Using Wearables for Travel Assistance

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Abstract: In the last decade, personal mobility has become more diverse and more complex. Public transportation networks have grown bigger and new travel modes, e.g., car sharing, have emerged. Thus the required electronic travel assistance, usually provided by smartphone applications, has been well-established and is generally accepted. Unfortunately using a smartphone application to check the itinerary while travelling can be a hassle. The traveller has to pull out the device, unlock it, start the application and find the required information inside the application. In the meantime he or she is distracted which causes a loose of time and also may lead to dangerous situations, e.g., in traffic. To improve this situation we developed a smartwatch application following the *Cascading Information Theory* principle which assists the traveller by displaying all journey-related required information on his or her wrist and notifies him or her when necessary. The prototype of the application was evaluated in an initial user test ($n = 5$) and improvement compared to a single smartphone application was assessed. The evaluation results showed that users prefer a smartwatch/smartphone based solution over a pure smartphone application and are distracted for a shorter timespan.

1 INTRODUCTION

Shifts in technology usage and globals trends, e.g., urbanization, change peoples mobility. Growing public transportation networks and new transport modalities, e.g., car sharing, give travelers more options and therefore, make traveling more complex. Simplifying the usage of such complex mobility services by assisting the traveler can potentially improve the acceptance and therefore lower emissions (Chapman, 2007) (Camacho et al., 2012). A lot of applications and projects, both stationary and smartphone based have been established for mobility services around the world and for various platforms (see Section 2). Most of these applications focus on the preparation of the trip. Traveler can compare different prices, departure times and itineraries and commonly also book the respective services. Although the planning of a trip might be complex itself, it is usually conducted in advance of the actual trip and the traveler is not on any sort of pressure (he or she has enough time and is in a familiar environment). In contrast, undertaking a trip usually involves a lot of stress, especially when multiple mobility services, e.g., connecting trains or planes, are involved. Traveler are in distracting and confusing environments, like train stations, have to carry luggage etc and meanwhile have to check for, e.g., departure information, therefore *Travel Assistance* applications are required. Travel assistance applications allow a quick information access to itinerary information and guide the traveler to his or her destination.

Most current travel-related smartphone application present a great amount of information (some of it usually redundant and unnecessary) and have an appealing GUI. These applications usually perform well in lab scenarios but lack usability in the real world. To mitigate these issues the *Cascading Information Principle* has been applied to mobile travel information (Samsel et al., 2014) and proven feasible (Beul-Leusmann et al., 2014). The Cascading Information Principle suggests "to unveil information about the game in as small amounts as possible to ensure the user's focus exactly on the desired objective. Thereby, confusion and misdirection of players by providing excess information is prevented and each iteration of new data can be applied directly."[1] Although, initially developed in a game context, the concept also applies to real world scenarios.

Wearables are smart devices which are usually worn as garments or accessories. Current examples are watches, bracelets, glasses, shirts and shoes. Although very different in nature, all wearables have

[1] http://techcrunch.com/2010/08/25/scvngr-game-mechanics/

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some common characteristics; They have low processing power, none or very few input and output methods like buttons or a display. Because of these properties wearables are usually used as an extension to an existing device, e.g., a smartphone. They allow a quick information access or a simple interaction via a single button press. It's easier and faster to check ones (smart) watch by turning the wrist, compared to check the smartphone by pulling it out of a pocket / purse, unlock it and maybe even start the respective app.

Thus, we realized a wearable-based travel assistance application, following the cascading information principle and evaluated the application in a real world field test.

The remainder of this paper is structured as follows: In Section 2, related research and existing applications are discussed. Section 3 derives our approach by listing requirements to the system, whereas Section 4 presents the working prototype implementation. The evaluation methodology and results are presented in Section 5 followed by Section 6 concluding the paper.

2 RELATED WORK

This Section gives a brief overview on related scientific work and existing applications.

