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EaSI: A prototype system based on unusual ways of interaction for identifying and providing audio information for points of interest

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Abstract

Seeking information for points of interest (POIs) yet relies on systems that use location services and traditional techniques of interaction. These ways of communication, based on optical interfaces, necessitate cognitive demand and attachment to mobile phone screen, as a result degrade user experience. We developed a system, named EaSI that consists of an android application, the DA14583 IoT Sensor adapted to user glasses and a pair of headphones. It uses novel ways of interaction such as head gestures and relies on auditory feedback in order, to reduce user's time and effort, to identify POIs and obtain information about them. System evaluation showed that our prototype significantly reduced user's time and actions in identifying points of interest compared to a conventional application that uses visual interface. Attractiveness and realistic and hedonistic quality were rated with an average score of more than 2, with excellent 3.

Keywords: Location based services, POI discovery, Gestural interaction, Head sensors, Auditory feedback.

Introduction

The widespread dissemination and use of mobile phones contribute to develop a plurality of applications and services. Many of them use user's location (Location Based Services - LBS) to provide services, such as discovering of Point of Interest - POIs, navigating in a selected geographic point and providing information about historical monuments, tourist routes and means of transportation.

One case of Location Based Services is the quest of information for a nearby point that draw user attention. In this situation, to obtain the desired information, a series of actions is necessary. For example, the user has to unlock and open the mobile phone, open the LBS application, locate on the digital map what is the icon that corresponds to the point of interest, select it and read the desired information.

This process by its nature is time consuming and can become even more complex and demanding in several cases, such as when the user needs to pan, zoom and center the map several times so that is capable of matching POI digital representation up with the desired real point. Given the non-knowledge of the region, the cognitive effort of digital map correlation

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with the physical world increases depending on the number of neighboring points of interest. Furthermore, it should be mentioned that most LBS applications use Google maps which involve their own digital representation of points of interest (Google Pois) making the map, in an urban environment, even more complicated to be read.

The abovementioned user interaction with the application requires cognitive effort and visual attachment on the mobile phone screen, mitigating its attention and its interaction with the real world, therefore affects and degrades user experience exploring the world using conventional LBS services.

Related Work

Mutation of physical world perception due to time and cognitive demand of user interaction with mobile phone visual interfaces has been a research field for many years (Hyman et al., 2009). Researchers attempt to point to the real world with their devices to reduce the time and effort in seeking of information procedure. As mobile phones enhance with evolved networking modules, orientation sensors and GPS units the technique of pointing and scanning of surroundings become more capable and efficient.

Studies using mobile phones as pointing device differentiate into mode that information is obtained. In the work of Lei and Coulton (2009), Carswell et al. (2010), Pombinho et al. (2010) and Meek et al. (2013) screen is used for information retrieval consequently the visual attachment is still present and interaction with real world is weakened.

In the studies by van Tonder and Wesson (2011), Jacob et al. (2012), Szymczak et al. (2012), Pielot et al. (2012) and Jacob and Winstanley (2013) is attempted to eliminate the necessity for mobile phone screen by providing information via haptic signals like patterns of vibration defined by strength and duration. Although users are released from dedication to mobile device screen the received information is plain, lacking details like the next navigation direction, the distance from desiring POI and the goal achievement.

The emerging Augmented Reality (AR) technology affects among other fields the POI discovery. As reported by Yovcheva et al. (2012), Ruta et al. (2014), Kamilakis et al. (2016) and Ioannidi et al. (2017) users locate, explore POIs and retrieve information about these ones through smartphone camera, specifically by camera image overlays with POI markers. Throughout the process their attention devotes to the real world even through smartphone screen, nevertheless come out difficulties in markers selection, overloaded screens with visualized information, mobility restrictions while using the AR apps and the necessity of handling smartphone with two hands.

In contemporary and sophisticated research, the developed systems exploit parts of users' body like hands and eyes using modern vehicle equipment and wearable devices to point neighboring POIs. In Rümelin et al. (2013) study, in an adapted car environment, information is obtained through infotainment system for POIs identified via pointing gestures. Although the encouraging results of system operation, driving safety issues may have arisen as users had reduced speed during the gesture procedure. In the previous survey, so as in the Gomaa et al. (2020) the hypothesis of controlled and relaxed driving conditions brings general use restrictions.

