E-TOURISM BASED ON GEOINFORMATION APPLICATIONS FOR SENIORS: REQUIREMENTS AND DESIGN GUIDELINES

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Abstract: Innovative e-tourism tools could combine virtual reality, audio-visual data and physical travel to create a unique tourism experience for different groups of users. The aim of this study is to develop a geoinformation system supporting e-tourism for seniors. The proposals included a social geoinformation service (geoportal) and a mobile application. The solutions were tested in religious tourism destinations. The study included development of the technical requirements based on the map reading skills of the surveyed group. The recommendations presented in this article increase the knowledge about the practice and development of such geoinformation solutions.

Key words: geoportal, tourist map, geographic information systems (GIS), seniors

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Introduction

The development of information and communications technology (ICT) has created new opportunities for many sectors and services, such as business, administration, education, health care and tourism. The COVID-19 (coronavirus disease 2019) pandemic has demonstrated the value and capabilities of these systems. Virtual tourism solutions can target various social groups that differ in age and physical ability. E-tourism could be defined as dynamical interactions between ICTs and the components of the classical tourism system (Buhalis 2003). It cannot replace direct tourism experience, but it can assist users in selecting tourist sites and trails, and it provides direct access to attractions and resources (such as museum collections) that cannot be visited by seniors and persons with physical disabilities. Innovative e-tourism tools combine virtual reality, audio-visual data and physical travel to create a unique tourism experience for this group of users.

The European Commission proposed the i2010 strategy (European Information Society for Growth and Employment 2010) to boost Europe's lead in ICT and to unlock the benefits of the information society for European growth and jobs, and it helps address the challenges of an ageing population (Cartwright et al. 2001). The strategy highlights the need for greater social and economic cohesion, which can be

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achieved by increasing the availability of ICT products and services and promoting digital literacy and skills (Janowski et al. 2014, Renigier-Bilozor et al. 2019). Various initiatives have been introduced in Europe, such as the Bridging the Digital Gap for Elders program, to make ICT solutions more available to seniors and to determine which and how technologies are used by older adults (Hill et al. 2015, Klimova et al. 2016). Numerous research studies have been conducted to analyse the role of technology in reducing social isolation among seniors (Mordini et al. 2009, Fan 2016, Khosravi et al. 2016), teaching older adults to use mobile devices (Williams et al. 2015, Fernandez et al. 2016), promoting digital skills and using dedicated Web applications (Williams et al. 2015, Fernandez et al. 2016). Research indicates that seniors are digitally excluded (Szmigielska et al. 2012) mainly due to psychological factors. Older adults have different needs and goals than younger members of society (Laurich 2002, Higgs et al. 2003, O'Hara 2004, Rodriguez 2012, Diehl et al. 2015). Websites are designed to attract users, and they contain excessive sensory input, including numerous advertisements and a wealth of information. Older users have different needs and expectations that are not effectively met by modern Websites (Yu et al. 2016, Ivankina et al. 2017).

The United Nations World Tourism Organization (UNWTO) defines tourism as 'taking a trip to a main destination outside the traveller's usual environment, for less than a year, for any main purpose (business, leisure or other personal purpose) other than to be employed by a resident entity in the country or place visited' (Ghanem 2017). Tourist services include accommodation and food services, booking services, travel agency services and services associated with culture, entertainment, sports and recreation. The main categories of tourism include domestic and foreign tourism, organised and independent tourism, and individual and group tourism. Active tourism, such as cycling, kayaking, hiking and mountaineering, is yet another category of tourism that requires physical skill and mental preparation (Poczta-Wajda, Poczta 2016). Different categories of tourism that address the needs of various target groups, including various age groups, have been proposed (Alén et al. 2012, Chen et al. 2021). Tourists who travel with children, young independent tourists and elderly tourists have different needs. The main objectives of tourism are to promote physical (physical culture) and psychological well-being (education and acquisition of knowledge), to broaden the traveller's knowledge about the world and to promote personal growth. Religious tourism is a niche within the segment of special interest tourism. There are two main subtypes of religious tourism: visits to religious and sacred sites that enable travellers to expand their horizons and acquire new knowledge (history of religious sites, sacral architecture in churches and sanctuaries) and pilgrimages that are undertaken mainly for the purpose of prayer, contemplation and participation in religious ceremonies (Collins-Kreiner 2018).

Information technology is increasingly used in tourism marketing (Albuquerque et al. 2018) and virtual sightseeing (Voronkova 2018). Virtual sightseeing offers new opportunities for seniors and physically disabled persons who are unable to participate in conventional tours. The popularity of virtual tours has increased during the COVID-19 pandemic. Virtual sightseeing includes virtual trips that enable people to tour museums and historical monuments without leaving their homes (Bartoszewski 2010). Websites and geographic information system (GIS) tools enable tourists to search for information about accommodation, restaurants, history of tourist destinations, travel options, ticket booking and tourist services (Albuquerque et al. 2018). In a broad sense, a GIS is an organised collection of computer hardware, software, methods, databases, procedures, human and financial resources, which is designed to store and display information. A GIS combines geographically referenced information with an object's attributes (data), and the results are presented graphically (Bielecka 2006). A GIS is the modern equivalent of a map.

Google Maps, Google Street View or other sites offering access to spatial data constitute a GIS tool that is well known and broadly used by tourists and persons involved in the tourist industry. They play a special role in the development of tourism as they are the main source of information about the location of facilities that are of interest to selected users. Geographic information Websites and applications, in general,

are designed in a manner to make them attractive to average users. There are many impulses and pieces of information that have to be searched for through functions placed there. For an elderly group of users, this manner of presenting the information is too complex and leads to resignation from these services, making them redundant. Another cause of problems related to using Websites can be the users' deteriorating health. Problems related to hearing or sight and instability of hand movement make elderly people become quickly discouraged with respect to using the Internet. In the literature, there are some analyses of the information and communication technology solutions and applications dedicated to the elderly or the description of these solutions' impact on seniors (Ramos-Soler et al. 2019).