Multiple approaches for pedestrians navigation have been introduced. (Baus et al., 2002) established a pedestrian navigation system with a hybrid solution titled Project REAL, already predicting the evolution of personal navigation systems ("Personal navigation systems that extend beyond today's use in cars will play a major role in the future."). The system is capable of automatically adapting to location changes and presenting directions to the traveler on a variety of different devices. (Wenig et al., 2014) discuss different approaches of combining maps and panoramic photographs for pedestrian navigation. They acknowledge the problem of distraction by pointing out an incident where a test participant disregarded a red traffic light while using the navigation system. (May et al., 2003) suggest a landmark based approach, which rely on orientation points like buildings as navigations cues instead of distances or street names. (Chowaw-Liebman et al., 2010; Heiniz et al., 2012) transfers this idea to a turn-by-turn approach to manage navigation inside large, complicated buildings using landmark representations for orientation rather than street names. A different approach for navigation assistance for pedestrians and public transport is Pulsemap (Zargamy et al., 2013), which rely on the results in

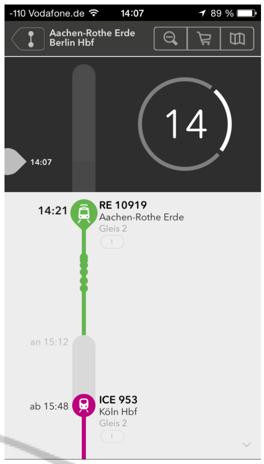

Figure 1: The Qixxit android application in travel companion mode (only available in German).

(Pascoe et al., 2000). Pascoe et al. state that travelers are distracted by audio and visual clues, which potentially lead to dangerous situations. Zargamy et al. approached this by using the vibrations of a wearables device. Different vibrations lengths convey different directions, e.g., 100ms denote "turn left", whereas 200ms denote "turn right".

Wearables, although a new technology, have been deployed to various fields of assistance applications, most notably to e-Health systems. (Jonas et al., 2014) introduced wearable technology to assist nurses in clinical care, whereas (Sun et al., 2014) present a wearable platform aimed towards patients. In (Jiang et al., 2014) the authors present a wearable glove for service and maintenance personnel.

Qixxit[2] is the newest travel information platform provided by Deutsche Bahn. It incorporates a travel companion (travel assistance) mode presented in Figure 1. It displays the time until the departure of the next connection, the respective train number and platform number, loosely following the Cascading Information principle.

3 APPROACH

This Section documents step-by-step the conceptual development of the approach. Our approach is based on the travel assistance concept introduced in (Samsel et al., 2014). In this work only the Wearables related extension is described.

[2] http://www.qixxit.de

3.1 Requirements

Before extending an existing information system with a wearable device, the developer has to decide which function the wearable device has to fulfill and which functional or non-functional requirements have to be met. Based on these factors a suitable device can be selected. Key requirements are wearability, interactivity, security, communication, battery runtime and real-time processing (Lymberis, 2005; Meng et al., 2011; Wei, 2014).

Wearability (R1) is the comfort of carrying a smart device. The device should not obstruct the movement of the user nor should the users appearance been altered in a negative way. Ideally, neither the user nor his or her surroundings should realize that he or she is wearing a device. This requirement is important for travelers, as unobstructed movement and discreetness are must-haves.

Interactivity (R2) is the ability of the system to offer services to the user. This typically involves some kind of input and output using, e.g., key presses, a display and such. For an assistant application conveying information to the user is required. Because of the distraction by the environment interaction should be possible with minimal cognitive effort, so the device should offer a simple and intuitive interface.

Security (R3) in context of wearables essentially means the device and its communication channel are protected from unauthorized access. As this work is only a prototype, security is not a concern.

Communication (R4) is a strong requirement for most wearable devices as these are mostly a part of a bigger system. The communication is nowadays usually realized as wireless technologies such as Wi-Fi or Bluetooth for short range communications with other devices of the user or long range communication like UMTS/LTE for a direct connection to the internet. As an assistant application running on a wearable device will typically be used in conjunction with smartphone, a short range communication technology is sufficient.

Battery runtime (R5) is a critical factor for travel related applications as a power supply is generally not available while traveling. With recent advances in battery technology, energy harvesting and power saving (Gorlatova et al., 2013) we can assume that current wearable devices are able to support most trips runtime-wise, especially in urban scenarios.

Applying the stated requirements to the available device classes listed in Section 1 the optimal device

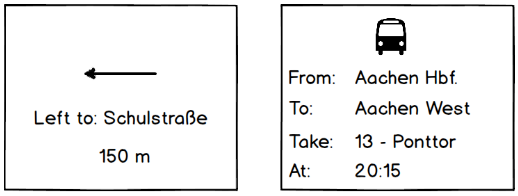

Figure 2: Paper prototype for for pedestrian-navigation and public transport navigation.

is found rather easily. R1 prevent smart glasses as these heavily interfere with the appearance of the traveler. R2 exclude simple wearables devices like e-textiles (shirts, shoes etc) or accessories (bracelets etc) as these usually don't have any way of interaction. The only remaining class is the smart watch. Smart watches are unobtrusive to wear but still have enough interaction and communication capabilities to fulfill assistance related functions.