Hsieh, Jylhä et al. (2018) and Hsieh, Orso et al. (2018) developed a POI exploration system based on wearable glove with embodied actuators for providing exploration and detection information through haptic feedback and a headset for POIs details retrieval. Despite the performance and the acceptance of the system the audio information is predefined for specific POIs and the content lacks real time update and connectivity with a ubiquitous service for points of interest exploration. Still, actions to information navigation are not supported, except the acceptance or refusal of the audio message delivery.

EaSI Service

Considering the peculiarities and deficiencies of previous research studies, as descripted above and taking in to account some directions for research of a similar work of Komninos et al. (2018), we designed and developed the EaSI (EAsy Seeking of Information) service aiming the elimination of the necessity for visual interface in POIs exploration, contributing to enhanced visitor experience. The service is based on head gestures and in an auditory interface for locating and retrieving information for points of interest near the user who carries a pair of glasses, a smartphone and a pair of headphones.

The cornerstone of the service, the DA14583 IoT sensor (Image 1), a small unit that might be embodied to wearable devices like glasses or smartwatches, consists of a 6-axis inertial measurement unit, including an accelerometer and gyroscope and 3-axis geomagnetic field sensor. Communication with the smartphone established by a Bluetooth system-on-chip module using the Bluetooth Low Energy (BLE) Protocol.

Image 1. Dialog Semiconductor 14583 IoT Sensor Board (source: https://www.digikey.sg/en/products/detail/dialog-semiconductor-gmbh/DA14583IOTSENSDNGL/5887065)

The DA14583 IoT sensor, adjusted in user glasses captures its line of sight via magnetometer values and head commands via accelerometer values. The Foursquare API accessed for the relative information and text to speech libraries of android ensure the modification of text to natural speech.

The concept of the EaSI operation is effortless. When the user identifies the point for which he is interested, approaches it, and performs a gesture that start the service -the Triger Gesture- which is to look down, restores his head to a horizontal level and to resume the previous movement sequence. An audio message informs him to stare at desired point after a played sound tone. For a few seconds, the application monitors and calculates the user bearing. A call to Foursquare API based on user location and bearing made for retrieving the neighboring POIs. The POI that has the minimum bearing deviation from user bearing is considered the desired point of interest. A new call to Foursquare brings back the defined information in text format and android text-to-speech libraries alters it to spoken words. Users might control what listens to, according to a head-based gesture interface which simulates a classic audio control interface, such as that used in audio players.

Gestures design

The trigger gesture that initiates the seeking process of POIs was associated with accelerometer values. It was observed that by moving the head on the vertical axis Z altered the value of Accelerometer Z from 1g (the user looks straight) to 0.5g (the user looks vertically towards the ground). The standard acceleration due to gravity is denoted by g. Values are non-zero due to gravity rather than non-movement of the user's head.

To avoid spurious gestures, we set as Trigger Gesture the above sequence twice, i.e., head down → head up → head down → head up (4 movements). 1g and 0.5g values were slightly differentiated to 0.9g and 0.6g to not require the user to restore his head to a perfectly horizontal plane or look vertically down and be easier to achieve the gesture.

A time limit is also set to accomplish each of four head movements at 2.5 sec, so giving support for a wide range of head movement speed. If after 2.5 sec, the next head movement non take place, then the process should start from the beginning thus eliminating the correlation of successive false movements (eg the user looked down and brought back his head)

The auditory information can be controlled with head gestures, enabling functions like pause, resume, stop, forward and rewind. Two focus groups were designed and were guided according to the guidelines of Kontio et al. (2004) and Krueger (2002). The purpose was to export new ideas and explored the simplicity, effectiveness and usability of the interface for the association of the classic audio control actions with head gestures.

Five people, men aged 39 to 46, from the same workplace were selected in the 1st group. They are all Information Technology graduates. All of them are motivated in technological developments and use applications and services of information and communication. In the 2nd team, five people, 3 women and 2 men aged 38 to 44 years old, were selected from the friendly environment. They are characterized as average tech users that use mobile applications and services to retrieve information and manage their personal data.