As the issue of development of geoinformation applications dedicated to the elderly has not been thoroughly discussed, the aim of this study is to develop technical requirements for a geoinformation system supporting e-tourism based on the map reading skills of seniors. The objective is also to formulate guidelines for developing functional and user-friendly applications. The test area for solutions is the religious tourism destination – Kalwaria Głotowska in Poland. The proposal assumptions include a social geoinformation service (geoportal) and a mobile application.

Study area

The proposed methodology and the functionality of the designed prototypes of the geoportal and the mobile application involved test trails in Kalwaria Głotowska (Poland, Fig. 1). The Calvary was built in the nineteenth century. There are artistically made sculptures, depicting the Passion of Christ, which are placed in the chapels made of stone and brick. Next to the Calvary, there is a church dedicated to the Most Holy Saviour and Saint Florian.

During testing of the proposals, the trails' accessibility was evaluated. Moreover, the functionality of the applications was tested (Fig. 2), which included the following aspects: graphic interface, menu screen – organisation and list of content, ergonomics and map and presentation of spatial data (points 1.1, 1.2, 2.1, 2.2, 3.1, 3.3, 4.1 and 4.2 in Table 1).

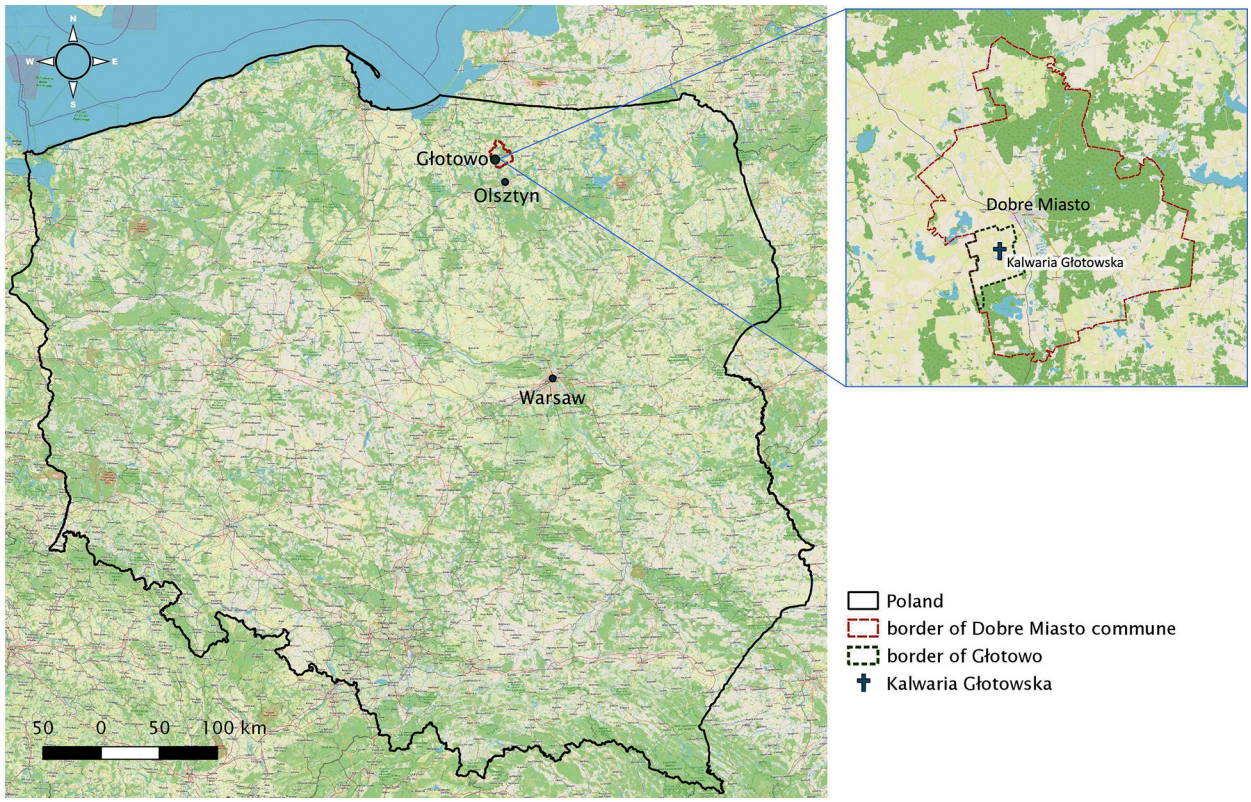

Fig. 1. Location of Kalwaria Głotowska (based on Open Street Map).

Table 1. Guidelines for developing a geoportal and a mobile application for seniors and persons with physical disabilities.

Design criterion	Recommendations
Graphic interface	1.1. Toned down colours, with a predominance of grey, blue and green 1.2. Functions are described in large font 1.3. High contrast option for users with visual impairments
Menu screen – organisation and list of content	2.1. Simplified and fixed toolbars that cannot be moved, minimised or removed from the application window 2.2. Minimal number of toolbars 2.3. Each taskbar icon performs only one function
Ergonomics	3.1. One user interface without additional content, dynamic elements or advertisements 3.2. Menu items leading to submenu items are visibly marked with text and/or clear graphic symbols 3.3. Minimal number of items on each menu/submenu
Map and presentation of spatial data	4.1. Simplified map with large graphic symbols that are explained in the legend; fixed legend in the map window 4.2. Simplified map functionalities, including zooming in and out, with large icons 4.3. Easy to use
Basic content	5.1. Links to religious sites, museums, churches, chapels, cemeteries and parks 5.2. Optional items – text, map, cartographic symbols and icons, abbreviations, legend
Additional content	6.1. Additional content, such as detailed maps, satellite and aerial images, is not required 6.2. Optional links to Websites with information about train and bus timetables, tourist information, weather forecasts 6.3. Additional tourist information is not required
Availability	7.1. The application is optimised for mobile devices
Travel route and test area requirements	8.1. Visiting sequence 8.2. Photographs, shopping for souvenirs and religious items 8.3. Terrain obstacles and other difficulties: lack of public toilets, lack of clear tourist signs, steep slopes, lack of rest areas, lack of paved trails 8.4. The route should be defined in the system and accurately marked on the map 8.5. The route should be adapted to the user's capabilities; the route cannot be defined independently by the user in the system
Symbols	9.1. Popular symbols or non-ambiguous symbols representing features on a map 9.2. Symbols and letters should have the same (large) size 9.3. Numerical terrain models and map layers should not be used to describe landform 9.4. Symbols and map icons should be simple 9.5. Obstacles should be represented by simple symbols 9.6. The level of difficulty and additional tourist attractions should be displayed on the trail

Fig. 2. Field survey of the designed trails.