For this work, the Sony SmartWatch 2[3] was chosen as platform as it appeared to have the best development environment in terms of functionality and API stability at that time.

3.2 Graphical User Interface

Based on the required information for travel assistance which have been derived in (Samsel et al., 2014) a paper prototype for the smart watch has been created. For pedestrian navigation information about direction, distance and street name are required. For public transport assistance information about departure and arrival station, vehicle information and departure and arrival times are required. Figure 2 shows the corresponding view for pedestrian and public transport.

4 IMPLEMENTATION

This Section demonstrates the actual prototype application.

The prototype was developed using Android Studio[4] and the Sony Add-On SDK[5]. It consists of two components with different functions; The smartphone component (shown in Figure 3) is responsible for the communication with the backend (using Wi-Fi/UMTS) and the user input. Its map view also serves a fall back for the navigation. The smartwatch

[3] http://www.sonymobile.com/de/products/accessories/smartwatch-2-sw2/

[4] https://developer.android.com/sdk/

[5] http://developer.sonymobile.com/knowledge-base/sony-add-on-sdk/

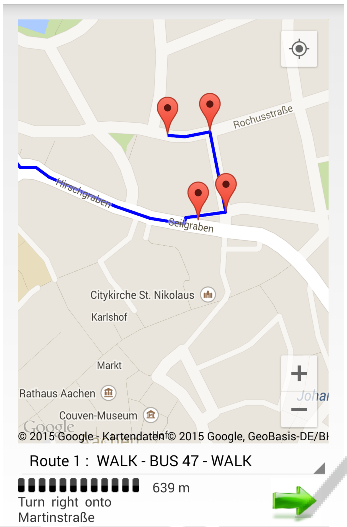

Figure 3: Example route parsed and visualized by the Route Activity.

component displays the actual routing instructions. The interaction between both components is handled by the Sony Add-On SDK using Bluetooth.

4.1 Smartphone Component

The Smartphone component consists of three different activities. The settings activity can be accessed via pressing the hardware-button, allows changing of static parameters, e.g., Server URI or standard zoom level of the used map. The main activity waits for a destination to be entered by the user. The activity than sends a request to the backend and requests current geolocation coordinates. Upon receiving the current location of the user, the activity starts the route activity by pressing a Plan-Button and sending the destination address and the current location of the user. The route activity sends a request to backend with input information from the main activity and parses the information provided by a backend. Afterwards the activity initializes and visualizes the parsed result on a map (see Figure 3), by using markers at each navigation step. Subsequently it calculates the distance between the user and the next waypoint, and alarms the user as soon as he or she is in the direct vicinity of the next waypoint. The calculated distance between the user and the next waypoint is also visualized by a static progress bar and a text field providing the exact value. The distance between the user and the next waypoint will be calculated each time the GPS-routine is called. Each bar blanks out if the user comes 50 meter closer to the waypoint. Also this activity sends gathered information about the next waypoint and the user location to the Smartwatch.

Figure 4: Application prototype demonstration.

4.2 Smartwatch Component

The main functionality of the smartwatch is to visualize the content received from the smartphone component. Upon successfully receiving the information, a vibrator is started to inform the user that he is in the direct vicinity of the next waypoint. The Smartwatch uses all information for the route and visualizes them in a similar manner as the Smartphone does, but without using the Map due to performance and visibility issues. The Smartwatch component also shows the distance to the next waypoint and uses a progress bar to visualize the value.

The compass functionality was not added to the applications since the compass/magnetic field sensor support from Sony's SmartWatch 2 has been removed. The compass functionality of the Smartphone could not been used either, since this would require that the user aligns his or her smartphone in his or her pocket/purse to the direction he is facing.

4.3 Routing Backend

To enable pedestrian and public transport assistance, a routing solution is mandatory. We opted for the open source routing planning framework OpenTripPlanner (OTP)[6]. OTP features intermodal trip planning with support for public transport, pedestrian navigation and even support for rental bikes. OTP is a Java application and consists of a server which performs routing and supplementary services offered via RESTful API.

