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# MODERN TENDENTION IN THE USE OF GPS TECHNOLOGY IN TOURISM INDUSTRY

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Abstract. The article is devoted to the analysis of the possibilities of GPS-technology (Global Positioning System) in the tourism industry. The study is devoted to the identification and analysis of functionality of mobile computing devices equipped with GPS receiver in tourism industry, the methods and means of their implementation, building on this basis a mobile information technology for tourist support at all stages of his journey. To achieve the goal a number of mobile information systems using data GPS, methods and means of their implementation, a comparative analysis of current cartographic services that are used in the developing of mobile information technology applications for tourist are analyzed. The study outlines the place of GPS-technology in the "Mobile tourist information assistant" system, and the role of Google Maps services for information technology support and implementation of the main tourist features in mentioned mobile information system.

Key words: GPS, global positioning system, mobile technology, tourist, tourism, location-based services, mobile application, location-based recommendations, travel guide, route planning, navigation, indoor navigation.

## INTRODUCTION

The use of modern Smartphones and tablets is becoming an integral component of information support of tourist during the trip. To determine the user's location by mobile applications can use technology platform of the Internet, radio signals and GPS data (global positioning system). The most common in the sphere of tourism are mobile information systems using GPS data. The technology that is mentioned has several important advantages: free distribution, independent from the operator and the territory coverage of mobile communication technology, precision of positioning.

Location services can assist the user in obtaining travel experience while staying focused on trip's main aim, to make the trip more comfortable, more memorable and informative [1].

In addition to new features, the emergence of mobile technologies with GPS antenna generated new needs of tourists, such as rapid and accurate determination of their location, personalized planning of tourist routes, the dynamic change of tourist route, and so on.

## OBJECTIVES

The goals if this research are:

- an analysis of current tourist information systems, based on information of the user's location;
- an analysis of the structure and operation of GPS (global positioning system);
- an identification of the methods and tools for building tourist mobile information systems based on dynamic information about the current location of the user;
- detection and identification of research areas and tasks that require further scientific and technological research.

The summarizing aim of the described in the paper research is the identification and analysis of the functionality of mobile computing devices equipped with GPS receiver for tourism. The development of new methods and means of their implementation, building on their basis a mobile information technology for tourist support at all stages of the trip.

## THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

### The analysis of up-to-date researches and profiles of the use of GPS technology in the field of tourism

The most common profiles of researches on the use of mobile computing devices equipped with GPS antennas and activity of the information services to determine the location of the user in the field of tourism are:

- information technology support during the tourist travel;
- information methods and tools for analysis of tourist behavior.

#### *The systems of the information support of the tourists during the trip*

Information systems of specified class often have functions of information processing of the current location of the user. The systems that have no such function are becoming less popular, because tourist is often unable to determine his location during the trip.

Popular mobile algorithmic applications for tourists that are based on GPS data are navigation systems, route planners, augmented reality systems and computer travel guides.

*Mobile navigation systems.*

The navigation task differs depending on the specifics of the environment [2].

Scientists of the International Association of Engineers (IAE) developed navigation system that provides the general information on the relevant route [3]. The approach assumes that the user creates and forms sightseeing trip plan by himself by selecting the desired tourist sites to visit from the proposed list. The optimal route is generated automatically on the mobile device but only that objects that are the part of the route are shown. During the trip, the user must rely on a digital map and GPS information. Authors of the system believe that the use of this application while traveling offers more opportunities to get richer and more positive impression from the trip to the tourists

Among the information technology developments in the field of navigation systems the navigation systems for water vehicles are becoming increasingly popular. Scientists of the University of Munich have developed an information system to support safe traveling in mined waters [4]. An essential feature of this system is particularly centimeter accuracy of the coordinate calculations and optimal route selection criteria according to the safety needs and duration of implementation of the trip

Actual profile of the research in the field of information systems that actively use GPS navigation techniques is planning indoor routes. The results of these studies are useful for the tourism industry, as numerous tourist sites have quite complex spatial structure and tourists may get lost or did not observe particularly interesting elements of objects and spaces without outside help of the professional guide [5].

Powerful navigation system GROPING (Geomagnetism and cROwdsensing Powered Indoor NaviGation) was established to support the process of movement inside buildings. The system is supported by Google Maps Indoor. The main users of the system are employees of the large corporations that are located in the complex structured buildings. The system allows managers to track the movement of their staff and new employees to find the right way in the building conveniently and quickly [6].