Materials and methods

The technical requirements of the designed system and methods for visualising, classifying and displaying tourist trails on maps were determined based on the map reading skills of the surveyed seniors (n = 100). Studies were conducted among a group of members of Third Age University in Olsztyn. Most of surveyed respondents were between the age of 61 years and 70 years. There were also seniors aged 71 to 80 years. The needs and expectations of seniors (60+) were surveyed to determine the key functionalities of a dedicated tourist geoportal and a mobile application, and the developed prototypes were tested. Data for the study were collected based on the results of a survey, as well as specific tasks and tests involving seniors. Four specific objectives of the main research are presented in Figure 3.

The survey questionnaire was developed based on information about the functionality of a geoinformation system (Davis 2003, Bielecka 2006, Bartoszewski 2010, Pachelski et al. 2012) and a mobile application (Collins et al. 2012, Darcey, Conder 2012, Karahoca 2012, Marinacci 2012). The questionnaire contained closed-ended, open-ended and ranking questions (objectives 1, 2 and 3) and problem-solving tasks (objective 2 – map reading skills; objective 3 – evaluation of geoinformation services; objective 4 – trip planning). The experiments were designed and observations were conducted based on the knowledge and experiences related to social sciences (Orzechowska 2012), thematic cartography (Jancewicz, Borowicz 2017), structure and operation of a GIS (Golis, Omazda 2011) and spatial planning (Jansson, Lingren 2012, Kowalczyk 2012, Kowalczyk 2014, Biłozor et al. 2018). Observations were conducted using an observational protocol template.

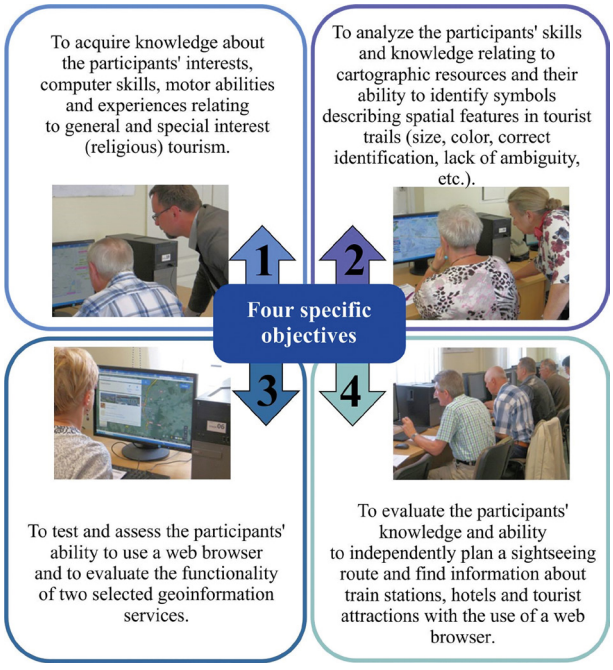

Fig. 3. Four specific objectives of the research. A survey of seniors' (60+) computer literacy skills conducted in the geoinformation technology laboratory.

The next step was developing concepts and assumptions in the process of designing virtual trails, which included the database of tourist destinations (natural, architectural and landscape sites), presentation of content in the geoportal and the mobile application (symbols denoting tourist trails and attractions), technical design of the geoportal and the mobile application, interface for the developed system and mobile application, and a prototype of the geoportal and mobile application. Functional assumptions and design criteria selection for the geoinformation applications developed in this study (Table 1) were based on software engineering and graphical user interface designing rules (Jaszkiewicz 1997, Galitz 2007).

The last stage was testing the proposals in the area presented in the section Study Area. Two trails were prepared. One of them was dedicated to seniors with some mobility impairments. Special QR (quick response) symbols allowed to navigate the testers and to present the information about the church and chapels. Seniors used mobile phones to test the functions of the geoinformation application developed in this study. During the field tests, observation was carried out, and remarks were written in observation sheets. Seniors also had an opportunity to provide feedback about the trails and applications.

Results

Seniors' (60+) computer literacy and the geoinformation technology skills

The majority of the surveyed respondents owned a computer with Internet access (77%), and 37% of the participants evaluated their Internet skills as fair. For most respondents, the Internet

was a source of news and information about domestic and foreign affairs, public transport, tourist information and weather. Only 21% of the surveyed subjects used online map services, whereas 44% were familiar with such services but did not use them on a daily basis. The vast majority of the respondents (84%) owned a mobile phone, and 7% used advanced phone functions. Most polled seniors (79%) visited tourist destinations at least once a year. The respondents used digital (46%) and printed (37%) tourist guides.

The following types of information were most frequently sought by the respondents: travel route and tourist attractions, tourist trails, trail difficulty and food services.

Most respondents searched for information about shrines, local museums and monuments, cemeteries, chapels and parks. They placed the greatest emphasis on toured sites, visiting sequence, prayer, travel memories, photographs and souvenirs and shopping for religious items.

Most respondents did not have mobility problems (70%), and 23% of the participants admitted that they felt more comfortable in the presence of other people during the trip. The following problems were most frequently identified: lack of public toilets, lack of visible tourist signs, steep slopes, lack of rest areas and lack of paved trails.

