






Smart Tourism Routes Based on Real Time Data and Evolutionary Algorithms

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Abstract. Tourism is an industry that has been growing rapidly in the last few years and it is expected that it will continue to grow. Due to the evolution of technology, mobile applications are being increasingly used in all kinds of industries, being one of them tourism. Presently there are already a few mobile applications used to increase the experience of the user when visiting a place, but these mobile applications lack some important features. This paper describes the development of a mobile application with integrated routing algorithms used to increase the experience of the tourists when visiting the city of Avila, Spain. The tourist will have at their disposal real time information about all the monuments available for visit, a full set of predefined circuits with different visit times and degrees of difficulty and also the possibility to create an optimized or personalized circuit combining the user preferences such as visiting time and number of monuments to visit.

Keywords: Tourism · Mobile applications · Routing algorithm
Real time data · Optimized route

1 Introduction

Tourism is one of the branches that has been growing more rapidly both in the number of tourists and in terms of tourist infrastructure. This growth has created the need for greater investment by cities not only in the restoration and preservation of monuments but also in the creation and improvement of support infrastructures for tourists [1].

In Europe, tourist activity is a source of considerable economic income that has been increasing in recent years. In Portugal, in 2016, there was a 1.4% increase in GDP (Gross Domestic Product) as shown in [2]. It also represents one of the largest sources of employment in major European cities. In [3] it is shown that in Spain between 2014 and 2015 there was an increase of around 13% in the number of jobs linked to tourism.

With the increase in the number of tourists and infrastructures, it is difficult for tourists to decide which tourist spots to visit and to collect information on these points due to the wide variety of sources. On the other hand, the available information about the main tourist attractions is not real-time information often finding itself outdated.

Not only tourists, but also municipalities have logistical problems in infrastructure control such as the number of daily visitors, occupancy rate and waiting times, among other factors, where real-time information is currently non-existent. Another problem encountered by the municipalities is the high number of possible platforms for sharing information about tourist attractions, making it increasingly difficult to concentrate the information in a single place accessible to all tourists [4].

In view of the panorama described previously, this work intends to develop a mobile application for tourists in order to improve their experience. The mobile application developed in the framework of SHCity project will have as a pilot area the historic city of Avila, Spain, due to its geometry and distribution of the main historical points that helps the development and testing of this application.

The remain of the manuscript is organized as follows. Section 2 introduces the evolution through the years of tourist mobile applications as well as some of the existing tourist mobile applications used on the experience phase. In Sect. 3 it is presented the architecture, the main features of SHCity mobile application and the architecture of the optimization algorithm used. Section 4, the highlight goes to the development of SHCity mobile application and its optimization algorithm. Section 5 contains the results of the developed applications with some examples of its functionalities. Finally, conclusions are offered in Sect. 6.

2 Tourist Mobile Applications

This section introduces the evolution of mobile applications, more specifically applications related with tourist activity. It also explains the different stages experienced by tourists when travelling. After this explanation a review of the existing mobile apps used to improve the tourist experience when visiting a location is offered.

2.1 Evolution of Tourist Mobile Applications

The development and use of mobile applications have been growing over the last few years. Since the first App Store appeared in July 2008, mobile applications are increasingly being used in various industries and activities as reported in [5].

According to [6], approximately 3.9% of the total number of active applications in the Apple App Store in 2017 are tourism-related applications, making tourism the seventh most popular category.

These applications can be divided into five stages of travel experienced by the tourist as represented in Fig. 1, going from the choice of destination to the sharing of experience.