*Route planner.*

Scientists of the Masaryk University (Czech Republic) developed methods and tools for planning optimal travel routes. They took into account parameters such as comfort, value, duration and informativeness. Researchers paid particular attention to the construction and speed of the information processing of the mobile route planner. The researchers developed original mathematical methods for planning travel routes have all suggested properties [7].

Scientists from Aarhus University (Denmark) have developed a mobile software and algorithmic application for indoor route planning, based on data from the GPS receiver. The features of this system are the following [8]:

- precise definition of the location;
- good quality and fast route planning;
- Augmented reality information labels;
- audio and map indoor navigation;
- Augmented reality mode.

An original route planning information system is a mobile software and algorithmic application created by scientists Mendes and Ribeiro [9]. Its main functionality is planning "healthy routes", such that avoid areas with the highest air pollution, road congestion, and more.

*Tourist computer guide.*

Scientists of Cultural Heritage Management Laboratory (CHMLab) have developed a powerful mobile travel application with functionality of computer travel guide. The system uses GPS to determine user's location, and gives information according to that data. The system is under improvement and implementation now [10].

Scientists of the University of Applied Sciences Zittau / Horlitts (Germany), Ronnie Kramer, Modshinh Marco and Klaus Nahen are to developing a mobile tourist guide called DTG (Dynamic Tourist Guide, that is based on contextual information. Mentioned mobile application identifies and stores user preferences in order to provide more personalized travel information. In addition, DTG plans travel routes and uses GPS technology for navigation and information support of tourist trips [11].

Under the guidance of Bruce Thomas, scientists of the University of North Australia have developed a mobile travel guide, based on information about the current location of the user. The main functions of the system are [12]:

- providing information on tourist facilities according to the place of residence in the form of hypertext markup language;
- Displaying users position on the map;
- Good quality mapping of the information on devices with small screen size;
- planning of tourist trips;
- planned tours saving;
- spatial navigation manual of the user.

*CRUMPET*

In the class of information systems that actively use GPS data a powerful tourist information system CRUMPET («Creation of User-friendly Mobile Services Personalized for Tourism») developed by scientists of social organization Information Technology (IST) shows up [13]. Its feature is functionality load for quite a full range of travel needs of the user. Because of the big list of features it is difficult to attribute the mentioned system to one of the classes that were submitted previously.

The system has the following features, which are separated by type of action and specificity [13]:

- the use of personal user information involves generating of personalized recommendations, taking into account of both individual and group needs and preferences, constant dynamic studying of user preferences when using the program;
- the use of GPS data involves the use of GPS data in the selection of its services, in the formation of tourist routes, in the imaging user's location on the map and its navigation.

The operation of the system is based on a set of scenarios and multi-agent technology, that is responsible for the execution of these functions and user interface implementation [13].

*Tourist behavior analysis.*

With the appearance of technological innovations that are geographic information systems and GPS the behavior of tourists, their goals, desires and preferences changed significantly [14]. On this basis, new methods of analysis of human behavior while traveling were developed. The possibility of tracking the movement of tourists by using GPS signals within the city allows us to identify the most popular tourist routes and facilities, and identify those parts of the city, that tourists should avoid during his travels [15].

GPS data is usually analyzed at the macro and micro levels. The example of macroanalysis is a general study and analysis of the movement of tourists during the Biathlon World Cup [16], where GPS devices were used by every tourist, management institutions and social infrastructures that were marked on digital maps. The macroanalysis can provide general information on the movement of people and is mainly used in situations where are big groups of people such as world championships, festivals and others [17].

Microanalysis needs the information on the factors that influence the choice of the route, such as climatic and natural conditions, available activities, socio-demographic characteristics and other features of tourist destinations. [17].

During the second symposium CAUTHE (The Council for Australasian Tourism and Hospitality Education) Sven Gross and Michael Hatch introduced a mobile information system to analyze the behavior of tourists. To improve the efficiency and ensure high quality of the system they conducted [18]:

•an analysis of the trajectories of GPS system users;

•a survey of user experiences;

•an analysis of the factors of attractiveness of tourist facilities.

The system performs a navigation function and is designed for mobile devices that operate basing on operating system Android [18].