Familiarity with the travel route (including the level of difficulty and the availability of tourist amenities) was not an important concern for the surveyed seniors. The respondents assessed their abilities (44%) or searched for optimal routes (56%) after arriving at their destination. The vast majority of the surveyed subjects (84%) had an interest in a dedicated geoportal. In their opinion, a dedicated portal should include text descriptions of the visited sites, a map with icons and symbols, and a legend. According to the respondents, a text description was the optimal form of presenting content on a map, followed by letter abbreviations and graphic symbols (icons, pictograms).

The surveyed seniors correctly identified map icons denoting hotels and restaurants (71%), churches, tourist information and car parks (64%) (Fig. 4). They were relatively familiar with the icons representing train and bus stations and the Stations of the Cross (the chapel icon was not always correctly identified, 38%/49%). According to the respondents, the least legible map icons were camping sites, natural monuments and water springs. Most respondents were not familiar with the landform icon.

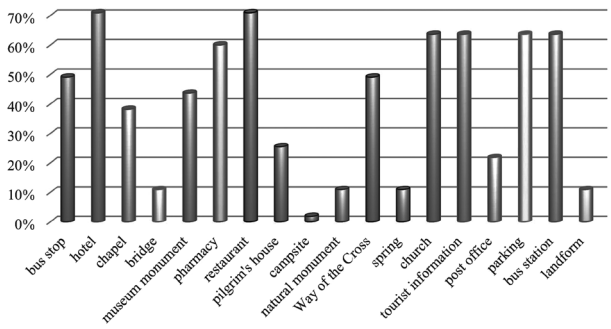

Fig. 4. Map icons correctly identified by the testers.

The respondents tested two selected geoinformation services, and the reported problems were analysed. Most seniors found it difficult to identify topographical objects in both services, and 60% of the respondents were unable to find these objects on a map. According to the testers, lakes, train stations and churches were 'easy' or 'relatively easy' to localise, whereas hills and wetlands were most difficult to find.

The route to a selected destination was correctly identified by 61% of the surveyed subjects. This task was regarded as easy by more than 50% of the respondents, and it was classified as difficult or impossible by the remaining subjects. Icons denoting accommodation services were correctly identified by 53% of the respondents, and this task was ranked as easy by 41% of the seniors, as difficult by 18% of the subjects and as impossible by 41% of the studied group. In total, 55% of the respondents were able to find tourist attractions. This task was evaluated as easy by 33%, as difficult by 28% and as impossible by 39% of the respondents. 33% of the surveyed seniors identified three tourist attractions, 12% identified two tourist attractions and 12% identified one tourist attraction, whereas the remaining respondents (43%) did not identify any attractions. These results were used to formulate guidelines for developing a functional and user-friendly geoportal and a mobile application for seniors (Table 1).

A database of tourist destinations

More than 50 natural, architectural and landscape sites were identified based on the results of the questionnaire survey, and their functions and attributes were described. The extent to which the identified sites fulfilled the requirements

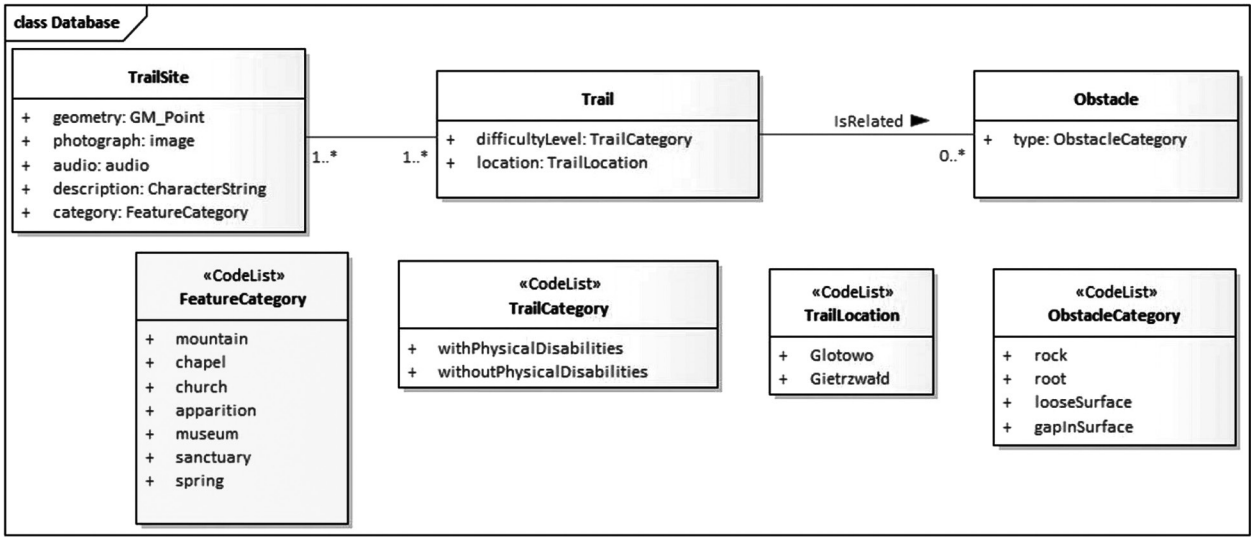

Fig. 5. UML diagram presenting the structure of a spatial database – graphic representation of a thematic map in the application window.

described in Table 1 (points 3.1, 4.1, 4.2, 6.1, 6.3, 8.4, 8.5, 9.1, 9.4 and 9.6) was analysed, and the results of the analysis were used to a select a group of suitable sites. The graphic symbols denoting these objects were developed and placed in the database. The structure of the multimedia spatial database is presented in an UML (Unified Modelling Language) diagram in Figure 5.

The presentation of content in the geoportal and the mobile application

The symbols denoting tourist attractions on the trail (Fig. 6) were developed based on the guidelines presented in Table 1.

Tourist trails characterised by different levels of difficulty were ranked and described with the use of graphic symbols (Table 2). The graphic symbol, definition, type of surface, accessibility and obstacles for each category of tourist trails are presented in Table 2.

