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Optimization of excursion routes using the mobile application "Citymapper"

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Abstract
The COVID-19 pandemic and the strict anti-epidemic measures introduced by various countries have accelerated the transformation of tourism around the world. The industry has lost hundreds of billions of dollars and millions of jobs. At the same time, digital startups have entered the market, and new opportunities for individual tours and formats of international cooperation have appeared. Trends for modern travelers are widespread low-cost, p2p services for tourists, which exclude intermediaries from the supply chain and allow the creation of unique and personalized travel experiences. At the present stage of the tourism sector development, information technologies and software tools play an important role. Evolution and technological progress have penetrated the tourism market and the organization of excursion activities. For example, unique multimedia guides for mobile phones using GPS navigation have been developed for tourists. Historically, transport has been a fundamental component of the tourism sector and has allowed tourists to travel comfortably and quickly. Advantages and disadvantages of a trip throughout a city on a sightseeing bus are considered. In this paper, we analyze the most popular market software for mobile applications for navigating tourists during travel. Such applications are generally very popular due to a high level of modern societal mobility and the need for operational navigation, primarily in new urban spaces. The market is quite saturated with software from different manufacturers, and such high competition dictates requirements for functionality and services provided to a user; therefore, manufacturers are forced to expand additional services to increase their competitiveness. Tourists' basic requirements for mobile applications on a trip were determined by tourist canvassing. Suggestions for improving mobile applications to navigate tourists on trips are provided, and special attention has been paid to creating the most comfortable and optimized excursion methods while taking into account tourist wishes.

Introduction

Analysis of foreign and Ukrainian publications shows that, in the tourism market, consumer behavior has tended to change towards greater self-dependence and independence from tourism enterprises. The popularity of individual tourism began to rise at the end of the 20th century and early in the 21st century. The rise in popularity of individual travels has been facilitated by the development of online technologies (online booking, e-tickets, various individual travel web forums, etc.) that allow

tourists to quickly find information and buy travel components.

The reasons for the development of individual tourism include high prices for tours from tour operators, the information available on websites, and the desire for travelers to organize a trip exactly the way they want, without adapting to the package tours. A feature of individual tourism is not only that the vacation is planned at will, but also the presence of a special atmosphere of the tour. Often, guides and tour operators include only the most popular places and the most visited objects in routes (Antonenko, Khutkyi & Karpova, 2018). If one plans a trip on his/her own, one can often find the sights unknown to most travelers, making the trip unique. There are several types of individual tourism, depending on factors, motivation, and purpose of travel: sports, health, urban tourism, cultural recreation, etc. Individual travel planning allows a tourist to use the organization services in the tourism sector, while also choosing the route, type, and category of accommodation facilities in which they want to stay, organize meals, select vacation spots, and also plan other travel parameters (Vishnevskaya, 2019).

The share of independent travelers among Ukrainian Google users increased from 27% to 33% in 2019, according to a study by the Kyiv office of Google. According to the Travel & Tech Industry segment, in 2017 the share of independent travelers accounted for 23% of all inquiries of Ukrainian-speaking and Russian-speaking users, and in 2018 it rose to 27%. Then, last year, the share further increased to 33% (European Commission, 2017).

The industry for individual travel is currently booming, from airline tickets and hotel reservations to rental cars and yachts. Market players are constantly looking for new ways to attract and retain customers, and lure them with interesting offers and favorable prices (Sizintsev, 2013).

Thus, according to recent studies of Google services (European Commission) (European Commission, 2017):

- Two-thirds of respondents used the Internet to organize their vacation and holidays;
- 4 out of 10 respondents chose at least one trip or vacation where they purchased different parts of the trip (for example, flights and accommodation) separately;
- more than half (55%) of respondents considered the recommendations of friends, colleagues, or relatives as the most important source of information when designing travel plans, while slightly less than half (46%) mentioned websites.