A popular class of information systems is a mobile system to analyze the movements of people in big cities. The target users of such systems is the taxi company and individual taxi drivers. The main its objective is to identify popular routes and stops to build optimal routes for public transport [19].

An innovative technology elaboration in the field of modern information technologies to analyze the behavior of tourists during the trip is GimToP Toolkit (GTK), which combines original methodological approach and processing technology trajectories obtained by using GPS navigation. The system integrates results of the analysis of users route with the survey data obtained by using special mobile applications [20].

**The analysis of modern IT developments in the sphere of GPS technologies and tourism**

According to the rapid growth of the developments of the tourism industry and the demand for good quality mobile travel applications leading IT companies in the world have developed a range of available tourist information of mobile technologies with GPS support. The mobile applications for route planning and navigation of the user have got the greatest popularity.

A good representative of route planners is a mobile information system Voyager: Route Planner. The goal of this application is automatized planning of optimal routes of trips. The system uses GPS technology to determine the user's location and its navigation according to a planned route. According to mobile application developers Voyager feature is the ease of interactions for the user and comfort of the interface [21].

A popular application in the field of route planning also is ViaMichelin. This software and algorithmic complex implements the following functions: determining users location by using GPS, the use of various types of maps that depends on the user desires (Michelin maps, Lite maps, satellite view maps), planning the optimal route by taking into account the mode of transport and information on the current level of traffic, the estimated cost of the route calculations by taking into account the data on toll roads, transportation fees, fuel prices, and the type of the transport, providing data on the points of interest [22].

A popular application in the sphere of route planning in general and tourism in particular is a software tool Route4Me. The main feature of this application is the existence of the possibility of forming a route between unlimited number of target points [23].

In the class of mobile navigation technologies there is a powerful software application BE-ON-ROAD. This system is a free navigation for devices based on operating system Android. BE-ON-ROAD uses cartographic database OpenStreetMaps, which are updated several times a year and can be stored in the user device and does not require a permanent connection to the Internet. Attractive features of the system are: free map update, night mode based on the local time zone, saving the route on the user device [24].

A popular offline GPS navigation application is the mobile navigator Navitel with capabilities using geo-social services and detailed maps of 62 countries [25]. The features of the system are autonomous mode, the ability to exchange information on social networks, saving the maps on the memory card in of the device, the dynamic information (the weather, traffic jams, road repairs, events, etc.), support of 3D mapping, multilingual navigation unlimited number of stop-points of the route.

In the class of mobile tourist navigation systems there should be allocated the software navigator Maps.Me. The system has all necessary features for offline GPS navigation and planning of tourist trips. The feature of the system is high detalization of maps and their dynamic update when the use connects to the Internet [26].

## THE MAIN RESULTS OF THE RESEARCH

### Structure and principle of the Global Positioning System (GPS)

GPS (Global Positioning System) is a set of electronic tools to determine the position and velocity of the object on the Earth's surface or the atmosphere [28]. This worldwide radio navigation system consists of 24 satellites NAVSTAR (Navigation Satellite Time and Ranging), several ground stations and nearly one million user devices. These segments of the system, namely space, surface, the user - are completely interdependent.

The space segment consists of 24 major and several additional satellites that are put on six different circular orbits located at an altitude of 20200 km above the ground and at an angle of 60 ° to each other so that from four to twelve these satellites are seen from any point of the globe (see Fig.1).

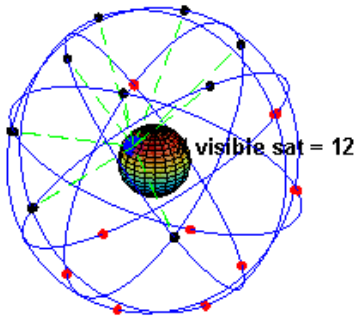


**Fig. 1.** The location of the satellites in space. An example of visibility from a certain point of the earth in certain time [28]

Ground segment consists of 12 stations: GPS master control station, ground antenna and monitoring stations (see Fig. 2).

Monitoring stations monitor the navigation signals of all the satellites in the continuous mode and send this data to the control station for further processing. Control station calculates the position of each satellite in the orbit and corrects data on its board time. In the future, this information is transmitted to the antenna station. In order to preserve the accuracy of calculations of the data for each satellite it is updated three times a day. Each satellite is always in sight of at least two ground stations [27].