The dominant view of the two focus groups, as the most intuitive matching of the control functions of audio information with head gestures, was:

- Forward → head movement right
- Rewind → head movement left
- Stop → head movement up
- Pause/Play → head movement down

Of the 3 sensors of the DA14583 IoT only the gyroscope can monitor the head movement in horizontal and vertical plane. After testing, the 120 degrees/sec was set as the Gyroscope Threshold to monitor the head movement. The gyroscope records the angular rotation speed of the head, allowing to record gesture with a slight shift of the head in a very short time. The gesture to control the audio information was to set the movement of the head in the direction - which was decided after the conduct of the two focus groups - and the restore of the head to the original position.

Therefore, each Gesture involves 2 head movements. The 2nd head movement was defined to be done within 2 sec when the first is recorded. It was also observed that when the head been returned to the initial position, sometimes there was an imperceptible oscillation of it, which triggered a new gesture. A time of 0.5 sec was set as an idle time, so when a gesture will be captured could not start a new one in this time interval.

Limitation of search radius of neighboring POIs

After extensive testing in the field to control the application function, the following phenomenon was observed. The user's distance from POI, for which it intends to retrieve information, affects the output of the application. Specifically, the longer the user's distance is from the desired point, the more likely is the application to wrongly calculate the desired POI. To deal with the above problem, the application should have a limit on the search radius of points of interest. This limit was defined by an experiment, which identified the maximum distance from which a group of people collect information about points of interest.

Five participants would give information for four POIs following experiment coordinator suggestions. The geographic location from which each participant would provide information on the requested POI, would be recorded on a mobile device (**Error! Reference source not found.**) The five chosen participants did not know the POIs, for which would give information. Points of interest of the experiment could be accessed from 70 meters due to the arrangement of the surrounding area, giving participants the choice to describe them from the distance they want, without being forced into approaches from nearby distances. After completing the experiment, the distances were measured with the Google Maps tool "Measure Distance" between the positions of the participants and the corresponding locations of POIs (**Error! Reference source not found.**).

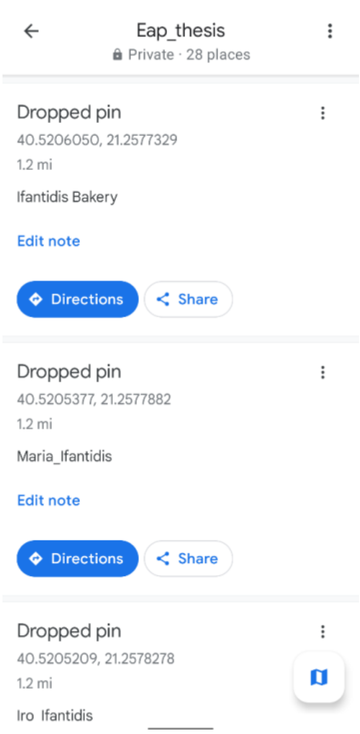

Image 2. List of participants locations in the experiment.

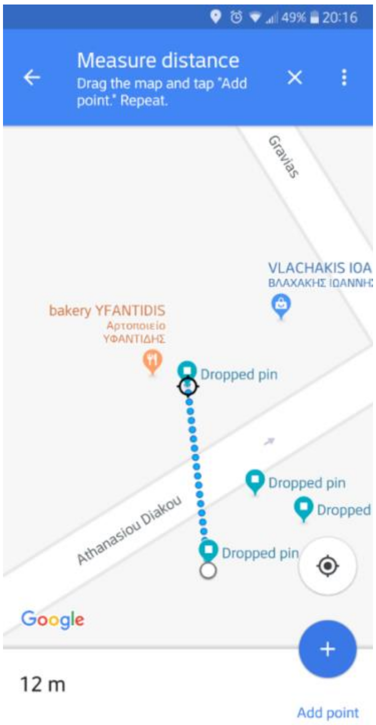

Image 3. Distance measurement on Google Maps

The furthest point from which one user described a point of interest was measured at 20 meters. Based on the specific experiment and its results, a search limit in android application for neighboring POIs was set at 20 meters.

Android application implementation

The EaSI application was developed in Android Studio (target SDK 26) consists of two services, two asynchronous interfaces and the main activity (Image 4). In BLE Service the connection of the DA14583 IoT Sensor to GATT Profile set up, ensuring the communication among the IoT Sensor and the application, the discovery of IoT sensor features and the capturing of the sensors' values. Location Service guarantees the monitoring of user location and broadcasts this to UI Thread.

