

Integrating Public Displays into Tourist Trip Recommender Systems

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ABSTRACT

Tourist Trip Recommender Systems (RSs) suggest points of interest (POIs) and combine them along enjoyable routes. Integrating public displays into the recommendation process promises to overcome the limitations of mobile devices, such as small screens, thereby enriching the user experience of a tourist trip RS. However, in practice, public displays are rarely integrated in this manner. In this paper, we show how a mobile RS for tourist trips can be adapted to public displays and propose a Distributed User Interface (DUI) approach where the RS is distributed among both public and private devices. The results of a preliminary user study indicate that integrating public displays is perceived as attractive and novel; however, people remain concerned about privacy issues when using a public display. Public displays become more interesting when used for group recommendations; thus, we outline how our proposed approaches can be integrated into a group RS.

CCS CONCEPTS

• **Information systems** → **Recommender systems**; • **Human-centered computing** → **Interaction techniques**; *Touch screens*;

KEYWORDS

Tourist Trip, Smartphone, Public Display, Distributed User Interface, Usability

1 INTRODUCTION

Recommender Systems (RSs) have been applied in various domains; however they are particularly popular in tourism where they allow users to receive suggestions for points of interest (POIs) or tourist trips comprising multiple attractions [2]. Today, mobile devices are the primary information access platform and tourists use mobile RSs to receive recommendations when traveling [18]. However, mobile RSs have to deal with various limitations, such as small displays and limited Internet access.

Public displays at touristic spots are one solution to overcome these limitations. Currently, public displays are used to display primarily static content, such as maps and timetables. The next step in public display research is to provide personalized content tailored to individual information needs by allowing the user to interact with the display and share their preferences. However, using public displays for personalized recommendations raises privacy issues, and some people are reluctant to use them because of social embarrassment [4]. A Distributed User Interface (DUI) is one solution to this problem. With a DUI, the user interacts solely

with their personal device to protect sensitive data, and the public display only receives and displays selected content, such as the final recommendation.

Our overall goal is to integrate public displays into tourism RSs. Previously, we developed TourRec, a tourist trip RSs that recommends sequences of POIs along enjoyable routes between a start point and a destination and adapts the routes according to user preferences and constraints [9]. An updated version of TourRec is available on the Google Play Store¹. In this paper, we show how TourRec can be adapted to public displays and introduce a DUI approach that combines the advantages of public and private devices. In a preliminary user study, we evaluated different approaches relative to usability criteria. In addition, we describe how to integrate our approaches into a group RSs.

The remainder of this paper is organized as follows: In Section 2 we present background information and related work. We introduce our approaches to integrate public displays into a tourist trip RSs and the results of a preliminary user study in Section 3. In addition, we explain how our ideas can be used in group RSs. Conclusions and suggestions for future work are given in Section 4.

2 BACKGROUND AND RELATED WORK

Tourism RSs can recommend different travel-related items, such as POIs, travel plans, and tourist trips [2]. Traditional tourism RSs often recommend sets or ranked lists of POIs from which the user can choose the attractions they would like to visit. The recommendations can be optimized by considering contextual factors, such as weather [3]. More advanced RSs can recommend complete travel plans composed of multiple travel items, such as a destination, a hotel, and nearby POIs. TripMatcher and VacationCoach are early travel RSs that use content-based approaches to match user preferences with potential destinations [17]. Other approaches to generate travel plans involve case-based reasoning [11, 19] or conversational UIs [12]. However, tourist trips are sequences of POIs along enjoyable routes [23]. For example, the City Trip Planner is a tourist trip RS that generates personalized routes and can integrate lunch breaks [22]. Another example is TourRec, the mobile RS that is the basis of this work (Section 3.1). Other tourist trip RSs identify routes that are considered scenic or pleasant [6, 16]. Only very few work has been done to recommend tourist trips to groups [20].

In the tourism domain, RSs are typically developed for mobile devices or desktop clients. Another idea to provide personalized recommendations to people who are already traveling is deployment

¹<https://play.google.com/store/apps/details?id=de.tum.in.cm.tourrec>

on public displays, such as information kiosks in trains stations, airports, and touristic areas. Public displays vary in size from small television screens to display static information, such as timetables, to large and interactive multi-user wall displays [15]. Interactive public displays can be differentiated based on input types and interaction techniques. Users can interact directly with a touchscreen or buttons attached to the display or they can use speech or gestures [14].

Even though public displays have many advantages compared to mobile devices, such as screen size, social embarrassment and privacy concerns prevent people from interacting with them. People may be uncomfortable entering sensitive data in a publicly available device [4]. Furthermore, passersby may be able to see sensitive content, a phenomenon referred to as *shoulder-surfing* [5]. Using a mobile device to enter personal information is a promising way to address privacy issues [1]. UIs that are distributed across multiple devices or interfaces are referred to as DUIs. With DUIs, the UIs can be displayed on different monitors, devices, or platforms, and they can be distributed among different users [21].