The experience phase, which is fundamental for the tourist, aims to provide information about the public transport network, the main points of interest and static

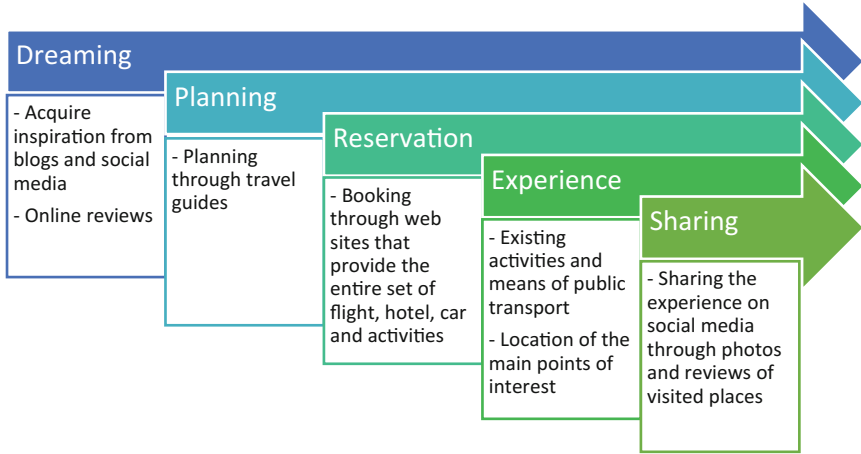


Fig. 1. Five stages of travel experienced by tourists. Adapted from [7].

information about these places. Some of these applications also have GPS directions to guide the tourist and use the application as a platform for interaction between different users.

2.2 FindNatal

FindNatal is a mobile application available for IOS and Android created in 2014 that aims to enrich the experience of tourists when visiting the city of Natal, Brazil. It was created to work independently and offline, presenting in its current version the following functionalities as described in [8]:

- English and Portuguese as available languages;
- Displays for each attraction photos, description, location, email, web page and opening and closing times;
- Shows from the current location of the user, which route must be followed to reach the selected destination;
- Sends an alert when the user is 500 m from a tourist point;
- Allows the user to evaluate both the points of interest visited and the city. This assessment can be made at the level of public cleanliness, safety, accessibility and tourist services.

This application is used not only to assist the tourist in finding the main points of interest, but it also shows the main bars, restaurants and hotels of the city.

2.3 SMARTAPPCITY

This is the first mobile application available in Spain that brings all the services of the city together on a single platform. Through a partnership with the municipalities or private entities, the data is provided by the entities and inserted into a database and

subsequently made available to the users of the application. It has, as presented in [9] a great amount of services such as tourism, traffic information and public transport among others. The service dedicated to tourism allows the user to view in a list or on a map which are the main tourist attractions. All these attractions have information such as the description, photos and directions.

2.4 Places and Trails

Mobile application designed to motivate and increase touristic exploration across the UK. Two options are available. The first being designated Places, where the main historical points are presented in list form or on a map. These locations can be manually selected from the list or a notification can be sent when the user is near one of these points. In [10] it is said that each point has information such as pictures, description, audio and video file. The second option is Trails, where, in list form, the available trails are shown, and users can also add their own trails, making them available for other users to enjoy. When offline, the application has illustrative maps to guide the tourist along the trails.

2.5 Edinburgh – World Heritage City App

Edinburgh WHCT mobile application has four pre-defined circuits with audio guide, where the user can choose the circuit from a list containing the four pre-defined circuits. In [11] it is explained that each of the circuits has a brief description and some photos of the places that the user can visit. The user can also add comments and photos of the visited places. The user is also able to send a postcard to other users, promoting interaction between the users of the application. It also has an interactive game with a set of objectives, where the user that can achieve more goals and visit more places has the highest score, which is stored in a table along with the scores of the other participants [12].

2.6 Norwich: Heritage City

Mobile application developed to share with the users the history of the buildings of Norwich, England. It has as presented in [13] a list and a map with the historical monuments available to visit, each with a brief description and photos, sending a notification when the user is near one of these monuments. It also contains a description of the city of Norwich with some historical facts about the city and an online notebook where the user places badges won from visiting the city historical buildings, thus motivating the user to explore and visit the city.

2.7 Comparison

Table 1 shows the comparison between the existing mobile applications briefly explained in the subchapters above, and SHCity mobile application presented in this work.