Utilizing received data in main activity of accelerometer, magnetometer and gyroscope, application captures the trigger gesture, user orientation, and the control gestures of auditory information respectively. User bearing calculated by magnetometer data is affected by the slope of sensor level from the horizontal level in user glasses. To deal with this issue we compensated the slope, considering pitch, roll and the accelerometer normalized values as analyzed in Using LSM303DLH for a tilt compensated electronic compass (2010) application note.

Foursquare and DetectLanguage interfaces were developed for supporting asynchronous data retrieval from corresponding APIs. Two calls are made in Foursquare API, the first returns the POIs in range 20m from user location and the second call fetches the data in text format of the selected POI like name, category, price category, number of likes, rating and one user tip. The desired POI among the neighboring POIs is set this with the minimum bearing deviation from user bearing.

The accurate transmission of the auditory information is considered critical for user experience and was developed via asynchronous call in the Language Detection API. We observed that text-to-speech libraries in android transform text to speech in predefined language, lacking the flexibility of multi-language support. POI's names and tips are written in several languages, so the language detection ensures the accurate and native speaking of information.

Finally, a testing interface was designed as depicted in **Error! Reference source not found.**. The buttons serve to control the application connection with the IoT sensor and for battery saving. TextViews were implemented to inspect app operation, control and evaluation. It is clarified that the service automatically initiates when we open the EASI application, it works while the screen is off, enabling users to bring the mobile device to their pocket or bag. All the above interface elements (Buttons, TextViews) could be absent without affecting the running of the application.

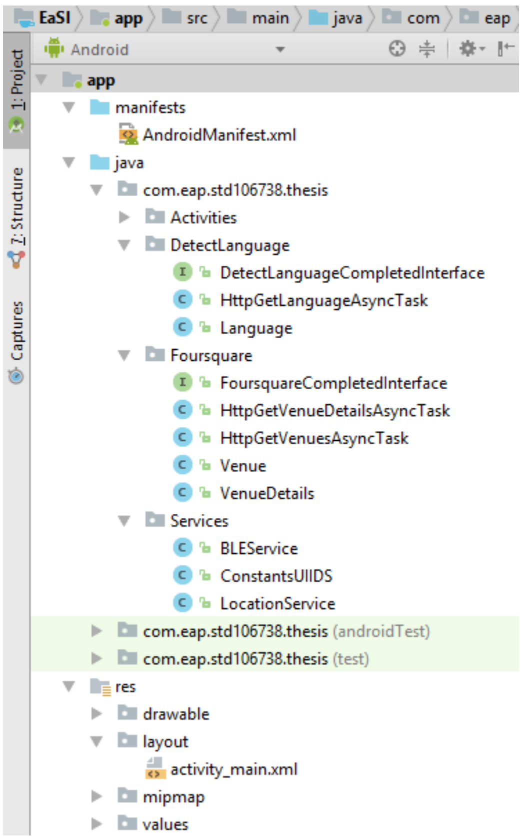

Image 4. EaSI application structure

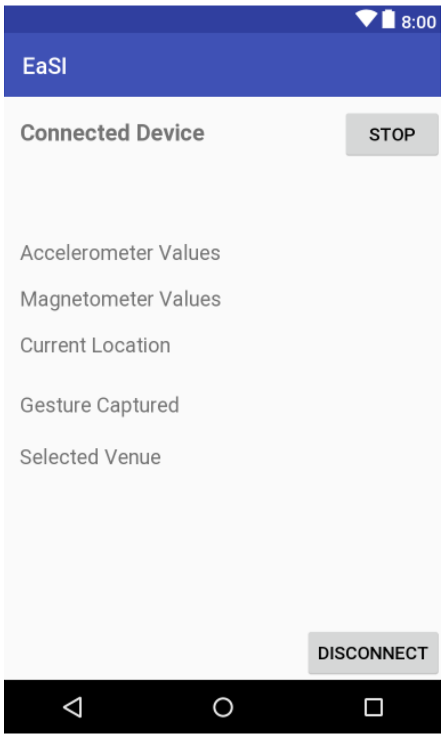

Image 5. EaSI application layout

EaSI Evaluation

EaSI evaluation examines whether the developed system can reduce user time and effort to interact with the application in POIs exploration by offering a more user-friendly and entertaining mode of interaction than the traditional systems that based in visual interfaces. In relevant research studies of new interfaces for POI discovery, which are implemented with new technologies such as Virtual and Augmented Reality Maps (Giannopoulos et al., 2017; Kamilakis et al., 2016; Lee et al., 2012) the evaluation was held via an experiment in which the novel interface is compared with a conventional one, regarding time of handling the experimental tasks as well as user interaction actions. Similar comparative evaluation methodology is also adopted in our research to compare EaSI application with Foursquare application.