The popularity of mobile travel applications according to the Travelport Digital survey is conditioned by the following aggregated data (PhocusWire, 2018):

- 58% use mobile applications to find flights;
- 53% use applications to find accommodation;
- 82% of travelers stated they would load the same number or even more route applications than last year;
- 35% like notifications about new products;
- 90% of tourism industry specialists will invest in a mobile application next year;
- 60% of tourism brands periodically update their applications.

The usage of mobile phones for booking tours is characterized by the following data (eMarketer, 2018):

- 82% of all travel bookings were made online through a website or mobile application in 2018;
- 48% of all smartphone users are happy to explore, book, and plan a trip to a new destination using a mobile device;
- 26% of search queries come from a mobile device;
- 69% of travelers say they enjoy using voice search when planning a trip;
- 72% of all mobile booking by travelers occurs within 48 hours;
- travel companies invest 70% of their advertising budgets in advertising on mobile devices.

Thus, we can say that tourists like to plan trips using a mobile phone since it is useful for finding the necessary information.

In recent years, there has been an increase in the usage of mobile devices (such as smartphones and tablets) to access information, products, and services before and during travel. If access to cheap high-speed internet continues to improve, this may open up additional opportunities for the use of these devices for tourism purposes.

Based on the above material, the purpose of this study was to analyze existing excursion services, identify and eliminate their shortcomings using mobile travel applications that have logistic capabilities.

Literature review

Leading scientists have investigated the role and influence of information technologies on tourism and hotel business development. The possibilities and advantages of using global systems for booking

and reserving tourism services in the context of tourism and hospitality market formation are outlined, and directions for using multimedia technologies in social and cultural services and tourism are presented.

Among the leading universities active in the field of information technology in the tourism sector are Bournemouth University (England); Lugano University (Switzerland); University of Central Sweden; Hong Kong Polytechnic University (China); University of Central Florida (USA) (Artemenko, Pasichnyk & Yegorova, 2020).

Among scientists who have raised the issues of studying information technologies and their influence on tourism development and analyzing their usage by tourists include V.V. Pasichnyk, O.I. Artemenko, I.V. Popik (Pasichnyk, Artemenko & Popyk, 2015), V.V. Egorova (Artemenko, Pasichnyk & Egorova, 2020), N.S. Morozova, M.A. Morozov (Morozova & Morozov, 2015), A.L. Chudnovsky, M.A. Zhukova, L.A. Rodigin (Morozova et al., 2014), etc.

Hącia E. (Hącia, 2016; 2019) raised the issues of difficulties in urban logistics due to the growing number of tourists, which gives rise to an increasing flow of people, goods, and information within a city. She also considered the possibilities of solving these problems, in particular using information systems.

Sierpiński G., Staniek M., Macioszek E. and Celiński I. (Sierpiński, Staniek & Celiński, 2016; Staniek, Macioszek & Sierpiński, 2017, April) proposed the use of GTPlanner, developed as part of the implementation of the international ERANET Transport III program, which is equipped with an additional function that allows the user to archive requests submitted by travelers and profile individual traveler needs in selected areas. In addition to its information function, GTPlanner also serves an educational role as it emphasizes the environmental impact of particular modes of travel, which promotes sustainable travel behavior.

Vishnevskaya K.V. (Vishnevskaya, 2019) determined that in connection with the crisis in the world and transition of the population to a lean consumption model, and a change in the purchasing patterns and dynamics of online sales for tourist services confirms this. Despite the decline in outbound tourism, which only partially includes covers for domestic tourism growth, online travel sales are growing due to the convenience of the online selection of the best price and the possibility for self-travel planning using mobile applications.

Miloradov K.A. (Miloradov, 2016) investigated the information support issues of transport and logistics services in the hospitality and travel industry and considered it at three levels: personal, corporate, and regional. The author also analyzed the functions of mobile applications and ways of using personal mobile Internet devices as communicators, navigators, guides, and considered possibilities for online travel designers. A study of the market segment for logistics services for corporate information systems of hotel enterprises was carried out, and the conclusion was that information systems of the ERP class act as a tool for implementing operational control. The possibility of computer tools for modeling traffic flows and the relevance of their application for solving problems for planning hotel infrastructure development at a regional level are shown. The author noted that the usage of automatically-controlled vehicles is a promising direction in the development of information and communication technologies for transport and logistics services in the hospitality and tourism industry.

