Web GIS in mountaineering in Croatia

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Abstract

Using maps is inevitable in many human activities as well as in mountaineering. Until recently, most of the spatial and attribute data of the mountaineer's interest could have been found only in analog form. With the development of information technology, global navigation satellite systems (GNSS), easily accessible measuring sensors and digital cameras, it is easier to collect, store, visualize, share, and update spatial data. The web GIS with its associated applications assumes dominance in browsing and dissemination of spatial data, and is applied in areas where there is a need for processing, analysis and visualization of various data that contain a spatial component, including mountaineering. When planning hiking, mountaineers need both spatial and attribute information on mountaineering facilities, checkpoints, and hiking trails in the form of GNSS traces. Through the interactive web application interface, it is possible to connect all these data, enabling easy viewing, browsing and analysis, or performing various spatial queries, which greatly facilitates the planning of hiking excursions. This paper presents a review and comparison of four most visited Croatian mountaineering portals: HPS's *Interactive Mountaineering Map of Croatia*, *Mountaineering portal* and *Geodetic mountaineering portal* developed at the Faculty of Geodesy of the University of Zagreb and *planinarenje.hr* portal developed by the group of mountain enthusiasts. Numerous data on Croatian mountains and peaks, mountain facilities, huts and hiking trails are now accessible through portals to anyone with Internet connection, either with the computers, tablets or smartphones. All users can browse, filter and download data from the portal, and there are additional options for authorized users such as commenting on portal content. Several thematic portals of neighboring countries were also analyzed (portal of the Slovenian Mountaineering Association, Slovak mountaineering portal and one Swiss mountaineering portal) and compared with Croatian portals. Finally, the importance of the web GIS portals for the development of mountaineering tourism was emphasized, as well as the ecological culture and the sustainability of the mountaineering environment (preservation of mountain trails and facilities, protection of endemic plants, karst and geological features, etc.).

Highlights for public administration, management and planning:

- The presented web GIS represent an effective and efficient tool for planning and conducting trips in mountain areas as it allows better organization and management of mountain content for the tourists and other hikers.

- Registered users can participate in the portal update (e.g. peak or hill endonyms) and this can be used by State Geodetic Administration for their register of geographical names (http://rgi.dgu.hr/pretrazivanje)

- The Web GIS can also be used as a support in the tourism development of local mountain areas with respect to the ecological culture and sustainability of the mountain environment.

1   Introduction

Using maps is inevitable in many human activities including mountaineering. Hiking books and conventional maps were the most important sources of numerous descriptive (attribute) and spatial information. Despite the rapid development of technology over the last decades, most of the spatial data related to the mountaineering facilities, checkpoints of hiking tours and hiking trails, until recently, was possible to find only in analog form as various publications and thematic maps. For ex-

ample, attribute information on mountaineering facilities and access roads could have been found in thematic textbooks, guides and diaries (logs), and visualization of the access roads (hiking trails) were available only on printed maps.

Information and communication technology have significantly influenced on many human activities including mountaineering (Čaplar 2019). Maps represent the best way to visualize the space around us while the internet provides the fastest access to maps, what conventional (printed) maps have never had (Kraak 2004; Tanfara & Tutić 2007). The availability of maps over the Internet in the form of web GIS applications made the maps more accessible to a larger number of people and enabled their popularization. Such applications have found numerous applications in many human activities including tourism and mountaineering (e.g., Jansen et al. 2008; Chang & Caneday 2011). Today, there are few people who do not carry mobile phones on hiking. With smart phones, they can not only know their position, but also access mountaineering web GIS applications that provide valuable information to users.

The development of Global navigation satellite systems (GNSS), laptops, smart phones and the ubiquitous Internet as well as the development of numerous and relatively easily accessible measuring devices (sensors), such as handheld (mobile) GNSS devices, has made it easy to collect, store, visualize, share and update spatial information. However, it is impossible to display this information in real-time, for example, on conventional maps. Thanks to mention progress in technology, many hikers today have detailed information and digital records of hiking trails in the form of GNSS trace, most often in .gpx format (Pašić & Špoljarić 2018). However, for hikers, when planning excursions, it's usually not enough to have just access to a specific GNSS trace of a hiking trail. In hiking, it is very useful to have spatial and attribute information about mountaineering facilities (houses, huts, shelters), information about checkpoints of hiking tours, mountain peaks and more.