A field survey was carried out, and four tourist trails (Fig. 7) were tested in three religious tourism destinations in Poland (Holy Mary Sanctuary in Gietrzwałd – 2 trails, Kalwaria Głotowska and historical church in Ząbruk in a part of Warmia Region that abounds in historical wayside shrine [chapels]).

All of the analysed religious tourism destinations feature additional tourist attractions, bus stops and car parks. Kalwaria Głotowska is the only site that features religious buildings, a cemetery, a park and natural and man-made obstacles

Fig. 6. Example of graphic symbols of tourist attractions.

on tourist trails. None of the tested trails had signposts indicating the direction to landmarks, sightseeing navigation or trail accessibility for seniors.

Testing the methodology for assessing religious tourism trails and the prototypes of the designed geoportal and mobile application

The designed graphic interface for the system and the mobile application prototype (Shapefiles ,

Table 2. Difficulty levels of tourist trails.

Symbol	Definition	Surface	Accessibility	Obstacles
Very easy 	Hard-top trail	Flat hard-top surface		None
Easy 	Flat and wide trail	Mud with occasional rough segments		Slope of 2° or less, rocks and ruts
Moderately easy 	Flat trail with varied width	Mud with occasional rough segments		Slope of <8°, rocks, ruts, loose surface
Moderately difficult 	Uneven trail	Mud and rocks		Slope of 12°, rocks, ruts, loose surface
Difficult 	Rocky trail	Mud, loose stones, uneven surface		Slope of 12° or more, loose stones
Very difficult 	Rocky trail, possible gaps in the surface	Mud, loose stones, uneven surface		Slope of 12° or more, loose stones, possible gaps in the surface

Fig. 7. Photographs of the area where the field survey was conducted.

files containing icons and descriptions, including text descriptions, photographs, sounds, warning sounds) and e-tourism graphic symbols are presented in Figure 8.

The prototype was tested by presenting the respondents with a video footage of the church in Glotowo, which is not accessible to some seniors. The respondents played the video by scanning a QR code (https://youtu.be/gJOrZXFhtE4). QR codes were also generated for different points on the trail. Descriptions, QR codes and landmarks were displayed on the tested trail. The trails selected for the experiment were somewhat challenging to test the participants' ability to use mobile devices and to verify the availability and readability of QR codes. The first trail covered the area around the church (sun-exposed area) and the church interior (low signal strength). The second trail intersected an area with diverse landform, obstacles and numerous trees. The results are presented in Table 3.

The results of the field survey demonstrated that most of the assumptions adopted in the design process were correct. Large amounts of

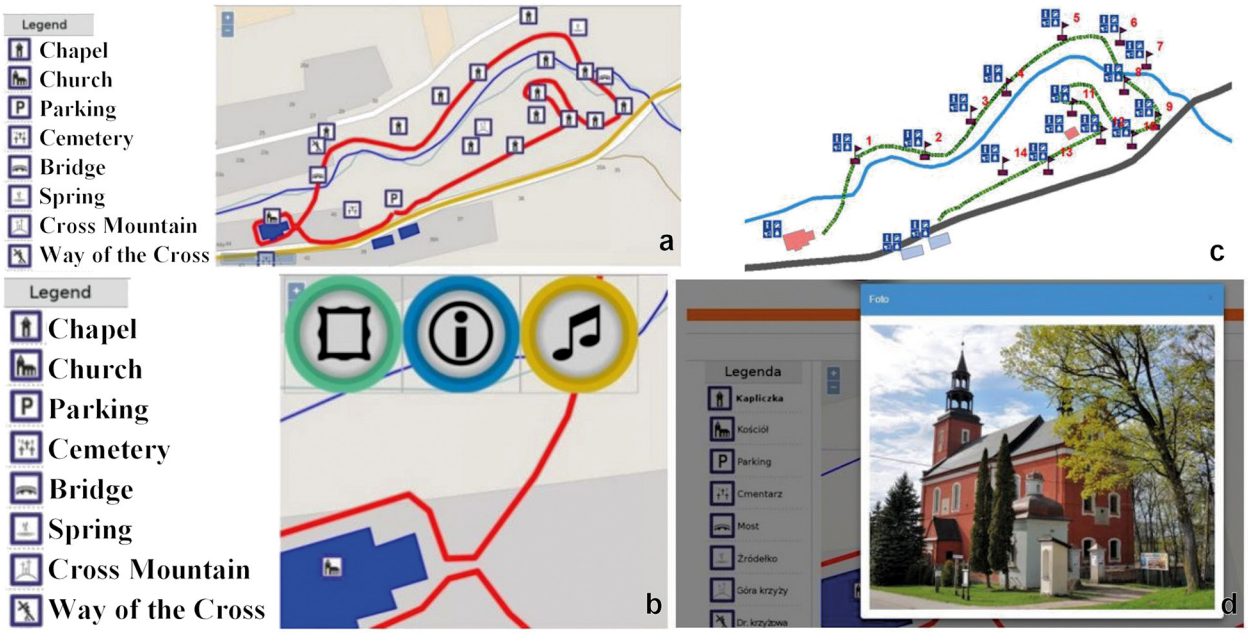

Fig. 8. Selected geoportal functions: (a) and (b) the trail and landmark icons; (c) an icons with additional functionality – photographs, information about objects and sound information; (d) photographs.

Table 3. Interpretation of the respondents' behaviours and impressions.