Tourism development using GIS systems, as exemplified by the Belgorod region, was studied by such scientists as T.B. Klimova, I.V. Bogomazova, Dumacheva, Vishnevskaya (Klimova & Vishnevskaya, 2014; Vishnevskaya, Klimova & Bogomazov, 2014; Vishnevskaya et al., 2014). They suggested the development of a program for the development of recreational tourism in the Belgorod region by using geographic information technologies, which include: studying the natural monuments and other tourist facilities in the Belgorod region; designing new tourist routes using geographic information systems for tourism; the creation of audio guides with excursions to the main sightseeing sites of Belgorod city; optimization of the selection process of hiking trails; publication of informational materials on tourism related to Russian and foreign languages; organization of workshops, seminars, exhibitions, competitions, and conferences; participation in the creation and improvement of the legal framework of tourism.

The same scientists also studied the mobile application market to simplify and improve the quality of travel. It was determined that in the modern world, the usage of advanced innovative technologies also have great potential in terms of optimizing the time and variety of choices of necessary tourist products for travelers.

In the work of O.V. Ilyina and L.P. Boyar (Ilyina & Boiar, 2018) the experience of mobile application implementation, in particular audio guides by leading tourist centers in Ukraine, was analyzed and the implementation prospects of this technology using

the example of the city Lutsk have been estimated. Theoretical and practical recommendations for the development of the authors' mobile application and its importance for increasing the attractiveness of the territory to tourists was described.

Ribeiro F.R., Silva A., Barbosa F., Silva A. P. and Metrôlho J. C. (Ribeiro et al., 2018) provided an overview of mobile applications that can be used to support people with disabilities in their travel activities. In this review, the authors examined key issues and some of the available alternatives and identified their positive aspects. The authors provided some preliminary recommendations for a collaborative and personalized support system for travel and tourism activities for people with disabilities.

Hrabar M., Kashka M. (Hrabar & Kashka, 2019) studied the market of mobile applications designed to improve the quality and speed of travel planning. So, the authors defined three groups of the most popular tourism applications throughout the world, depending on the source of downloads: Overall Downloads; App Store; Google Play. In two groups, namely Overall and Google Play, Uber took first place in terms of downloads. On the App Store, the most downloaded application was Google Maps. Three leaders in all subgroups included Waze and Where is My Train. Thus, the most popular tourism applications in the world (according to their functional purpose and number of downloads) are related to car searches, booking hotels and tickets, food searches, and navigation systems.

Research by D. Dickinson and V. Filimonau substantiated the usage of mobile technology to increase travel through a mechanism to motivate mobile application users to form temporal-spatial connections (Dickinson et al., 2018: 397).

The usage of information technology to create optimal excursion routes was the subject of works of Z. Xiang and B. Pan (Xiang & Pan, 2011), whose goal was to identify patterns in online travel queries across tourist destinations. Utilizing transaction log files from several search engines, the analysis showed important patterns in the way travel queries are constructed, as well as the commonalities and differences in travel queries about different cities in the United States. The ratio of travel queries among all queries about a specific city seems to be associated with the "touristic" level of that city. Also, keywords in travelers' queries reflect their knowledge about the city and its competitors. The authors offer insights into the way tourism destinations are searched online as well as implications for search engine marketing for destinations.

Also, these authors (Pan et al., 2011) studied the issue of search engine marketing (SEM). Because of dynamic relationships among travelers as information searchers, search engines, and an online tourism domain, the authors argued that a new dynamic model must be developed that captures these relationships to better inform SEM practices. The goals of their paper were to synthesize research related to SEM in tourism and related fields and to present a model that describes evolving dynamics in search engine marketing. The implications of the model for tourism marketing and research were discussed.