Due to all the above, this paper highlights the need for mountaineering portals as well as the importance of active user participation in completing and updating information on portals (crowdsourcing). Furthermore, the paper provides for four most visited Croatian mountaineering portals an overview and analysis of positional and attribute data, their up-to-date and reliability, as well as the possibilities of web GIS queries.

Several thematic portals of neighboring countries were also described and comparatively analyzed:

the Slovenian Mountaineering Association portal, the Slovak mountaineering portal and one Swiss mountaineering portal. It is indisputable that web GIS based applications are important for extending the tourist offer, therefore the importance of web GIS portal for the development of mountain tourism is emphasized in the paper as well as the ecological culture and the sustainability of the mountaineering environment (preservation of mountain trails and facilities, protection of endemic plants, karst and geological features, etc.). Croatian Mountaineering Association (HPS), in its program and strategy for the development of Croatian mountaineering by 2025, clearly states that the association is the bearer and promoter of nature excursion with minimal damage to nature and the whole environment (HPS).

2 Web GIS and crowdsourcing

Today's technology (hardware and software), affordable or free of charge and accessible to a wide range of potential users, enables collecting of spatial data of hikers interest and the development of thematic web GIS applications and portals for their visualization, analysis and sharing. GIS software allows users to view spatial information in the appropriate formats. Thanks to them, interpretation, visualization and understanding of spatial data have become very simple today. Unfortunately, everyone does not have access to GIS, so, web GIS becomes a cheap and easy way of disseminating geospatial data and processing tools (Alesheikh et al. 2002). By creating a web GIS application, it is possible to connect all data of interest for hikers through an interactive web interface and allow easy search, browsing and sharing of those data. Web GIS applications have many advantages over the classic desktop GIS software's. The user can access the application from any location via the internet browser, so we are talking about a global approach that brings a large number of users. Most web GIS applications only require an internet browser, meaning there are no limitations to just one operating system, but can be used on almost all platforms. The application update is in one place (on server), allowing all users the up-to-date version. Furthermore, it is possible easy to use other, different applications (Miler 2015).

In web GIS applications designed for hikers, it is very useful to have a record of all accessible hiking huts, homes and shelters and attribute information in photo and text form. Along with numerous information on mountaineering facilities, infor-

mation about checkpoints, mountain peaks and hiking trails that are most often in the form of GNSS trace, are of great importance. Such comprehensive and complete web GIS portal which encompasses all essential information to hikers, provides for user of the portal an overview, visualization and analysis of all data. Some portals allow additional interaction through user comments on sub-pages of individual objects or checkpoints as well as the ability to upload and share their own GNSS traces as well as commenting and evaluating of existing content. In that way, users are directly involved in updating the data and completing the content of the application. Such a way of interaction is called crowdsourcing.

Crowdsourcing imply the process of collecting data from different groups of people, mostly unprofessional and with insufficient knowledge of computer and web technology (Leymann 2009). Such data is transmitted and stored on shared computer units (servers) or computer clouds. Crowdsourcing is a new paradigm of data collection with the help of sensors which are currently available to most people. How here, the most often are used mobile devices that allow you to determine location, we talk about voluntarily collecting of spatial data (Volunteered Geographic Information, VIG). In that way, a completely new discipline of location-based services is developed, which in some way complements official cartography.

For hikers, the most interesting and thematic most complete web GIS applications are those with dynamic views of digital maps and access to spatial queries using attribute or geometric data. Such web GIS applications are analyzed in the paper.

3   Croatian mountaineering portals

Croatia has a long history of mountaineering which proves the fact that Croatia is the ninth country in the world that founded the mountaineering society back in 1874, when organized hiking begins. Since then, more than a hundred mountaineering facilities have been built and numerous hiking trails have been made and marked along the Croatian mountains. Today, after 145 years of existence, the Croatian Mountaineering Association (HPS), the traditional and legal successor of the Croatian Mountaineering Society, has more than 30 000 active hikers organized in more than 290 mountaineering associations (Croatian Mountaineering Association 2019). Information on Croatian mountaineering, mountains, facilities and mountaineering associations is published on the HPS

website (https://www.hps.hr). In addition to the official HPS website, on the Croatian mountaineering web there are several similar thematic portals, and which are additional sources of information for hikers (Smukavić et al. 2014).