**Fig. 2.** Ground Station Global Positioning System

Depending on the needs of the user the following types of GPS receivers signals can be used [27]:

• Handheld GPS receiver, that is able to determine the user's location with an error not exceeding 15m;

• Differential GPS receiver (DGPS), which is able to determine the user's location with an accuracy of 1m radius;

• Professional GPS receiver with the Real-Time Kinematic process (RTK) support, which determines the location of an object to centimeters.

When switching on the GPS receiver it is in one of three starting states [36]:

• Cold start: Receiver does not contain any saved information on the latter's location and the current time.

• Warm start: Receiver contains data about previous user's location and the current time, but the term of relevance of temporal data has expired.

• Hot start: a state when the receiver has access to all necessary data and it is valid and correct.

GPS receivers perform the following functions: accumulate the data from satellites, measure the signal parameters, calculates the position, speed and time.

To determine the exact location of the user, GPS receiver must determine the distance to each of the visible satellites and measure the duration of the movements of the signal from the satellite to the receiver, and calculate the time delay.

During the process of determining the location of the following errors may occur [27]:

• User side errors: delays caused by the ionosphere and troposphere, the satellite clock error, and so on.

• Equipment errors: interference receiver antenna direction, electromagnetic radiation, many receiving streaming data, etc.

### Construction of the tourist information systems with the functions of route planning and navigation based on GPS data

Good quality location-based are available because of the GPS receivers that are embedded into custom mobile device.

***Information sources of systems that are based on GPS technology***

These systems in addition to data from the GPS signal receiver use information from road maps databases, data and points of interest (POI), dynamic data such as traffic and weather.

*Road map databases.* Databases of this kind consist of road maps converted into digital format of segments of corresponding maps. For example, the map of the United Kingdom consists of about a million individual segments of roads. Maps are stored in vector format as segments of lines (connections) that are roads and intersection points that are intersections or other road features. Each line must start and end points and data on road distortion. [29]

Among road databases and maps should be separately identified services such as Gooqle Maps, OpenStreetMap (OSM) and Yandex.

Gooqle Maps is a set of databases that are based on the free map service and technology provided by Google. Service enables the usage of cartographic data and

satellite images of the earth's surface, and provides access to an integrated business listing and maps of roads, with function of routes planning [30].

OpenStreetMap is a free service of creation and use of publicly available maps of the world, founded in the UK in July 2004 by Steve Coast. OpenStreetMap, in fact, is not just a map in the conventional sense, it is most likely a base of geospatial data. It contains the geographic coordinates of individual points and information about the objects of the highest order – lines that connect points, connections, which may include points and lines, and the attributes of these objects. Therefore services that differ among themselves, by the way of mapping data or functionality, can be built basing on the same OSM data [31].

Yandex is similar to Gooqle Maps service, created by Russian developers. IT has more detailed information on cities of Russia and CIS countries [32].

Bing Maps (earlier service called Live Search Maps, Windows Live Maps, Windows Live Local, MSN Virtual Earth) is the cartographic service from Microsoft, part of the portal Bing. The feature of this service is a small need for internet traffic and high speed of drawing of the map layers. But Bing maps differ because of insufficient detalization [33].

*POI databases.* Mobile concierge-type services help users to identify of the location of certain institutions or attractions near a given location. To this purpose mobile travel applications use databases that include information on places that might be interesting for tourists. These databases contain detailed information on the POI, such as their location, purpose, features, photos, etc [29] These are highly structured and big databases [37].

Conventional points of interest databases are integrated with roadmaps database. For example, Google maps service has integrated POI databases. Its feature is the availability of information on the desired location that is support by the panoramas and indoor plans [30].

Yandex.Maps have a so-called cards of the facilities – tags attached to objects on the map that consist information on the location of the object, its work hours, features, review, and so on.

*Dynamic data.* In this representation information that is relevant for a short period of time, for example, traffic vehicles in certain segments of the route [38], information about weather, etc is given. Such information is usually useful for drivers and tourists that are limited in time, and their subsequent actions can greatly depend on its content. [29]

As a results of the analysis of available cartographic service authors formed comparative matrix functional characteristics of mentioned services (see. Table 1).

***The general structure of GPS-based information systems***

The basis of the location-based system, is so-called "engine" that is an essential algorithmic complex that modifies GPS data (see. Fig. 3).

The basic functions of mentioned complex are geocoding, routing and search for POI.