3 INTEGRATING PUBLIC DISPLAYS INTO A TOURIST TRIP RECOMMENDER SYSTEM

In this section, we describe TourRec and show how it can be adapted to public displays. We also introduce a DUI approach that combines private and public devices. In addition, we summarize the results of a preliminary user study performed to evaluate these approaches and explain how such approaches can be integrated into a group RSs.

3.1 TourRec

TourRec is a mobile tourist trip RS that combines multiple POIs along enjoyable routes [9]. Prior to requesting a recommendation, the user can specify their travel preferences by rating various categories, such as *food* or *nightlife*, on a scale from 0 to 5. The user must specify an origin (e.g., the user’s current location), a destination, a start time, and the maximum duration of the trip. A *PlacePicker* UI allows to select the origin and destination by searching for a location or selecting it directly on a map. Recommendations are displayed on a map or as a list of POIs with additional information, such as predicted arrival times and suggested durations of stay (Figure 1a). Note that the UIs were designed using Material Design, a design language introduced by Google².

To generate tourist trips based on user queries, TourRec communicates with a backend we developed for this purpose. The backend architecture is modular and scalable, which allows us to add and evaluate new clients, recommendation algorithms, and data sources.

3.2 Public Display Variant

Public displays have become increasingly common in touristic areas; however, they are still not used for personalized recommendations. The potential advantages are obvious. The user does not need their own device with Internet connection while traveling. Larger displays can facilitate orientation in an unknown area and support the selection of a suitable recommendation when all relevant data,

such as POI information, a map, and context data, are displayed on a single UI. Furthermore, a public display can facilitate decision making when used by a group because the recommendation can be viewed by all members of the group. More advanced approaches allow the user to modify the recommendation directly on the public display and send it to the personal device. These advantages represent our motivation to integrate public displays into our TourRec application.

In this work, we use a kiosk system equipped with a 55-inch multi-touch screen in portrait orientation. Similar tourism information kiosks can be found in many touristic areas. We tried to keep the changes to the smartphone’s UIs to a minimum so that the only independent variable tested in our user study was the interaction type rather than other changes in the layout. Thus, the public display application applies the same layout but attempts to benefit from the larger display area wherever possible.

Figure 1b shows a tourist trip recommendation on the public display. Again, the final recommendation is presented both on a map and as a list of POIs. However, the public display variant takes advantage of the larger screen and displays both modes simultaneously. The map and list are displayed on the top and bottom of the screen, respectively.

We used the AngularJS framework to implement the public display application. The kiosk system runs Windows 10 and the application can be accessed via any web browser.

3.3 Distributed User Interface Approach

The DUI approach distributes the recommendation process among the smartphone and the public display. The two main reasons for this approach are: (i) users can keep sensitive data on their private device but view the recommendation on a large display, and (ii) users can prepare a route request prior to traveling and display a recommendation on a public display as required.

We decided to use a QR code for the pairing between the smartphone and public display because it has been shown that this method provides high usability in similar scenarios [24]. Furthermore, QR codes are already used in common software, such as WhatsApp³, to pair a desktop client and a smartphone.

After the user formulates a route request, the extended smartphone application allows the user to send the recommendation to a public display. The user must scan the QR code using the smartphone’s camera to transmit the request to an intermediary server application we have developed. The public display fetches the route request from the intermediary server application. To identify the correct smartphone, each request is labeled with a unique ID that is also encoded in the QR code. After the public display receives the request, it forwards it to the backend and receives a recommendation, which is then presented to the user.

The smartphone and public display applications are the same as in Sections 3.1 and 3.2; however, they are extended by the pairing feature. The intermediary server application is a web service implemented in node.js.

²<https://material.io/guidelines/>

³<https://www.whatsapp.com/>

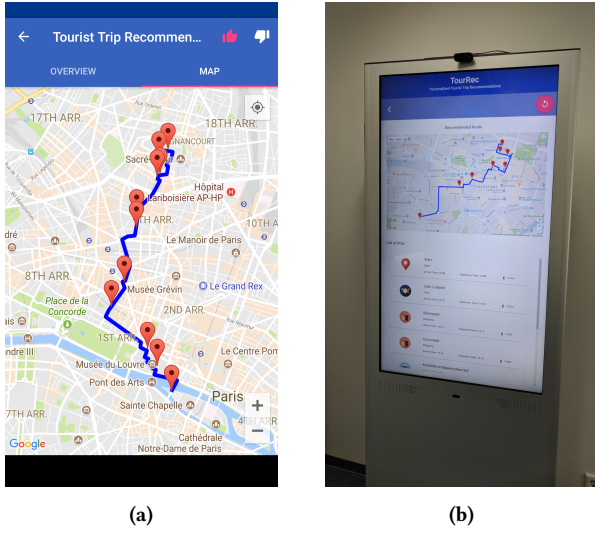


Figure 1: Tourist trip recommendation in a) the mobile application and b) the public display application

3.4 Preliminary User Study

We conducted a preliminary user study to obtain initial feedback on the proposed integrations of public displays.