This paper describes and analyzes the four most visited Croatian mountaineering portals with web GIS capabilities: HPS's *Interactive Mountaineering Map of Croatia*, *Portal planinarenje.hr* of group of mountaineering enthusiasts and *Mountaineering Portal and Geodetic Mountaineering Portal* developed at the Faculty of Geodesy of the University of Zagreb. The representation of positional and attribute data on the portals as well as their up-to-date, reliability and webGIS query capabilities were analyzed. The portals are updated by numerous users who record GNSS traces when hiking, take pictures of checkpoints on the peaks and mountain facilities (crowdsourcing). The reliability of this data is analyzed by comparing GNSS traces with each other, comparing these traces and other data with thematic maps of the Croatian Mountain Rescue Service (HGSS), topographic maps of the State Geodetic Administration (DGU) and other mountaineering maps such as SMAND mountaineering map (https://www.smand.hr/?l=en). Attribute data on facilities and other mountain objects and checkpoints are compared with data on the websites of individual mountaineering societies and the Croatian Mountaineering Association and with data from the HGSS.

Several open source information technologies that do not depend on end – user device platforms have been used in the development of these three digital logs. The Python programme language was used for the back – end of the hiking log with its web framework Django, while JavaScript, HTML and Cascading Style Sheets (CSS) were used for the front – end of hiking logs with Leaflet and Bootstrap library, where Leaflet is a JavaScript library for interactive maps, and the Bootstrap library adjusts the content of the e-log to the resolution of the end user's device. For data storage was used PostgreSQL database with its PostGIS spatial database extender (Tomac & Špoljarić 2016).

3.1   Interactive Mountaineering Map of Croatia

Since mid-December 2018, the HPS website has an independent informatics unit — *Interactive Mountaineering Map of Croatia* (https://www.hps.hr/karta/). Its main purpose is to publish reliable and up-to-date information on hiking trails, facilities, most important peaks,
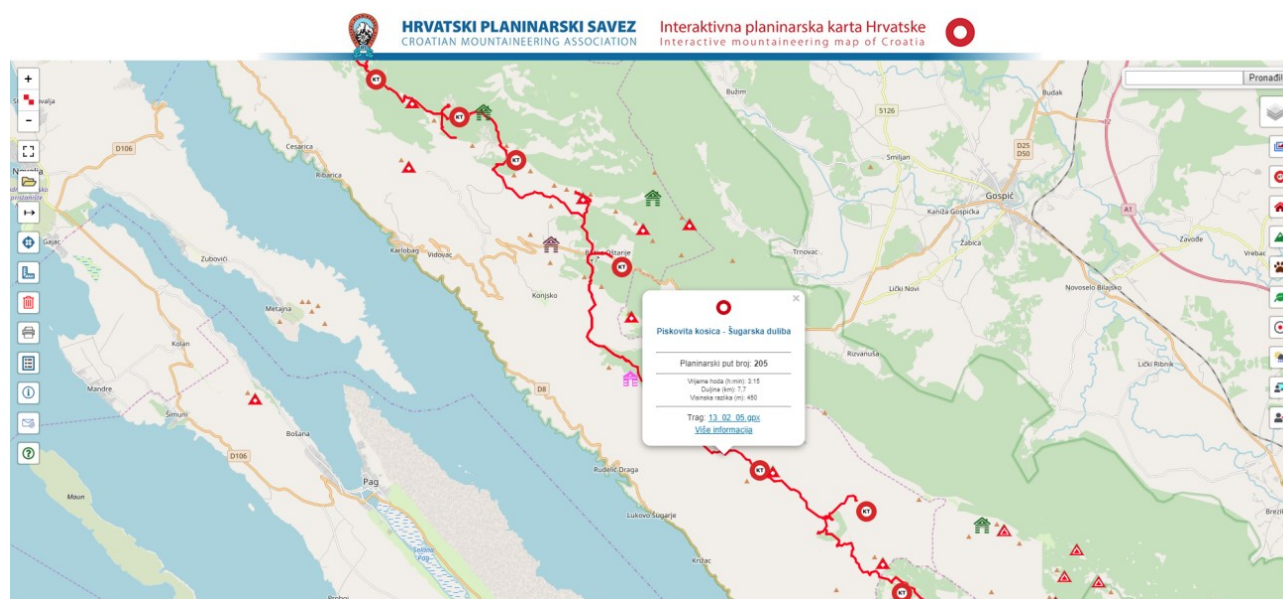
Fig. 1 Main Interface of the Interactive Mountaineering Map of Croatia portal (Croatian Mountaineering Association 2019)