Table 1. Comparison between the different mobile applications.

	FindNatal	SMARTAPPCITY	Places and trails	Edinburgh-WHCT	Norwich: Heritage City	SHCity
Real time information about each attraction	✗	✓	✗	✗	✗	✓
List of tourist attractions	✓	✓	✓	✗	✓	✓
Custom circuits	✗	✗	✗	✗	✗	✓
Audio guides	✗	✗	✓	✓	✗	✓
Directions	✓	✗	✗	✗	✓	✓
Pre-defined circuits	✗	✗	✓	✓	✓	✓
Information about each attraction	✓	✓	✓	✗	✓	✓
Evaluation of each attraction	✓	✗	✗	✗	✓	✗

When analyzing Table 1, it is verified that there are already some applications to support the tourist experience, some with more functionalities than others. Of all the mobile applications analyzed only SHCity has custom circuits, that means, none of the other applications allows the user to select monuments to include in a circuit. As for real-time information, apart from SHCity, only one other application has this functionality, providing real-time meteorological and traffic information to its users.

As for the SHCity mobile application, it can be concluded that in comparison with the others it is the most complete in terms of functionalities. It stands out in relation to the other ones by the use of real-time information such as occupation, waiting time, temperature and time of visit, information that will be provided to the mobile application by a set of sensors existing in all the main points of interest of the city.

3 SHCity Mobile Application Architecture

With the ambition to improve the tourist experience when visiting the city of Avila, Spain, a mobile application was developed. This application intends to give the user in a simple and intuitive way different functionalities represented in Fig. 2, that will improve his visit to the city. It also has four different languages available such as Spanish, Portuguese, French and English.

The architecture of the mobile application is divided into four main functionalities, being them:

- **Monuments/Places List** - A list of all the monuments available for visit is shown, along with the accessibility information of each monument. These monuments can also be represented in a location map, where in both cases the user can choose one

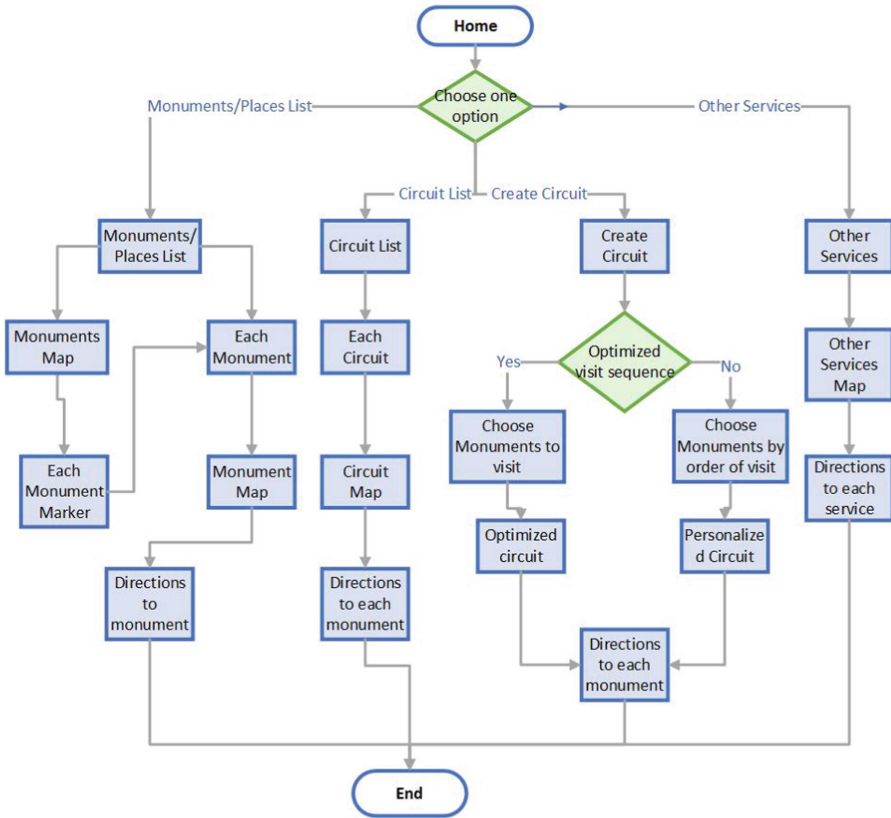


Fig. 2. SHCity mobile application flowchart

of the monuments available. When a monument is chosen, photos, a brief historical explanation and real time information is shown. The user then has the option to get directions from his current location to the chosen monument.