Additionally, is attempted to examine the usability and user experience of using EASI application through the User Experience Questionnaire (UEQ) and the Nasa-TLX tasks. The experimental procedure consists of two tasks. In first task users have to identify the indicated POI “Idees art Cafe” from a location point that isn’t visible its name, using both applications EaSI and Foursquare. POI’s name is the requested and metrics are the successful identification, the execution time, the number of gestures that made in EaSI and the number of actions in digital map of Foursquare. In the second task, users using both applications are asked to identify the indicated POI “Sokaki Restaurant” and answer questions associate with information retrieval like the price category, rating and one user tip. Metrics are the number of questions that answered correctly at first attempt and if not, the navigating actions in both apps for seeking of answers. Ten users participated in the experiment. A significant amount of time was given to be familiarized with the two apps after an extended demonstration. All users' actions in both interfaces were recorded with a screen recording application and analyzed after the end of the procedure for the results retrieval.

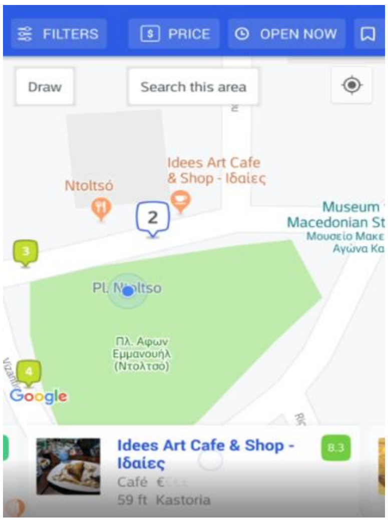

Image 1. Locate POI “Idees art Cafe” in Foursquare interface

Image 2. Identify POI “Sokaki Restaurant” with EaSI app

In 1st task all the users successfully identified POI "Idees art Cafe" using both apps. The mean time needed for POI identification was in EaSI application 21.9 sec and in in Foursquare application 32.1 sec (Figure 1). Confidence level is calculated for all the graphs at 95%. Comparing the mean identification times, using the T-test method and Alpha level: 0.05, significant difference between the two distributions is observed.

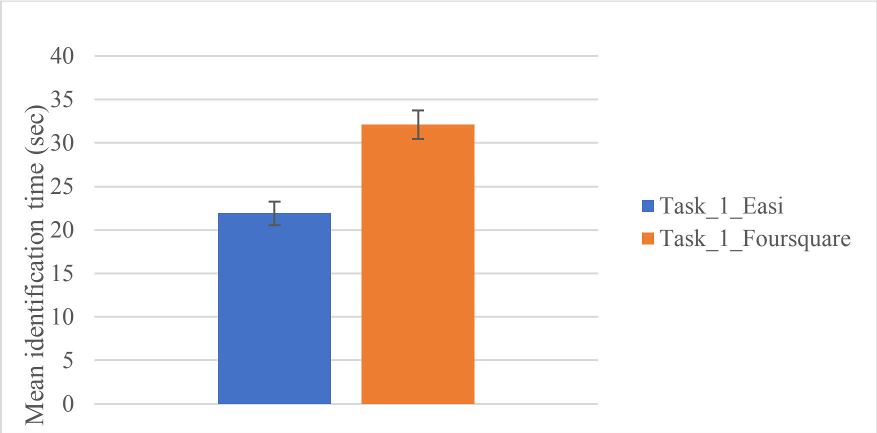

Figure 1. Mean identification time of POI "Idees art Cafe".

Using EaSI in first task, users had to make the trigger gesture to start the identification process (4 head movements) and after listened the name of POI make the stop gesture (2 head movements) to stop the reproduction of the remaining message. All users successfully accomplished the trigger gesture and 3 out of 10 didn't execute the stop gesture at the 1st attempt but did it in 2nd.