Issue	Interpretation
Trail accessibility for persons with mobility impairments (120′)	Fatigue, problems with traversing steep slopes (impossible for wheelchair users), entering the church (stairs, no wheelchair ramp), visiting several chapels, crossing the bridge (wheelchair users)
Comparison of trails for users with and without mobility impairments (70′ – longer trail, 40′ – shorter trail)	The trail was evaluated as relatively easy. The respondents reported fatigue, and some participants had to take short breaks during the hike, including in sites that were landmarked in the application. The trail for mobility disabled users was evaluated as relatively easy. The multimedia application offered a valuable experience for users who were unable to visit the museum due to the absence of disability-friendly facilities.
Accessibility and visibility of symbols	The accessibility and visibility of symbols and QR codes were evaluated as satisfactory (signs were placed at an appropriate height and in convenient locations, which enabled the respondents to find the relevant content on the map).
Readability of symbols	The readability of the applied symbols was satisfactory. The symbols were interpreted intuitively.
Comprehension of cartographic symbols	The applied cartographic symbols were easy to understand. Different interpretations were proposed in a limited number of cases.

information (symbols, links to Websites, satellite maps) increased the complexity of the task for participants who used tablets and smartphones. The functionality of the application was evaluated as satisfactory, and most respondents were able to access information about the tourist trail. Signal strength and data transmission speed were limiting factors, and image quality was influenced by the type of display and exposure to ambient light (strong sunlight). Image quality was evaluated as highly satisfactory under good lighting conditions. The QR code proved to be a good solution. The QR code enabled smartphone users to access additional descriptive information in an intuitive manner.

Discussion

The study concerns developing technical requirements for a geoinformation system supporting e-tourism. Guidelines for developing a functional and user-friendly geoapplication dedicated to the elderly formulated in this study complement general design rules for common applicable spatial information solutions.

In the present study, most of the surveyed seniors (60+) owned mobile devices and used the Internet. However, only a small percentage of the participants searched for tourist information on dedicated geoportals and geoinformation services, and the majority of the respondents had a preference for conventional (printed) tourist guides, maps and atlases. Many seniors, particularly socially active respondents, were physically active and travelled to various tourist destinations. The surveyed subjects had an interest in both general tourism and special interest tourism, and they had a high demand for additional information about tourist destinations and attractions. The respondents were familiar with popular tourist symbols (hotels, restaurants) and were able to identify the corresponding large icons and colours on topographic maps. The surveyed seniors found it more difficult to identify less popular symbols and cartographic icons (natural monuments, water springs) probably because these objects generally attract less interest during tourist trips. This also applies to contour lines denoting the land slope and, consequently, the difficulty of the trail. The relevant information is very important for seniors (60+). Therefore, the respondents' inability to correctly interpret such symbols indicates that they were not familiar with these icons and that other or additional symbols should be used to represent difficult trails (steep slopes). The map legend should be simple and legible, and geographic information could also be presented with sound. Impaired sensory perception was observed in some of the respondents.

Seniors who found it difficult to find certain types of information could be divided into two categories: those who regarded the task as challenging but managed to find the required information and those who experienced problems and were unable to complete the task. The respondents' remarks, in particular those relating to text descriptions as well as the colour and size of the icons, should be taken into consideration when designing geoportals dedicated to older adults (60+). Special attention should be paid to landform symbols that are often illegible, difficult to interpret or not available in geoinformation portals.

The study demonstrated that system functionalities do not fully meet the needs of senior users. The respondents had problems with interpreting the content of geoinformation services, finding specific functions and browsing the Internet. Some participants found it difficult to point with a mouse or a touchpad, and they were unable to zoom in or out on the map. The results of the study suggest that the respondents differed in their computer literacy skills. Around 50% of the respondents completed the tasks without significant problems, whereas the remaining respondents often failed to achieve satisfactory results. Finding tourist attractions was the most difficult task, whereas finding the route and accommodation was the least challenging task. These results could be attributed to the fact that most map services feature standard route finding functions that are relatively easy to use for less-advanced users. More complex tasks that require additional skills and knowledge (such as finding accommodation and tourist attractions) can pose a greater difficulty. Despite this, these tasks are not impossible to accomplish for seniors.

In an evaluation of the accessibility of trails designed for persons with mobility problems as well as the time required to traverse each trail,

some seniors reported fatigue and identified the encountered physical obstacles. The most frequently reported obstacles were problems with traversing steep slopes (wheelchair users), entering the church (stairs, no wheelchair ramp), visiting several chapels and crossing a bridge (wheelchair users). Persons with mobility problems needed up to 120 min to cross the entire trail in Kalwaria Warmińska, and some participants were unable to finish the trail. These observations were used to design a trail for persons with mobility impairments. The designed trail was evaluated as problem-free, and the respondents praised the application for its multimedia content, which enabled them to visit sites that were not accessible. Disabled users needed 40 min to complete the proposed trail. The trail for disabled tourists was the shortest of the proposed routes, and it was designed to eliminate spatial obstacles such as steep slopes with an incline greater than 30°, escarpments, and unstable surfaces (gravel, rocks, tree roots). Seniors without mobility impairments completed the dedicated trail in around 70 min (including prayer and stops on the route). The trail was not difficult to traverse, but some seniors experienced fatigue and had to take short breaks. The legibility of tourist signs was evaluated based on the time taken by the users to plan their next move. The decision-making time ranged from 7 s to 5 min. The tested symbols were legible for most users. In a small number of cases, the time required to interpret the symbols was longer due to poor eyesight and the distance between specific landmarks. The accessibility of symbols was evaluated as satisfactory (signs were placed at an appropriate height and in convenient locations, which enabled the respondents to find the relevant content on the map).

The application was tested under various field conditions. The test area was selected to pose a certain challenge for the users. The application enabled the participants to acquire valid information about the trail. The respondents found it difficult to use the mobile application and keep their eyes on the screen when traversing an incline, in particular when moving up or down the stairs. Trails featuring physical obstacles require greater concentration, and the simultaneous use of mobile devices could be more challenging. Physical obstacles, such as dense tree cover, can also compromise signal strength and data transmission speed. In such cases, large data files (video, audio) take longer to download and maps cannot be smoothly scrolled. Only mobile Internet was available on both trails. The quality of the designed application can be improved by connecting to a Wi-Fi network. Image quality is influenced by the type of display and ambient light. On the first trail, image quality was low due to excessive exposure to direct sunlight. Image quality was very high in shaded locations. Touchscreen functionality is strictly correlated with the size and type of the screen. The designed application was more difficult to use on a smartphone (a smaller screen requires greater concentration and accurate pointing), and it was significantly more legible on a tablet. The QR code proved to be a good solution for accessing additional information about tourist attractions on the trail. The users could intuitively access descriptive information about various objects and sites by scanning QR codes with their smartphones. The QR scanning functionality did not cause any problems, and data transmission speed was the only limitation. The user interface was generally legible and comprehensible for the users. However, access to information was restricted by physical obstacles on the trail and signal strength.