The optimization of excursion routes was addressed by A.V. Balandina, O.A. Zamaraeva, and E.I. Sagizov (Balandina, Zamaraeva & Sagizova, 2015). Their work described Bus Turistic tourist routes operating in large European cities – Barcelona (Catalonia, Spain), Paris (France), and Moscow (Russia). They considered the advantages of traveling around the city on a sightseeing bus and also compared route durations, the richness of the excursion program, and ticket prices.

Methods of research

The following general and specific research methods were used in the research process:

- systematic analysis and logical generalization to systematize data about the development of modern tourism and existing electronic applications for travelers;
- survey method, namely questioning (in the process of collecting data on the shortcomings of the City Sightseeing service)
- graphical method for visually representing the processed analytical data;
- methods of multicriteria optimization (when forming scientific and applied approaches to optimizing the functioning of mobile applications).

Research and data analysis

Mobile applications have taken individual travel to a new level: all the options of a small travel agency can now easily fit in your pocket. GPS and maps, a currency calculator, and a city guide, a dictionary, and convenient hotel search – a competent set of applications helps a user plan trips and save time and money.

Based on our research and research conducted by Skyscanner (Zakharova, 2019), which tested more than a hundred apps for smartphones, the most

Table 1. The most useful and convenient mobile travel apps

Sections	Applications	Sections	Applications
Fees	PackPoint	**Budget**	XE Currency Converter – currency converter; Expensify – vacation budget; Budgy – shared expenses.
Flights	Skyscanner; Flightradar24 – aircraft tracking, flight data collection; SkyGuru – fighting aerophobia.	**Culture and communication**	Google Art & Culture – culture guide; Yuggler – entertainment for children; izi.TRAVEL – audio guide; TravelMe – audio guide.
Moving by car, bus, train	Rome2Rio – the route planner; RailPlanner – trains in Europe; Uber – cheap taxi; Google Maps – taxi price comparison; Zipcar – car sharing; park4night – camping places	**Language**	Google Translate – translator; Duolingo – language training.
Cycling	Mobike – city bike rental; Strava – tracker for cycling and running.	**Food**	Foursquare – restaurant search; HappyCow – vegetarian and vegan restaurants; Vivino – wine selection.
Non-standard housing	Couchsurfing – hospitality network; TrustedHousesitters – home care.	**Communication and shopping**	WiFi Map – passwords of public Wi-Fi points; Apple Pay and Google Pay – contactless payments; AVO – cheap calls in roaming.
Maps and routes	MAPS.ME – offline maps; OruxMaps – offline maps for hiking; Citymapper – public transport.	**Comfort and safety**	Relax Melodies – sounds for sleeping; D Minder – safe time in the sun; Life360 Family Locator – family direction finder.

useful and convenient travel apps were selected. The applications were divided into sections: fees, flights, moving by car, bus, train, cycling, non-standard housing, maps and routes, budget, culture, and communication, language, food, communication and shopping, and comfort and safety (Table 1).

Today, the world is developing a range of services aimed at ensuring the comfort of tourists who independently organize their holidays abroad. Options for individual planning and organization of excursions are expanding. In particular, City Sightseeing offers sightseeing tours in 100 cities in 32 countries around the world (City Sightseeing, 2020).

In each serviced city, buses travel around main attractions, which are described in synchronous audio recordings in one of several languages using disposable headphones that tourists leave for themselves. Having bought a ticket, tourists can get off and on the bus unlimitedly (that is, the "hop-on-hop-off" – "entered-out" system) at special stops along the ring route. In large cities, bus networks have several overlapping routes, some of which go beyond it to visit important attractions in the suburbs.

Table 2. Comparative characteristics of City Sightseeing excursion routes

Indicator	Barcelona (Spain)	Paris (France)
Number of routes	3	4
Number of stops	44	50
Frequency of travel, min (depending on the season)	5–25	10–30
Discount availability	+	+
Ticket price, €:		
Child	16	15
Adult	27	29

The well-known routes of the City Sightseeing network in major European cities – Barcelona (Catalonia, Spain) (City Sightseeing Barcelona, 2020), Paris (France) (City Sightseeing Paris, 2020) are shown in Table 2.

