order them by giving them a classification from 0 to 100%. This task has the objective of validating **H4** and **H5**, allowing the comparison of both the order and values given by the users, to the values obtained by the DOI and the ADOI, for similar scenarios.

Second and Third tasks – The second task was an introductory task, where each concept was briefly explained to the users and enough time was given for them to freely experience with the application. Similarly, task three allowed the user to test the three DOI modes: Standard DOI, Exploratory DOI and Adaptive DOI.

Fourth task –The fourth task placed the users in a scenario were implicitly they were told to find "something new" and also that they were short on time. This task had the objective of finding out, if most users choose to use the Exploratory DOI, thus validating **H1**. Furthermore, the use of the temporal distances was also analysed (for validation of **H3**).

Fifth task – Finally, in the last task the user had to search for a restaurant near their workplace, at noon. The objective of this task was to understand how many users choose each DOI mode. From the information obtained we intended to understand if **H2** and **H3** are valid.

3.4 Phase 2 - Results and Discussion

To perform the comparison between the relevancies given, by the users, to each POI, and the values that were obtained by the Standard DOI and the Adaptive DOI, we subtracted the values stated by the users from both the DOI and the ADOI values, and compared the results.

We found that, for both, the relevancies calculated by the algorithms are, on average, lower than those given by the users. This fact is probably due to the penalizing nature of both DOI functions, when compared to the way the users classify the POIs. One user stated that by simply being a restaurant he would classify it with a 50% value.

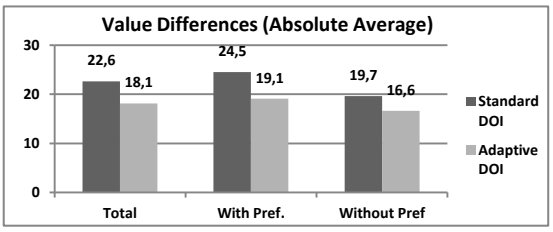

Figure 2: DOI vs. ADOI: average value differences

Concerning the absolute relevance value differences (Figure 2), both functions had deviations from the values given by the users (around 20%). However, when we consider only the differences in the order (Figure 3) we have, on average a difference under 1, which indicates that it is, in general, in accordance with the user's preferences.

In all the scenarios considered, the Adaptive DOI had better results than the Standard DOI, obtaining both values and order that better matched the values indicated by the users. This confirms **H5**; however, surprisingly **H4** is disproved since even for

users with no difference in preference, the Adaptive DOI had better results. In fact, the results obtained with the different groups of users do not shown a significant difference between them.

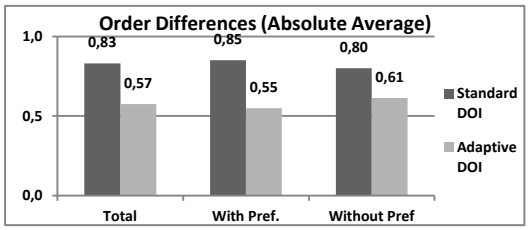

Figure 3: DOI vs. ADOI: average order differences

To validate **H1**, we examined how many users chose to perform their query of task 4 with the Exploratory Mode. Despite the slightly worse usefulness classification, only two participants used other DOI modes, thus validating **H1**.

Concerning **H2**, the hypothesis is only partially validated. While in task 5, two thirds of the participants preferred to use the Adaptive DOI, when asked which one they would prefer, we obtained mixed responses, with an equal number of users preferring each mode. Instead, more than half the users prefer to have both functions available. This is, in part, contrary to what we would suppose, since the Adaptive mode consistently obtains results that better match the user's classifications.

Finally, regarding **H3**, our results partially contradict our hypothesis. Despite being, in general more used than the geographical distance, when we asked the participants which one they would prefer, we had twice as many participants choosing the geographical distance. It should, however, be stressed that, more than half the participants would prefer to have both distances available.

4 CONCLUSIONS AND FUTURE WORK

Our work provides evidence that user preferences change, sometimes significantly, depending on the context in which they are (both temporal and geographical).

We can also clearly witness an improvement in both the values and the order of the POIs when using the adaptive DOI. This improvement suggests that the use of richer contextual information can significantly improve the way applications model and identify the user interests, enabling a better selection of the information presented to the user and its relevance. By having a better judgment on the choice of presented information, and displaying it in a way that more closely resembles the frame of mind of the user, we can considerably reduce the cognitive load associated with these systems and increase their usability.

We also witnessed some classifications by the users that raised interesting questions. For example, one of the users classified a restaurant with 0%, because the Type was vegetarian, and the user really disliked that type of food. This hints that, possibly, there should not only exist positive preferences, but also, negative ones.

Regarding future work, we intend to explore a number of different contexts that could also be used to further filter and partition the Historical Context database. The use of the current climate conditions in the area of the user, for example, can alter the preference for restaurants with or without a seafront, depending on whether it is raining or not. Similarly, when the users were considering the vacation scenario in a different country, many expressed the desire to choose the restaurant type as "typical". This indicates that the notion of being abroad (easily found by analyzing the user coordinates) can also significantly alter the user preferences.

REFERENCES

Adomavicius, G., Kwon, Y., 2007. New Recommendation Techniques for Multi-Criteria Rating Systems. In *Intelligent Systems, IEEE, 22 (3), 48-55*.

Adomavicius, G., Mobasher, B., Ricci, F., Tuzhilin, A., 2011. Context-Aware Recommender Systems. In *AI Magazine, 32 (3), 67-80*.

Carmo, M. B., Afonso, A. P., Pombinho, P., Vaz, A., 2008. Visualization of Geographic Query Results for Small Screen Devices. In *Proc. of the Visual 2008, LNCS 5188, 167-178.*

Heimonen, T., 2002. Information Visualization on Small Display Devices. *Master Thesis. Department of Computer Sciences, University of Tampere*.

Holtzblatt, K., 2005. Designing for the Mobile Device: Experiences, Challenges and Methods. In *Communications of the ACM, 48 (7), 33-35*.

Jannach, D., Karakaya, Z., Gedikli, F., 2012. Accuracy Improvements for Multi-Criteria Recommender Systems. In *Proc. of the EC'12, 674-689*.

Pombinho, P., Carmo, M. B., Afonso, A. P., 2009. Evaluation of Overcluttering Prevention Techniques for Mobile Devices. In *Proc. of the IV'09, 127-134*.

Pombinho, P., Carmo, M. B., Afonso, A. P., 2012. Context Aware Point of Interest Adaptive Recommendation. In *Proc. of the CARR 2012 workshop, in Conjunction with IUI 2012*.

Reichenbacher, T., 2008. Mobile Usage and Adaptive Visualization. *Encyclopedia of GIS. Part 16. Heidelberg: Springer Verlag, 677-682*.