Conclusions

The study proposed a social geoinformation service (geoportal) and a mobile application dedicated to seniors. The solutions were implemented for the religious tourism destination in Poland called Kalwaria Głotowska. The applications presented in this study included guidelines for functional and user-friendly geoinformation solutions dedicated to the surveyed group, which were developed in this study.

The results indicated that when designing applications for the elderly, special attention should be paid to their needs and expectations because both natural and man-made obstacles pose the greatest challenge for this user group. Ground surface, slope and route length are important considerations for seniors and people with mobility impairments. Requirements for the geoinformation e-tourism applications should include graphic design, ergonomics and spatial data presentation adapted to user skills.

The presented study makes a contribution to the development of information society. It addresses important topics such as the influence of civilisation on the human life span, improvement in the quality of life and activation and integration of seniors through tourism.

The study paves a way for further research on seniors' perception of cartographic information, and it offers valuable inputs for improving tourist signs on trails intended for disabled visitors.

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Author's contribution

Conceptualization: K.K, A.M.K and A.Z.R.; Methodology: K.K, M.K and A.Z.R; Software: A.M.K, A.Z.R. and M.B.; Validation: K.K., A.M.K, A.Z.R. and M.B.; Formal analysis: K.K., A.M.K, A.Z.R. and M.B.; Investigation: K.K., A.M.K, A.Z.R. and M.B; Resources: K.K., A.M.K, A.Z.R. and M.B.; Data curation: A.M.K. and M.B.; Writing – original draft preparation: A.M.K. and A.Z.R.; Writing – review and editing: A.M.K. and A.Z.R.; Visualization: A.M.K. and A.Z.R.; Supervision: K.K. and A.Z.R.

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References

Albuquerque H., Costa C., Martins F., 2018. The use of geographical information systems for tourism marketing purposes in Aveiro region (Portugal). *Tourism Management Perspectives* 26: 172–178. DOI 10.1016/j.tmp.2017.10.009.

Alén E., Domínguez T., Losada N., 2012. New opportunities for the tourism market: Senior tourism and accessible tourism. In: Kasimoglu M. (ed.), *Visions for global tourism industry: Creating and sustaining competitive strategies*. In-Tech, London 139–166. DOI 10.5772/38092.

Bartoszewski A., 2010. The latest achievements of information technology and tourism – New challenges and opportunities. In: Denek K. (ed.), *Education of tomorrow, The process of upbringing in and out of school*. Humanitas Publishing House, Bucharest: 20-35.

Bielecka E., 2006. *Geographic information systems – Theory and applications*. PJWSTK, Warszawa.

Biłozor A., Kowalczyk A.M., Bajerowski T., 2018. Theory of scale-free networks as a new tool in researching the structure and optimization of spatial planning. *Journal of Urban Planning and Development* 144(2). DOI 10.1061/(ASCE)UP.1943-5444.0000424.

Buhalis D., 2003. *eTourism: Information technology for strategic tourism management*. Pearson (FT/Prentice Hall), London.

Cartwright W., Crampton J., Gartner G., Miller S., Mitchell K., Siekierska E., Wood J., 2001. Geospatial information visualization user interface issues. *Cartography and Geographic Information Science* 28(1): 45–60. DOI 10.1559/152304001782173961.

Chen F., Dai S., Xu H., Abliz A., 2021. Senior's travel constraint, negotiation strategy and travel intention: Examining the role of social support. *International Journal of Tourism Research* 23: 363–377. DOI 10.1002/jtr.2412.

Collins C., Galpin M., Käppler M., 2012. *Android in practice*. Manning, New York.

Collins-Kreiner N., 2018. Pilgrimage-tourism: Common themes in different religions. *International Journal of Religious Tourism and Pilgrimage* 6(1): 8–17. DOI 10.21427/D73428.

Darcey L., Conder S., 2012. *Android wireless application development volume I: Android essentials*. Addison-Wesley, Boston.

Davis D.E., 2003. *GIS for everyone: Exploring your neighborhood and your world with a geographic information system 2*. ESRI, Inc, Redlands.

Diehl M., Wahl H.W., Brothers A., Miche M., 2015. Subjective aging and awareness of aging: Toward a new understanding of the aging self. *Annual Review of Gerontology and Geriatrics* 35: 1–31.

Commission of the European Communities, 2010. i2010 – A European information society for growth and employment. Online: https://op.europa.eu/en/publication-detail/-/publication/4bafb6d8-1f35-4993-b0cf-6b6fb34d8c81 (accessed 5 June 2022).

Fan Q., 2016. Utilizing ICT to prevent loneliness and social isolation of the elderly: A literature review. *Cuadernos de Trabajo Social* 29(2): 185–200.

Fernández C., Esteban G., Conde M.Á., Rodríguez-Lera F.J., 2016. ICT for older people to learn about ICT: Application and evaluation. In: *International Conference on Learning and Collaboration Technologies*, Springer, Cham: 292–302.

Galitz W.O., 2007. *The essential guide to user interface design: An introduction to GUI design principles and techniques*. Wiley, New York.

Ghanem J., 2017. *Conceptualizing "the Tourist": A critical review of UNWTO definition*. Online: https://core.ac.uk/download/pdf/143490244.pdf (accessed 5 June 2022).

Golis E., Omazda A., 2011. Metody badania ergonomii interfejsów stron internetowych. *Prace Naukowe Akademii im. Jana Długosza w Częstochowie. Edukacja Techniczna i Informatyczna* 6: 109–115.