According to the results of a comparative assessment of well-known and popular excursion routes in major European cities, the following advantages of traveling in a new city can be distinguished using City Sightseeing routes:

- you can start the tour and interrupt the route at any time because the ticket is valid for 1, 2, or 3 days;
- the vehicle comes to a stop in fixed intervals, usually not exceeding 10–20 minutes, and stops at the main attractions of a city;
- comfortable review and simplicity of information;
- time-saving;
- the presence of an individual multilingual audio system;
- providing discounts for getting acquainted with other city sights (cost of entrance tickets, cumulative discounts, etc.).

This service is very convenient for individual travelers because there is no need to develop routes to get to the main attractions. If the traveler does

not know about a particular attraction, it is already included in the route, so they will not miss it. There is also an option to save money and time when sightseeing in a new city.

However, City Sightseeing services have some drawbacks. We investigated City Sightseeing users (150 people were surveyed, 50 people were clients of Kharkiv travel companies, 50 people were UIA customers and 50 people were questionnaires using Google survey forms (Google, 2020)), and the following most significant shortcomings were highlighted (Figure 1):

1. Poor audio guide quality (18 people, 12%).

The disadvantages of the audio guide are that it is not always possible to find the language necessary for the tourist. For example, in many cities, there is no Russian language, and everywhere except Ukraine (Kiev) – Ukrainian. In addition, the recording quality is not always high, and taking into account street noise, the story of the audio guide is not always clearly audible. Another drawback noted in the reviews is that the story of the audio guide often lags behind the passing objects, so the whole effect of the story is reduced to zero.

2. Low comfort of movement (15 people, 10%).

Double-decker buses, the second floor of which is open, are used to provide services. Tourists who want to take beautiful photos prefer to be located on the second floor; however, at the peak of the season, these places can be occupied, which reduces the comfort of the trip on both the first and second floors. In bad weather, a trip on such a bus is also not very attractive, since rain and wind do not facilitate placement on the second floor, and space may be limited on the first floor.

3. Short validity of tickets during the day (27 people, 18%).

In many cities (Italy, Spain, etc.) the first bus leaves at 9:30, and the last at 16:50. Compared with public transport (buying a single ticket for the whole day), City Sightseeing service loses significantly, as objects of tourist attraction begin to work earlier (many from 9:00) and usually end around 20:00. After 17:00, the City Sightseeing ticket is no longer valid, and tourists will need to purchase a ticket for city transport or forego sightseeing after 17:00. The exception is the City Sightseeing service in New York (USA), which operates 24 hours per day.

4. Lack of logistics component (53 people, 35.3%).

A user of the City Sightseeing service is given a map with the sights marked on it and headphones for connecting an audio guide; however, tourists do not have the option to determine how much time they need to spend on inspecting a particular object to return to the bus stop and take the next bus without waiting. It is also not possible to determine how much time it will take for tourists to explore several objects or use several route lines with a transfer between them without waiting.

5. The price-quality ratio is not satisfactory (37 people, 24.7%).

The above disadvantages were transformed into a single minus – the ratio of price-to-quality of the services provided. It should be noted that the minimum ticket price for an adult user of the City Sightseeing service is 18 euros in Kyiv, Ukraine (City Sightseeing Kyiv, 2020) and 19.8 euros in Prague, Czech Republic (City Sightseeing Prague, 2020). It is much more expensive than buying a single ticket for the whole day in Prague (4.40 euro ticket for public transport for 24 hours (Shvarts, 2020)).