- **Circuit List** - A list of predefined circuits with different durations and degree of difficulty is shown, these circuits were developed by the municipality of Avila along with the cities tourism officials. When one of these circuits is chosen, photos and information about the circuit is shown, the user can then choose to see the circuit in a location map and start the visit.
- **Create Circuit** - In this option the user has the possibility to create his own circuit. The user can choose between an optimized or a personalized circuit. In the first case after picking out witch monuments to visit, an optimized circuit using a routing algorithm is created, saving the user the most amount of time possible. In the personalized circuit option, the user selects the monuments by order of visit, obtaining in the end a circuit with the chosen order. In both cases, the total duration and distance is shown and when the circuit is started the mobile application shows directions to each monument.

- **Other Services** - Here the user can see the location on a map of the main pharmacies, hospitals and green areas located near the monuments available for visit. Directions to the service location are also available.

The optimized circuit explained above, is based on a routing algorithm developed with the objective of saving the most amount of time possible when visiting the city. As represented in Fig. 3, this algorithm receives user information such as the time available for the visit and real time information about the monuments that the user has chosen, such as visiting time, waiting time and the walking duration between monuments.

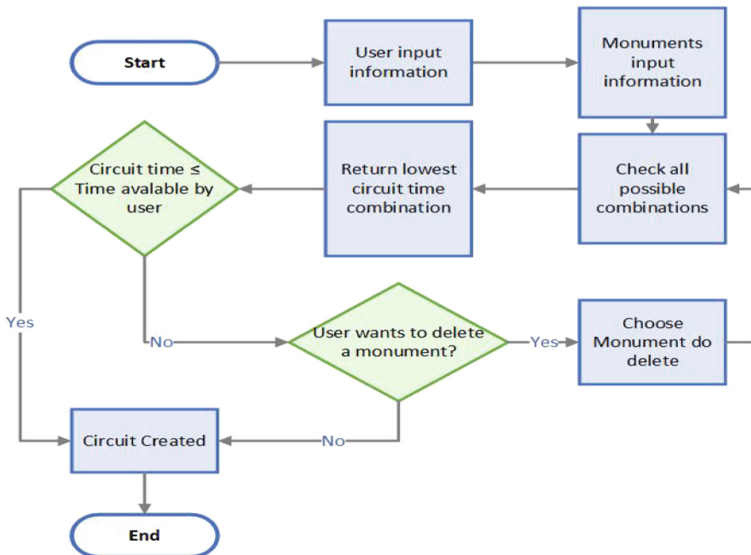


Fig. 3. Routing algorithm flowchart

Using evolutionary algorithms with the user input information and the monuments information, the algorithm checks all possible combinations and returns the combination with the lowest time. It then verifies if this time is lower than the time provided by the user. If it is, the optimized circuit is created, if not the user is provided with the option of deleting a monument. If he doesn't want to delete a monument a circuit is created with the original monuments. If the user wants to delete a monument, the algorithm starts again but without the deleted monument, therefore obtaining a lower circuit time.

3.1 Evolutionary Algorithms

The evolutionary algorithm tries to find the best solution between the available possible solutions for a certain problem. These algorithms are presented as methods that use

basic principles of evolutionary theory and genetics, based mainly on the survival paradigm of the fittest [14].