3.4.1 Goals and Setup. We evaluated the three variants of the single-user RS relative to user experience, execution time of the selected tasks, and comfortability of use in a public space. The user study followed a within-group design. We allowed the participants to test the prototypes in random order to avoid biased results due to the learning effect. The participants were asked to execute three tasks for each interaction technique: (i) create a route between two predefined POIs, (ii) create a route between two predefined POIs with their own travel preferences, and (iii) create a route from the current location to a predefined destination.

The participants were asked to fill out a User Experience Questionnaire (UEQ) after every interaction technique. The UEQ is a semantic differential with 26 items grouped into six user experience aspects: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty [10]. A benchmark data set that enables comparison of the performance of each aspect to other systems, exists. In addition, we included one extra question asking the user how comfortable they felt using the prototype in a public place.

In total, 16 people participated in the user study. All participants were bachelor or master's degree students or had recently graduated. Overall, the participants had rather limited experience with interactive public displays, e.g., 50% of the participants had never used a similar system previously.

3.4.2 Results and Discussion. We performed statistical tests where applicable to determine whether the performance of the interaction techniques differed significantly at the 5% level relative to any of the aforementioned aspects. We used Repeated Measures Analysis of Variance (ANOVA) when the results were distributed normally and the Friedman test in other cases. The Shapiro-Wilk test for normality was performed to select the correct significance

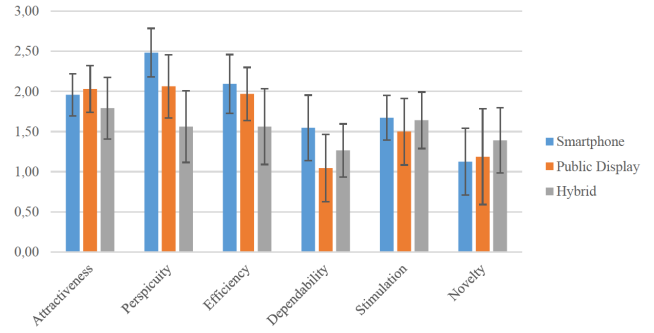


Figure 2: UEQ results for three interaction techniques

Table 1: Task Times

	Task 1	Task 2	Task 3
Smartphone	33.38 s	77.44 s	25.56 s
Public Display	34.69 s	73.06 s	33.63 s
DUI approach	43.81 s	81.19 s	36.81 s

test. In case of a significant difference, we performed a post-hoc test to identify where the difference occurred, i.e., between interaction techniques.

Figure 2 shows the results of all prototypes relative to the six UEQ aspects. As can be seen, the attractiveness of all prototypes is considered *excellent*, which means that it is among the 10% best results of the benchmark data set. However, perspicuity is significantly higher for the stand-alone smartphone mode compared to the DUI approach ($\alpha = 0.002$). Many people are familiar with the stand-alone smartphone variant than a hybrid approach. For dependability, the difference between the stand-alone smartphone and public display modes is significant ($\alpha = 0.006$), which means that the participants felt more in control of the interaction when using a smartphone than a public display. Moreover, the public display's dependability score was *below average* compared to the benchmark dataset because the public display scored very low for the *Secure vs Insecure* item. Thus, further effort to protect user data and prevent *shoulder-surfing* is required. Our DUI approach appears to be a promising solution because its dependability is similar to the stand-alone smartphone variant. Furthermore, the DUI approach demonstrates the highest novelty, which means that this approach feels the most innovative and creative. However, this difference is not yet significant.

Table 1 shows the average execution times for each task and prototype. The execution times of Task 1 are significantly shorter for both the stand-alone smartphone mode ($\alpha = 0.007$) and the stand-alone public display mode ($\alpha = 0.015$) than the DUI approach. Task 3, which requires the user to give the system access to their current location, is significantly faster on the smartphone than on the public display ($\alpha = 0.002$) and for the DUI approach ($\alpha = 0.003$). There is no significant difference between the execution times of Task 2 which included entering the travel preferences before requesting a recommendation.