Thus, the main disadvantages are:

- high price – the use of public transport is 2–4 times cheaper;

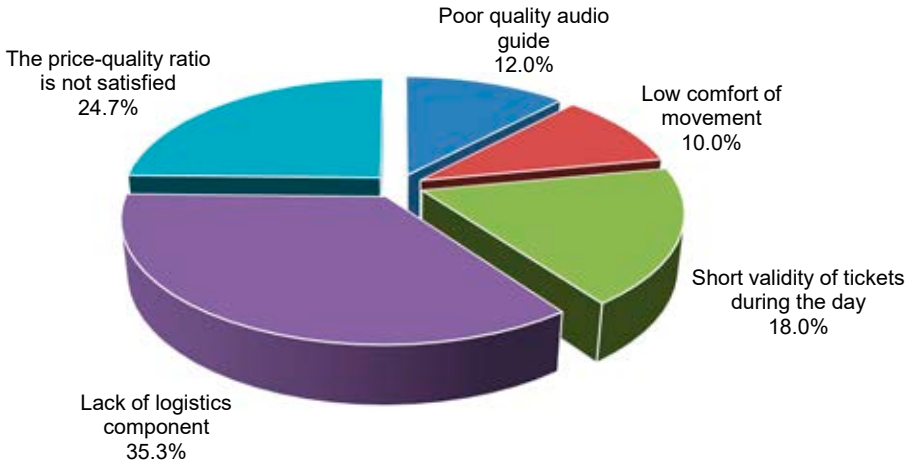

Figure 1. Structural indicator of City Sightseeing deficiencies

- a large flow of tourists in the "high" tourist season, which causes full buses;
- excursion services are developed only in large cities;
- lack of a logistic component, which does not allow planning a trip depending on the amount of free time, cultural preferences, and other factors.

Proposition

Taking into account the advantages and disadvantages of excursion services such as City Sightseeing, the authors propose the following optimizations:

1. Depending on the objects of the visit (indicating the time for each object);
2. Depending on the length of stay in the city (5 hours, 10 hours, 2 days, but no more, since tickets are usually valid for 1–2 days, two less often);
3. Depending on the number of selected lines on which the route will be laid during the day (1 or 2 lines; maybe 3 – but this is an exception because the third is usually paid separately and is not included in the main ticket).

Since the City Sightseeing excursion service is an offline service, the authors propose to develop a mobile application for individual tourists that allows them to optimize their tourist route as much as possible regarding their wishes. There are many applications for travelers, and each country and even city has developed its own applications for tracking city transport. The most popular 10 apps for Android in the world are Cabify, Citymapper, Curb, EasyWay, Lyft, Moovit, OneBusAway, Transit, Uber, and local transit apps (Hindy, 2020). The authors propose improving the popular smartphone application Citymapper (Citymapper, 2020).

Citymapper is an application for composing city routes taking into account public transport – metro, buses, trams, aeroexpress, and trains, as well as on foot, by taxi, and bike rental. It operates in 30 cities around the world. This application builds routes according to the specified parameters and shows the most convenient and shortest routes, which can be built depending on whether a tourist is walking, riding a bicycle, taking a taxi, or public transport, along with the cost of travel (Figure 2).

The application also includes the option for buying a single ticket for all types of transport (although this service is currently only available in London, it is planned to be introduced in all available cities).

According to studies, this application is one of the most popular among tourists, which is why we propose expanding its capabilities and making it even more convenient for travelers. This application will both improve the operation of the investigated City Sightseeing service and make the travel of individual tourists more comfortable, who build their routes on their own using specialized tourist mobile applications.

The authors suggest adding filters to build sightseeing routes that include attractions. This will allow independently traveling tourists to organize excursion routes without using excursion services or a bureau. This will significantly reduce the cost of the excursion and enable tourists to independently choose the attractions that are interesting to them