In our case we need an algorithm that given some initial parameters is able to give in a short period a solution that is considered satisfactory. To obtain these results we used genetic algorithms, this is a robust algorithm that regardless of the initial parameters, satisfactory solutions are always given. Using recombination operators, a network of solutions is created, then the best solution is given. The advantage of this evolutionary algorithm in comparison with others is that it does a less exhaustive search, saving a lot of time and at the same time giving a solution that is viable.

4 Implementation

With the increase in the number of mobile applications, several new platforms for mobile application development were created. After some research, two stood out from the many that currently exist, Android Studio and Outsystems. Both are well known and exist for quite a long time.

Outsystems was the platform used to develop SHCity mobile application because of its simplicity, capabilities and support. It also has online courses that help beginners grow and get more comfortable with the platform which was really helpful and motivating. The platform works with blocks and all of the styles were created using CSS. It also allows communication with REST API's, which was in this case very helpful, not only to get the real time information of the monuments but also to connect with Google Maps API, which are the maps used in SHCity. These maps restrict the use of some functionalities such as the avoidance of stairs, narrow streets or elevated areas. The algorithm was also developed in the Outsystems platform. The development of the algorithm was made with blocks of conditions, which made it difficult to include some of the specifications that were set in the beginning of the project.

5 Application Results

With SHCity mobile application we are able to increase the experience of the tourist when visiting the city of Avila, Spain. As represented in Fig. 4, the user is able to get real time information and directions about all the monuments in the monuments/places list option. The user is also given the total distance and duration from the current location to the monument selected. As the user walks, a stick figure will follow the user's location so that the user can guide himself through the correct path.

When the user wants to create its own circuit two options are given, optimized or personalized circuit creation. In both cases as represented in Figs. 5 and 6 the total circuit time and duration is given and then the user will be able to get the directions in order, to each of the monuments chosen.

Analyzing Figs. 4 to 6, we can see a simple and intuitive mobile application that stands out from the ones that already exist in the area, going from the real time information provided to the user to the creation of optimized and personalized circuits which take in account this real time information.



Fig. 4. Monuments/places list option



Fig. 5. Create optimized circuit option

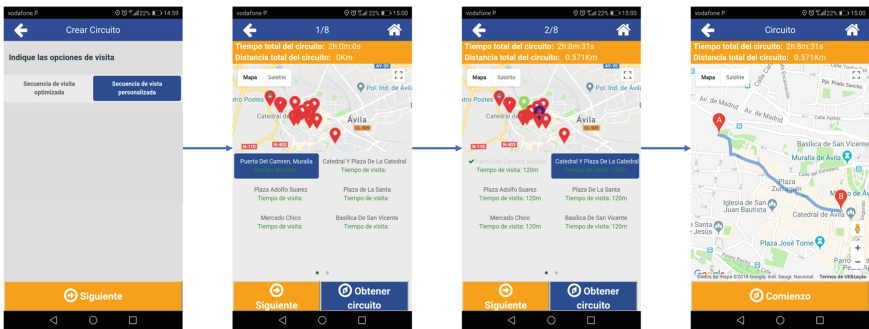


Fig. 6. Create personalized circuit option

After analyzing these results, we came to the conclusions that some improvements can be done. The most significant one is the use of a different development platform that allows the development of a stronger and more versatile algorithm. Allowing the user to save some circuits and share them with other users is also a functionality that

will improve the functionality of SHCity mobile application. Other improvements will be suggested by users during the mobile application test phase.

6 Conclusions

From the research conducted it was clear that many studies and projects were already developed addressing mobile applications for the tourism industry, in this particular case applications used to improve the user experience. The literature review has allowed to identify these mobile applications and its main features.

The work presented in this paper aims to improve the tourist experience when visiting the city of Avila, Spain. Comparing with the different mobile applications, SHCity has all the main features that were considered important to the tourists when visiting a city. In order to highlight SHCity mobile application from the others we use real time information about the occupation rate and waiting time, information that is also used to create the optimized routes, improving like no other application the tourists experience. From the results presented this application is very simple to use but with a high level of functionality and features that meet the need of the tourists.

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