OpenTripPlanner includes a graph builder tool which parses any provided General Transit Feed Specification (GTFS) data feed and determines the required map excerpt. The required map data is then automatically downloaded from OpenStreetMap. To support public transport navigation we converted timetable data supplied by the local mobility service provider into the GTFS format.

[6]http://opentripplanner.com

5 EVALUATION

To evaluate the application respectively the approach a user-oriented field test was conducted.

5.1 Methodology

The prototype application introduced in Section 4 was assessed in a field test to determine the general feasibility of the approach and to identify both technical and usability problems with the prototype application itself. The field test comprised a introduction to the general handling of the smartwatch and smartphone, a introductory scenario and two tasks which had to be solved by navigating using the application. The purpose of the scenario was to give the test participants a contextual framing to balance out the different backgrounds of the participants.

Scenario: “Assume you are a student using a smartphone and smartwatch, owning a student ticket and using public transportation frequently. You work for the student union and you often have contact to other students with a variety of different fields of study.”

Task 1: “You start your day with the first lecture in Audimax. During the lecture you receive an email with the notification that your next tutorial had to be moved to another building. Unfortunately, you do not know the exact location of the building, but you received the address of the building. You want to know, how to get as soon as possible to the unknown destination. The address you received via email is Rochusstrasse 14 in Aachen.”

Task 2: “After your tutorial, you realize that you still need to hand in an internship report for your friend. Your friend is studying mechanical engineering and is currently working in Hamburg. He has to hand in his report today and he gave you his internship report yesterday. You know the address of the destination, but you do not know the exact location of the building. You planned your trip yesterday, but with the moved tutorial you are not sure how to get to the destination now. The address of your destination is Sandkaulstrasse 9 in Aachen.”

During the test, participants were instructed to apply the thinking aloud method which means to comment on their interaction with the application. For lowering the cognitive load, task instructions were handed over only after completing or terminating the previous task. Verbal comments were briefly noted and the number of interactions with smartwatch and smartphone were logged. The feedback of participants was collected with a questionnaire based on the Computer System Usability Questionnaire (CSUQ) (Lewis, 1995; Lewis, 2002): CSUQ has a total of 19 questions, which are grouped into four different properties. The Usability evaluates out of questions 1 to 8, the Information Quality evaluates out of questions 9 to 15, the Interface Quality evaluates out of questions 16 to 18 and the overall rating evaluates out of all properties and an additional question 19. Lewis et al. suggested to use a Likert scale for the questionnaire. In this work a Likert scale was used, with a range of: 1 (strongly disagree) to 5 (strongly agree).

Five test participants took part in the evaluation. All five were male. Their age was $M = 25.8$ years (M = mean value), $SD = 3.63$ (SD = standard deviation). Four of them were students, one was a research assistant. All participants stated they are enthusiastic about technology, particularly computing.

5.2 Results

The three questions with the highest user rating mean were: Question 16 ($M = 4.8$, $SD = 0.45$, ”The interface of this system was pleasant.”), Question 7 ($M = 4.6$, $SD = 0.89$, ”It was easy to learn to use this system.”) and Question 6 ($M = 4.4$, $SD = 0.55$, ”I felt comfortable using this system.”). The three questions with the lowest user rating mean were: Question 9 ($M = 1.4$, $SD = 0.89$, ”The system gave error messages that clearly told me how to fix problems.”), Question 11 ($M = 1.75, SD = 1.5$, ”The information (such as on-line help, on-screen messages and other documentation) provided with this system was clear.”) and Question 10 (M = 3.2, $SD = 0.84$, ”Whenever I made a mistake using the system, I could recover easily and quickly.”). The other questions had a mean rating between 4.2 and 3.8. The best rated questions pointed out that the groups Interface Quality and Usability scored best and the group of Information Quality scored worst. The Usability was rated with $M = 4.14$, $SD = 0.81$, the Information Quality was rated with $M = 3.07$, $SD = 3.3$, the Interface Quality was rated with M = 4.2, $SD = 0.77$ and the Overall Rating was $M = 3.83$, $SD = 1.08$.