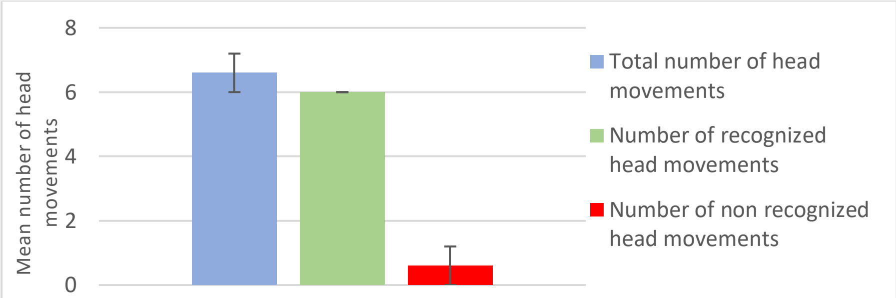

Figure 2. Mean number of head movements in POI "Idees art Cafe" identification using EaSI app.

Users' actions in the identification process in the Foursquare application map interface in Task_1 are depicted in the figure below.

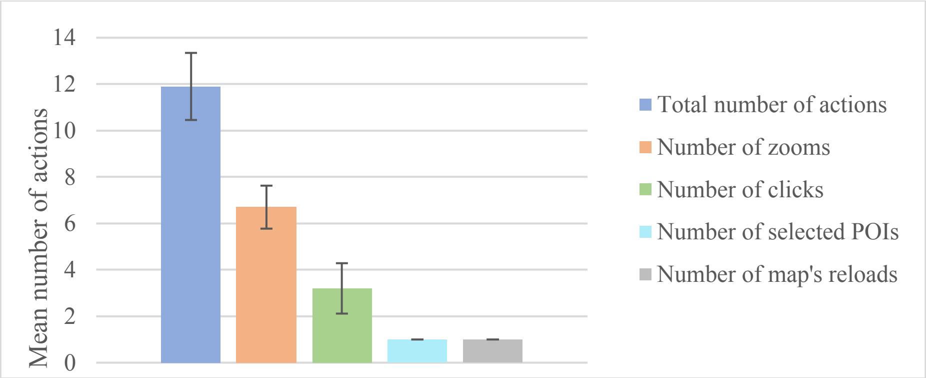

Figure 3. Mean number of actions in POI "Idees art Cafe" identification using Foursquare app

By trying a correlation between the gestures with the actions made on the map, aiming at comparing the two mean values, as a comparison of the burden to identify points of interest using the two applications, is deduced that there is a significant difference between the two. The result was obtained by the Ttest method and alpha level:0.05, for the distribution of the number of gestures, with mean value 6.6 and for the distribution of number of overall actions on the map, with mean value 11.9.

In the 2nd task all users answered directly and correctly to 3 questions using the EASI app. Using the Foursquare app 8 out of 10 users answered directly and correctly to 3 questions, 2 users answered directly and correctly to 2 questions, while in one they did not answer at all and came back to the interface of Foursquare sought for the answer. From analysis of these statistics there is no significant difference in information retrieval using the two applications.

In Figure 4 is depicted the score of the EaSI evaluation using the UEQ method. The range of the scales is between -3 (horribly bad) and +3 (extremely good). The scales of the UEQ grouped into pragmatic quality (perspicuity, efficiency, dependability) and hedonic quality (stimulation, originality) as depicted in Figure 5. Users evaluated with mean value, greater than 2, all the scales of measuring the user experience. This grade expresses the positive views of users to identify and obtain information on points of interest using the EASI application.

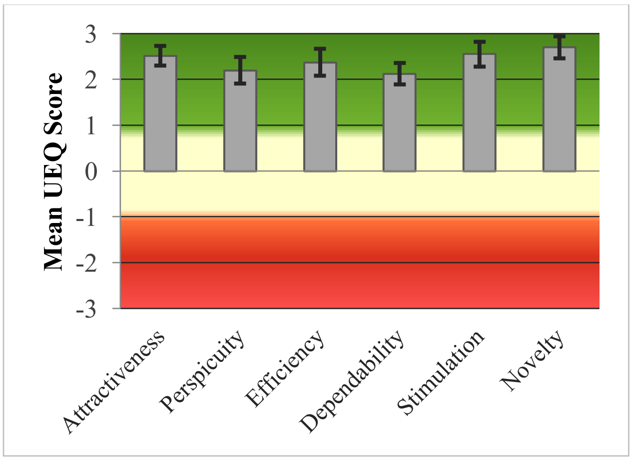

Figure 4. Evaluation of the EASI application to identify and obtain information of interest points