**Table 1.** Comparative matrix of functionality of cartographic services

| Functional Characteristics / Cartographic services | Google Maps | Open StreetMap | Яндекс Карти | Bing Maps |
|---|---|---|---|---|
| Available Road maps | + | + | + | + |
| Available satellite view | + | – | + | + |
| Available building indoor plans | + | – | – | – |
| Street view | + | – | + | + |
| Points of interests detalization (max 4 p.) | 4 | 2 | 3 | 1 |
| Dynamic information (traffic jams) | + | – | + | + |
| Dynamic information (weather conditions) | + | – | – | – |
| Detalization (max 4 p.) | 4 | 3 | 2 | 1 |
| Speed of map layers drawing (max 4 p.) | 1 | 3 | 2 | 4 |

Geocoding is a transformation of the place address into earth in a pair of coordinates (longitude and latitude) to display the point on a road map. This is a basic function of geospatial application system. The precision of direct and reverse geocoding is critical when taking into consideration the results of the system as a whole [29].

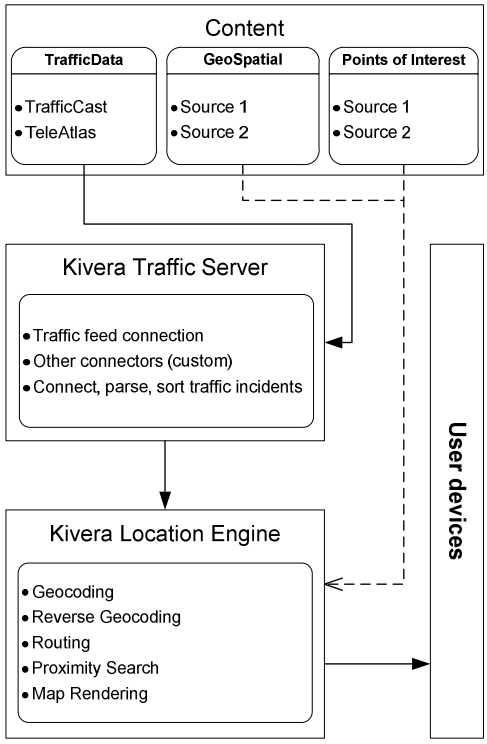


**Fig. 3.** Engine Architecture Systems Kivera, based on data from the GPS [29]

The implementation of routing features is about calculating optimal routes between points, taking into account a number of criterias, such as cost of the route, personal user preferences, and so on. It should be noted that the construction of a tourist route has certain

peculiarities. In many cases, the system might not contain information about all the waypoints, so calculations should be based on personalized information about the user and trip duration to determine the recommended list of POI in order to create the most interesting route according to user preference.

Equally, important function of the complex is the search POI. When searching for objects the location, its preferences and schedule target objects should be taken into account.

***Implementation of the navigation functions***

One of the major functions of GPS-based information systems is user navigation. By performing the function of computer guides, navigation systems navigate the user to the selected object on the planned route of the trip. This function is vital for the tourist when he is in unfamiliar region during the trip.

Deploying global positioning system (GPS) radically changed the structure and quality of service navigation systems.

The example of general architecture of navigation systems is presented in Fig. 4. System components include client-side devices containing a GPS receiver (smartphone, tablet, car GPS navigator, etc.). The client device can be completely independent, in the case of the use of cloud-based technology [29].

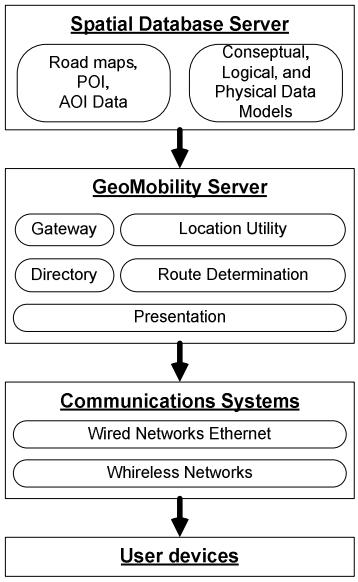


**Fig. 4.** General architecture of navigation systems

The server part of the system consists of spatial database server and GeoMobility server. Client devices are connected with the server side using communication components of the system [29].