Besides the usability assessment using the CSUQ, participants gave detailed feedback on the prototype’s visualization and features by writing down comments in the questionnaire and uttering them during the evaluation. Many positive comments were made on the prototype in general. One participant stated: ”I really liked that the Smartwatch displayed the distance to the next waypoint while navigating by foot.” Another participant stated: ”I really liked the vibration notifications.” In addition, they acknowledged the minimalistic design of the applications, the integrated map and the automatic step-by-step support during the journey. Further negative comments addressed the Information

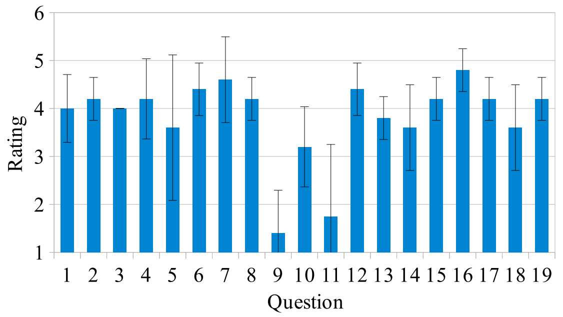

Figure 5: The mean value and the corresponding standard deviations, of the collected user ratings for all CSUQ questions. The values have a range from 1 (strongly disagree) to 5 (strongly agree).

Quality of the application. Test participants criticized that the information about the cardinal directions after deboarding from public transport or starting their navigation, wasn't helping to find the directions they had to go to. One participant also said: "I wasn't really using the progress bar, if I needed the information about the distance I always used the [displayed] value."

The participants used for the first route, the Smartphone application seven times in total ($M = 1.4$, $SD = 0.55$) and for the second route 11 times in total ($M = 2.2$, $SD = 0.84$). The Smartwatch has been used 54 times in total ($M = 10.8$, $SD = 1.92$) for the first route and for the second route 86 times in total ($M = 17.2$, $SD = 4.15$).

5.3 Discussion

The worst rated questions are easily explainable since this prototype did not implement any error messages or additional information (such as on-line help or other documentation). In fact, these questions were better rated than thought, since some users just didn't run into errors while evaluating the application. If one removes the three questions about error messages and on-line help or other documentation, the Information Quality rating increases to $M = 4$, $SD = 0.65$ and the Overall rating increases to $M = 4.13$, $SD = 0.72$. Overall, the participants preferred using the Smartwatch instead of the Smartphone, which is shown by the number of interactions (Smartwatch $M = 10.8/M = 17.2$ vs. Smartphone $M = 1.4/M = 2.2$). The smartphone component can be considered as a backup solution for complex situation in which the smartwatch is not sufficient, e.g., if the participants did not know in which cardinal direction they had to go or if they were not sure if they are still on the right track. During the evaluation one could observe that the progress bar was not used by the majority of the participants. Most of the participants did not look at the smartwatch while navigating, they rather performed one navigation step and afterwards went forward until the next vibration signal appeared to deliver the next navigation step. Some users also stated that they would like to use a compass for the cardinal directions directly on the smartwatch (was not possible due to technical restrictions).

6 CONCLUSION

This paper presented an approach for assisting travelers on their public transport-based journey using a wearable device. The prototype was realized following the cascading information principle using a Sony SmartWatch 2 and using OpenTripPlanner as routing backend. The prototype application was evaluated in a real world field test to gain insights about the feasibility of the approach and usability issues with the specific implementation. The results showed that general approach of using a wearable in addition to a smartphone for navigation is beneficial compared to only using a smartphone.

Future Work

Although, this work showed that the approach is feasible, there is still some work remaining. The feedback provided by the participants revealed that showing the distance to the next intermediate point is not useful; while walking participants had problems approximating the distance and while riding a bus, it is irrelevant. Instead, it is supposedly better to calculate the remaining time based on the walking speed or using realtime traffic information for public transport. (May et al., 2003) suggested another approach for navigation, by adding information about their surroundings (e.g.: Turn left at the cross-way with the traffic light.). This approach could be used to avoid to use cardinal directions, but would require a huge amount of underlying data. Potentially the Cascading Information principle might be transferable to wearables applications in different domains, but this is beyond our scope. The user test itself, with a relative low number of participants, can hardly give any quantitative feedback. Consequently in a further iteration of the development cycle the evaluation should be conducted with a higher number of participants. Last but not least, the presented application is just available for a single platform, for Sony SmartWatch. For a productive usage, more wearable platforms have to be supported.

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