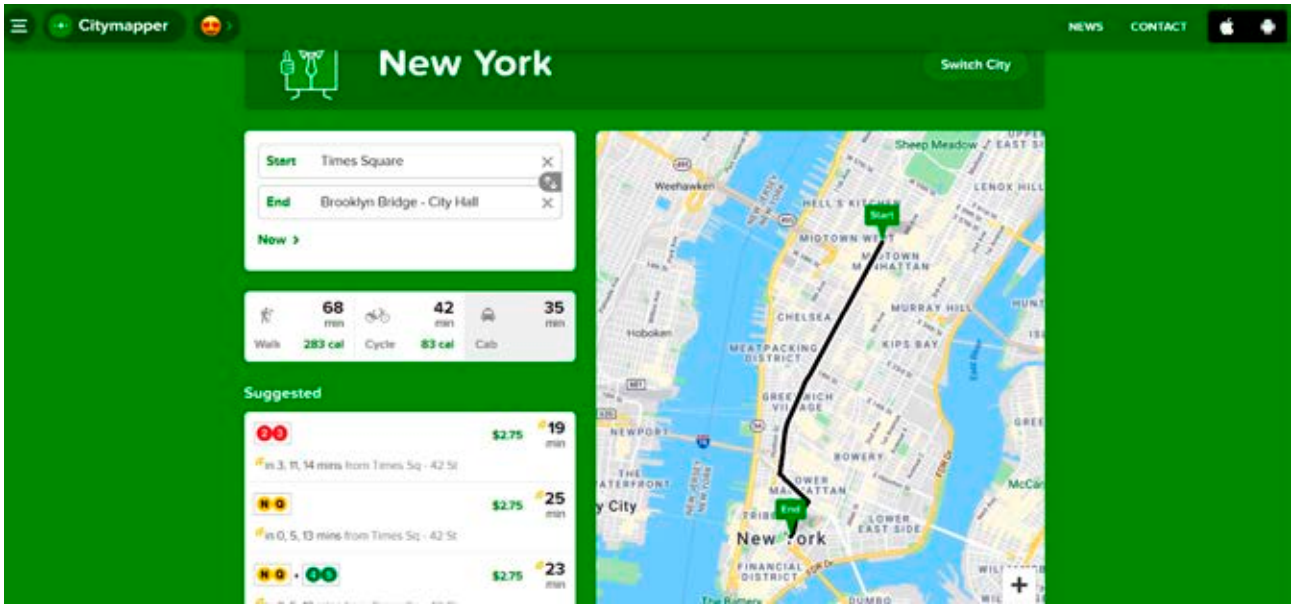

Figure 2. Interface of the mobile app Citymapper

and the time of their visit. With the help of the audio guides izi.TRAVEL (izi.TRAVEL, 2020) and TravelMe (TravelMe, 2020), tourists can find more detailed information about the selected excursion objects.

There are four ways to build excursion routes:

- by the amount of free time of a tourist;
- by the number and type of attractions;
- for specific attractions;
- by the amount of free time and attractions.

By the amount of free time tourist. The user enters their location and the amount of time that they are willing to spend on the tour. The application gives them the nearest attractions and the amount of time that they must spend to get to them. Having chosen attractions of interest, the tourist will get the most optimal excursion route, taking into account the time for sightseeing (for example, architectural monuments – 30 minutes; museums – 1 hour).

By the number of attractions. The tourist enters their location and indicates the time period (if necessary) and the number of attractions, as well as their type (for example, a museum, temple, or monument) that they want to visit. The application shows them the most optimal excursion routes at the user's request.

For specific attractions. If a tourist has an unlimited amount of time and wants to visit certain objects, then they can choose specific tourist sites (e,g., BigBen, Tower and London Bridges) and the time to examine them. The application will develop the most convenient and optimal excursion route.

By the amount of free time and attractions. The user enters their location, indicates the amount of time for the tour, and the number of attractions. The application then provides the best excursion routes to choose from.

This proposal is still under development, but we hope that it will soon be possible to implement and improve the quality and comfort of independent excursion routes for tourists.

Discussion and conclusion

This paper analyzed the most popular market software for mobile applications for navigating tourists during travel. The popularity of such applications is generally very high, which is determined by a high level of modern societal mobility and the need for operational navigation, primarily in new urban spaces. The market is quite saturated with software from different manufacturers, and high competition dictates some requirements for functionalities and services provided to a user; thus, manufacturers are forced to expand their services to increase competitiveness.

After surveying tourists that use the City Sightseeing service, the basic requirements of tourists for mobile applications while traveling were determined. Proposals were developed to improve the Citymapper mobile application for navigating tourists on trips, and special attention was paid to create the most comfortable and optimized excursion methods, taking into account tourist wishes.

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