**Mobile tourist information assistant and GPS technology**

A group of researchers from the National Lviv Polytechnic University are working on innovative technological project "Mobile tourist information assistant", within which a prototype of integrated mobile software and algorithmic complex of next generation is being developed.

As a result of preliminary analysis the authors of this article outlined of GPS technology in the "Mobile tourist information assistant ", which is a set of software and algorithmic tools to support all stages of tourist trip and the implementation of basic user information and technological motto "EVERYTHING! HERE! IMMEDIATELY!" [34]. It is proposed to implement GPS components in the system to support tourist trips to the castle "Palanok" in Mukachevo, Khust castle in Transcarpathian region, the so-called "Golden Horseshoe of Lviv" (a tourist route that includes a visit of Pidhirtsi, Olesko and Zolochiv castles) and support tourist routes in the center of the city Lviv, as historic monument, protected by UNESCO.

The need to in the use of GPS technology is embedded in the core objective of the mentioned program-algorithmic complex, that is providing tourist with full information support during the realization of the trip and after it is finished, which is impossible without tied to fast locating of the tourist on the map.

It is proposed to use GPS technology to support the following functions of the system "Mobile tourist information assistant":

- tourist route planning;
- navigation the route;
- user indoor navigation within a tourist facility;
- provisioning of tourist information in accordance with the user's location;
- generating location-based recommendations;
- analyzing the trajectories of the user to provide better quality of personalized recommendations;
- attaching the information about the location of the user to photo and video files;
- using the user trajectories when forming a trip diary.

When planning the trip route the system can use the location of the user as starting point. The system can create a route to a point on the map or offer personalized route planning according to the information on tourist attractions in the vicinity of the user and his personal preferences.

Technological realization of navigation features in travel information systems differs depending on the environment [2]. It is assumed that the system MIAT will navigation the user as in the central part of the city Lviv, as within the indoor areas of tourist sites (museums, within of historical monuments, castles). Navigation will, as in the form of traditional information support of the user movement between certain points of the route, as in the form of tourist guide that will dynamically provide the user with information about the objects that are in his sight and are parallel to trajectories of planned route.

The feature of indoor navigation in tourist facilities needs an accurately determined user's location, so there are high requirements for the development of significantly more powerful GPS data processing tools. The system should respond to small changes of user’s location. "Mobile tourist information assistant" will provide interesting tourist information about the objects that will be in close proximity to the user of the system while visiting museums of Lviv city center, which is protected by UNESCO and a number of historic castles of

Ukrainian Transcarpathia and castles of "Golden Horseshoe" tourist route.

When providing the user with the recommendations of "where to go?", "where to eat?" and so on, the system will take into account not only the preferences of the user, but also the distance between objects and the current location of the user.

GPS is a powerful source of information that can be used to support forming of the recommendations by the system and for more detailed filtering of tourist information, so to provide the user with high quality personalized support while traveling [35]. In this regard, a system MIAT is no exception. It is assumed that the system will analyze the trajectory of tourist trips, so to promote improvements of the quality of recommendations.

In addition, the system will use the data on the tourist movement for automatic generation of the diary his trip. GPS component in the system MIAT will also actively support photo and video files geo-tagging.

## CONCLUSIONS

Good quality mobile travel information and technological tools of tourist support should definitely involve the use of GPS technology. They are the main base of popular mobile travel applications, as navigators, route planner, travel computer guides, augmented reality systems. A popular trend in the use of GPS technology is its use for studying user preferences and habits in order to provide good quality tourist personalized recommendations.

To build a multifunctional complex of tourist information system by using GPS technology good quality verified database of road maps and tourist sites, as well as the sources of dynamic information should be selected. The analysis of current cartographic databases suggests that the GoogleMaps service is one of the most powerful sources of map data that is available for the use in the development of mobile travel software and algorithmic applications.

Promising areas of research are:

•the development of new methods and means of indoor navigation of users;

•the development of new methods for the improving of the locating accuracy;

•the development of intelligent tourist GPS-based decision support systems.

In the "Mobile tourist information assistant" it will be provided the implementation of functions of indoor user guidance and navigation, as well as their verification on examples of the schemes of the routes in the castle "Palanok" (m. Mukachevo) Khust Castle (m. Hust), Olesko, Pidhirtsi and Zolochiv castles, of which the last three are "Golden Horseshoe of Lviv region" and within the central part of the city, which is the historical heritage of UNESCO.

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