The analysis of execution time shows that there is nearly no difference between the public display and smartphone interaction techniques. This is surprising because many participants had no previous experience with interactive public displays.

Comfortability using a smartphone in a public place is significantly higher than when using a public display ($\alpha = 0.005$) and using the DUI approach ($\alpha = 0.005$). During the study, 75% of participants explained that using two devices is a disadvantage and too complex because they could obtain the same recommendation using a single device. However, 25% of participants emphasized that preparing the route recommendation in advance, e.g., by entering route parameters on the smartphone, while waiting in line to use the public display could be a significant advantage in practical use.

3.5 Group Recommender System

The results of the preliminary user study show that integration of public displays into a tourist trip RS is perceived as attractive and novel. However, the advantages of a hybrid approach are less appreciated when used by single users. The feedback received indicates that public displays could become more valuable when a group of users attempts to agree on a tourist trip.

The simplest ways to find a group recommendation is to use only a single smartphone or allow one group member to use the public display on behalf of the group; however, this requires the group members to agree on the group's travel preferences in advance. A more sophisticated approach uses one smartphone per user, thereby allowing each user to independently enter their travel preferences. In this case, the preferences of all users are merged automatically by the RS using a social choice strategy [13]. Networking Application Programming Interfaces (APIs), such as Google Nearby⁴, can be used to share travel preferences and recommendations between smartphones without an Internet connection. Thus, only one device is required to request a recommendation from the backend and broadcast it to the other users. One advantage of this approach is that the users do not have to reveal their travel preferences, which avoids social embarrassment and manipulation [7].

When a public display is available, no Internet-connected device is required. The public display variant presented in Section 3.2 can be used by a group if the group's preferences are entered by a single group member. Furthermore, we suggest an extension to our DUI approach where each user enters their preferences using their personal device and the recommendation is displayed on a mutual screen. Thus, this approach uses the same UIs as the previous prototypes. However, the collected preferences are aggregated automatically before the public display shows the recommendation to the group. This approach combines different advantages of the previous solutions, i.e., users do not have to reveal travel preferences and the mutual display facilitates discussions among group members, which helps the group determine consensus [8]. More advanced approaches allow the group to modify the recommendation on the public display and send it back to their devices.

To summarize, the strategies we suggest for a group RS can be distinguished by the following dimensions.

- Small screen vs. large screen

- One user enters the preferences for the group vs. every user enters the preferences separately
- User preferences are revealed to the group vs. preferences are hidden from the group
- The recommendation is displayed on a mutual screen vs. the recommendation is displayed on each individual's device

Our goal is to compare these different approaches to determine which specifications under which conditions facilitate the process of finding a tourist trip for a group. For this purpose, we plan to conduct user studies with different group types, such as families, friends, or colleagues. The results will show us which approaches perform best relative to different usability criteria and if there are any differences depending on the type of user and group.

4 CONCLUSION AND FUTURE WORK

In this paper, we have shown how public displays can be integrated into a tourist trip RS. We adapted a smartphone application to public displays and extended it with a pairing functionality to realize a DUI approach. In a preliminary user study, very high attractiveness was demonstrated by all approaches. However, the results of our preliminary study show that public displays provide limited advantage when used by single users. As a result, we have outlined how our approaches can be extended to enable group recommendations. In future, we will implement these extensions and compare the different approaches in larger user studies with real groups to evaluate how they support tourist trip recommendations in a group context.

Integrating public displays into a tourist trip RS offers tourists many advantages compared to mobile devices; however, privacy concerns relative to using a public display remain. The DUI approach presented in this work allows the user to keep sensitive data, such as travel preferences, on the private device while benefiting from the public display. This is particularly important in a group recommendation scenario where the users want to share a mutual display but not reveal their personal preferences to other group members. However, further efforts are needed to protect the data on the public display, such as the actual recommendation. Different approaches to prevent *shoulder-surfing*, such as blacking out parts of the display or mirroring a passerby's position and orientation to warn the user have been developed [5]. Future work should evaluate how these approaches can be adapted to the tourist trip scenario and group recommendations on public displays.

One main limitation of our preliminary study is the fact that it was conducted as a lab study. The advantages of a large display could become clearer when the user is actually traveling. On the other hand, social embarrassment and privacy concerns could become a significantly larger issue when passersby are present. Hence, in a real-world scenario, the users could accept the presented DUI approach more easily compared to the public display variant.

ACKNOWLEDGMENTS

This work is part of the TUM Living Lab Connected Mobility (TUM LLCM) project and has been funded by the Bavarian Ministry of Economic Affairs, Energy and Technology (StMWi) through the Center Digitisation.Bavaria, an initiative of the Bavarian State Government.

⁴<https://developers.google.com/nearby/>

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