Higgs P., Hyde M., Wiggins R., Blane D., 2003. Researching quality of life in early old age: The importance of the sociological dimension. *Social Policy and Administration* 37(3): 239–252. DOI 10.1111/1467-9515.00336.

Hill R., Betts L.R., Gardner S.E., 2015. Older adults' experiences and perceptions of digital technology: (Dis) empowerment, wellbeing, and inclusion. *Computers in Human Behavior* 48: 415–423. DOI 10.1016/j.chb.2015.01.062.

Ivankina L.I., Trubchenko T.G., Krukovac E.M., Shaidullina A., Shaftelskaya N.V., Chernyak V.K., 2017. The use of information and communication technologies by elderly people (Sociological Survey Data). In: Casati F., Barysheva G.A., Krieger W. (eds), *Lifelong Wellbeing in the World – WELLSO 2016* 19: 235–242. DOI 10.15405/epsbs.2017.01.32.

Jancewicz K., Borowicz D., 2017. Tourist maps–Definition, types and contents. *Polish Cartographical Review* 49(1): 27–41. DOI 10.1515/pcr-2017-0003.

Janowski A., Jurkowska A., Przyborski M., Sobieraj A., Szulwic J., Wróblewska D., Wieczorek B., 2014. Improving the quality of education through the implementation of the diplomas and group projects during engineering studies in cooperation with employers. *6th International Conference on Education and New Learning Technologies* 7–9 July 2014*:* 1837–1843.

Jansson M., Lindgren T., 2012. A review of the concept 'management' in relation to urban landscapes and green spaces: Toward a holistic understanding. *Urban Forestry and Urban Greening* 11(2): 139–145. DOI 10.1016/j.ufug.2012.01.004.

Jaszkiewicz A., 1997. *Software engineering*. Helion, Gliwice.

Karahoca A. 2012. *Advances and applications in mobile computing*. BoD–Books on Demand, Rijeka.

Khosravi P., Rezvani A., Wiewiora A., 2016. The impact of technology on older adults' social isolation. *Computers in Human Behavior* 63: 594–603. DOI 10.1016/j.chb.2016.05.092.

Klimova B., Simonova I., Poulova P., Truhlarova Z., Kuca K., 2016. Older people and their attitude to the use of information and communication technologies–A review study with special focus on the Czech Republic (Older people and their attitude to ICT). *Educational Gerontology* 42(5): 361–369. DOI 10.1080/03601277.2015.1122447.

Kowalczyk A., 2012. The iconic model of landscape aesthetic value. *European Spatial Research and Policy* 19(2): 121–128. DOI 10.2478/v10105-012-0018-3.

Kowalczyk A.M., 2014. The analysis and creation of landscape aesthetic value network models as important elements of sustainable urban development. *The 9th International Conference Environmental Engineering* 2014, 22–23 May 2014. DOI 10.3846/enviro.2014.123.

Laurich R., 2002. The platinum web: Sites dedicated to senior Citizens on the internet. *Collection Building* 21(4): 174–182. DOI 10.1108/01604950210447421.

Marinacci J., 2012. *Building mobile applications with Java*: *Using the Google Web Toolkit and PhoneGap*. O'Reilly Media, Inc, Sebastopol.

Mordini E., Wright D., Wadhwa K., De Hert P., Mantovani E., Thestrup J., Vater I., 2009. Senior citizens and the ethics of e-inclusion. *Ethics and Information Technology* 11(3): 203–220. DOI 10.1007/s10676-009-9189-7.

O'Hara K., 2004. "Curb Cuts" on the information highway: Older Adults and the internet. *Technical Communication Quarterly* 13(4): 426–445.

Orzechowska G., 2012. Counteracting the educational and social disadvantage of people in late adulthood. In: Szarota Z. (ed.), *Adult education towards disadvantaged individuals and groups*. Pedagogical University in Kraków, Kraków.

Pachelski W., Chojka A., Zwirowicz-Rutkowska A., 2012. *Fundamentals of building spatial information infrastructure.* Publishing House of the University of Warmia and Mazury in Olsztyn, Olsztyn.

Poczta-Wajda A., Poczta J., 2016. The role of natural conditions in qualified agritourism – Case of Poland. *Agricultural Economics* 62(4): 167–180. DOI 10.17221/97/2015-AGRICECON.

Ramos-Soler I., Martinez-Sala A.M., Campillo-Alhama C., 2019. ICT and the sustainability of world heritage sites. Analysis of senior Citizens' use of tourism apps. *Sustainability* 11: 3203. DOI 10.3390/su11113203.

Renigier-Bilozor M., Janowski A., Walacik M., 2019. Geoscience methods in real estate market analyses subjectivity decrease. *Geosciences* 9(3): 130. DOI 10.3390/geosciences9030130.

Rodríguez C.I.R., 2012. Seniors and technology, ergonomic needs and design considerations. *Work* 41(Supplement 1): 5576–5578.

Szmigielska B., Bąk A., Hołda M., 2012. Seniorzy jako użytkownicy Internetu [Seniors as Internet users]. *Polish Academy of Sciences, Warsaw* 2: 141–155.

Voronkova L.P., 2018. Virtual tourism: On the way to the digital economy. *IOP Conference Series: Materials Science and Engineering* 463(4): 042096.

Williams D., Wang MT., Chang CH., Ahamed S.I., Chu W., 2015. ShowMeHow: Using smart, interactive tutorials in elderly software development. In: Bodine C., Helal S., Gu T., Mokhtari M. (eds), *Smart Homes and Health Telematics. ICOST 2014. Lecture Notes in Computer Science*, Vol. 8456. Springer, Cham. DOI 10.1007/978-3-319-14424-5_6.

Yu R.P., Ellison N.B., McCammon R.J., Langa K.M., 2016. Mapping the two levels of digital divide: Internet access and social network site adoption among older adults in the USA. *Information, Communication and Society* 19(10): 1445–1464. DOI 10.1080/1369118X.2015.1109695.