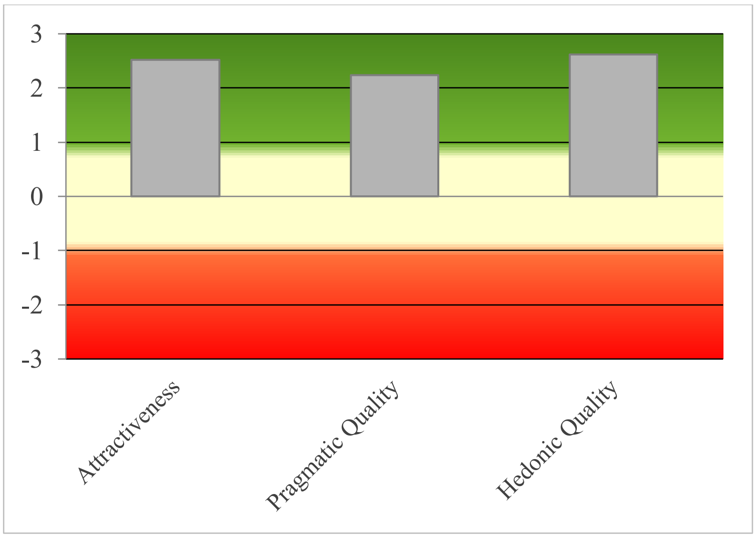

Figure 5. Pragmatic and Hedonic Quality scale of the EaSI app evaluation

By checking consistency, according to Cronbach's Alpha-Coefficient, for scales attractiveness, perspicuity, efficiency, stimulation and novelty the coefficient was calculated above 0.7, exposing the adequacy of consistency (Table 1). For the dependability the index was less than 0.7. Due to the small number of participants <50, no negative conclusion can be drawn for the consequence of that scale.

Table 1. Cronbach's Alpha-Coefficient for EaSI app in 2nd task

UEQ Scales	Cronbachs Alpha-Coefficient	> 0.7
Attractiveness	0.76	Yes
Perspicuity	0.81	Yes
Efficiency	0.82	Yes
Dependability	0.46	
Stimulation	0.82	Yes
Novelty	0.81	Yes

At the end of the experiment, several users expressed their enthusiasm for the functionality and innovation of the EaSI application, noting that the search time is significantly shorter. Two users were impressed with how smoothly the gestures controls are captured. Three users expressed that they prefer the intake of information in an audible manner, rather than the visual way.

On the contrary, one user expressed that he feels more familiar and prefers visual intake of information. Finally, one said that has cervical syndrome, had difficulty with the execution of vertical movements of the gestures (Trigger Gesture, Pause/Play, Stop) and failed to execute the stop gesture at first attempt at Task_1.

Conclusion and Future Work

Our prototype developed aiming to enhance visitor experience in situ seeking of information. The gestural interaction and the auditory feedback, vital elements of our system, eliminate entirely the need for visual interaction. Additionally, we offer real time updated information, multi-language support and gestural control of spoken information.

User time and effort in POIs exploration reduced significantly, comparatively with a conventional app such as Foursquare, as was deduced from the evaluation procedure. Specifically, the mean identification time of the requested POI is calculated using EaSI application at 21.9 sec and using Foursquare at 32.1 sec. Also, the mean number of actions needed for POI discovery were 6.6 gestures using EaSI service and 11.9 overall actions in digital map using Foursquare.

EaSI service gained high praise and total acceptance as advocated from the user experience questionnaires. The attractiveness, realistic quality and hedonistic quality of the EaSI service use were evaluated with mean value, greater than 2 in a scale from -3 (horribly bad) to +3 (extremely good).

Our future vision is the evolution of EaSI by enhancing the robustness, and the quality of service through error correction of the monitoring values. Specifically, using a filter Kalman for enhance user location accuracy and a correlation algorithm of magnetometer values with these of gyroscope for magnetic interference mitigation in calculation of user orientation.

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