hiking tours and other HPS data that will make easier for hikers and other users to plan excursions and hiking expeditions. This interactive map represents a sort of web GIS since the user can, by clicking the mouse, choose between several base maps, modify the content that is displayed and execute certain queries (searches). The user can select one of the sixteen available cartographic base maps, with OpenStreetMap is the default. It is possible to change the size of the map view (zoom), search thematic content of the map specifying the toponym or name that is being searched, delete the existing and add own objects, measure the distance, read the coordinates or print the map. The map shows different objects such as hiking trails, huts, houses and shelters, arbors, springs, highest peaks and others (Čaplar 2019). User interactivity is realized through the icons on the right and left sides of the map area. So, with the mentioned above, it is possible to select one of 43 different areas that are composed of geographic units within a certain number of peaks, hiking trails, huts or shelters are located. Furthermore, it is possible to show checkpoints of five different hiking tours, among which stands out the *Croatian hiking tour* (HPO), display mountain peaks higher than 1 500 m, national parks and nature parks and determine the geolocation if user access the portal via the mobile phone. Fig. 1 shows the homepage (main interface) of the *Interactive Mountaineering Map of Croatia*.

After clicking on the selected object, the floating window will display with the basic information about the object. By clicking on »Više informacija« (More information), HPS's website opens with additional information about this object. For example, by choosing a hiking trail, detailed information on its name, start and end point, time of travel, length and height difference with detailed description and annotations appear. In the same window it is possible to download a GNSS trace in .gpx format. Choosing a home, huts or shelter, window with detailed descriptions and information about the selected object also appear while clicking on the mountain peak or checkpoint shows the coordinates and the associated photo. Interactive Mountaineering Map of Croatia uses the data collected and processed by the HPS Commissions: Hiking trails Commission, Commission for mountaineering facilities and Advertising and Publishing Commission. On the map are displayed only those objects which are recorded in HPS official registers and databases, and these are 1100 trails and more than 1000 different objects and locations (Čaplar 2019).

3.2 Portal planinarenje.hr

Portal planianrenje.hr (*https://planinarenje.hr/gorja*) has developed a group of hiking enthusiasts to make easier for lovers of natural beauty and intact areas to go and stay in this environment (*Portal plan-*

inarenje.hr 2019). The portal contains information on numerous mountain destinations (mountain peaks) and hiking trails with detailed descriptions in the form of text, photos and tables, all complemented by visualization on the map. As a base map, the portal uses OpenStreetMap, where search by destination name, or name of the trail to a certain peak is enabled. As shown in Fig. 2 (left), on base map there are icons that indicate the peaks of mountains (destinations). By clicking on the icon of the selected peak, the floating window with the name and the altitude of the peak opens and clicking on that window opens a new page with a detailed description and list of hiking trails leading to that peak. For each trail within database of this portal, a detailed description with numerous information, which are used by hikers for orientation and tracking the trail towards the goal, is given. With description, for each trail, cartographic visualization on Google Map as a base map is provided, with an interesting object for hikers along the trail, such as mountain huts, peaks, natural beauties and attractions, but also information about the traffic infrastructure near the start and end points of the trail. In addition to this, the portal gives us statistics and overview of the trail in tabular form. For example, here we can find information about walking duration, altitude of start and end point of the trail, altitude differences, length, complexity, marking of the trail and average slope. With the table, transversal section (profile) of the trail is shown

in 2D and 3D format. All of this is shown in Fig. 2 (right). The particularity of this portal is that it does not only cover the mountains in Croatia but can also information about the peaks in neighboring countries can be found: Austria, Bosnia and Herzegovina, Bulgaria, Montenegro, Slovenia, Switzerland and Italy. For registered users the portal offers additional features such as downloading a GPS trace of some trail in .gpx format, commenting on portal content and uploading photos, while the review of the uploaded photos and comments is available to all users.

3.3 Mountaineering portal

For the purpose of improving the mountain web content in Croatia, on the Faculty of Geodesy in Zagreb was developed a web GIS application – Mountaineering portal (www.planinarski-portal.org) with a dynamic review of the maps and the ability to perform various spatial queries on mountaineering facilities and checkpoints (Pašić & Špoljarić 2018). The application is intended to be a complete web GIS portal that includes all relevant information about mountaineering facilities, checkpoints of HPO and hiking trails. Along with the current overview and analysis of all thematic data (homes, huts, shelters, HPO checkpoints, hiking trails etc.), the portal enables interaction to users by offering them the ability to upload and share their own photos and GNSS traces of hiking trails. In this way, many
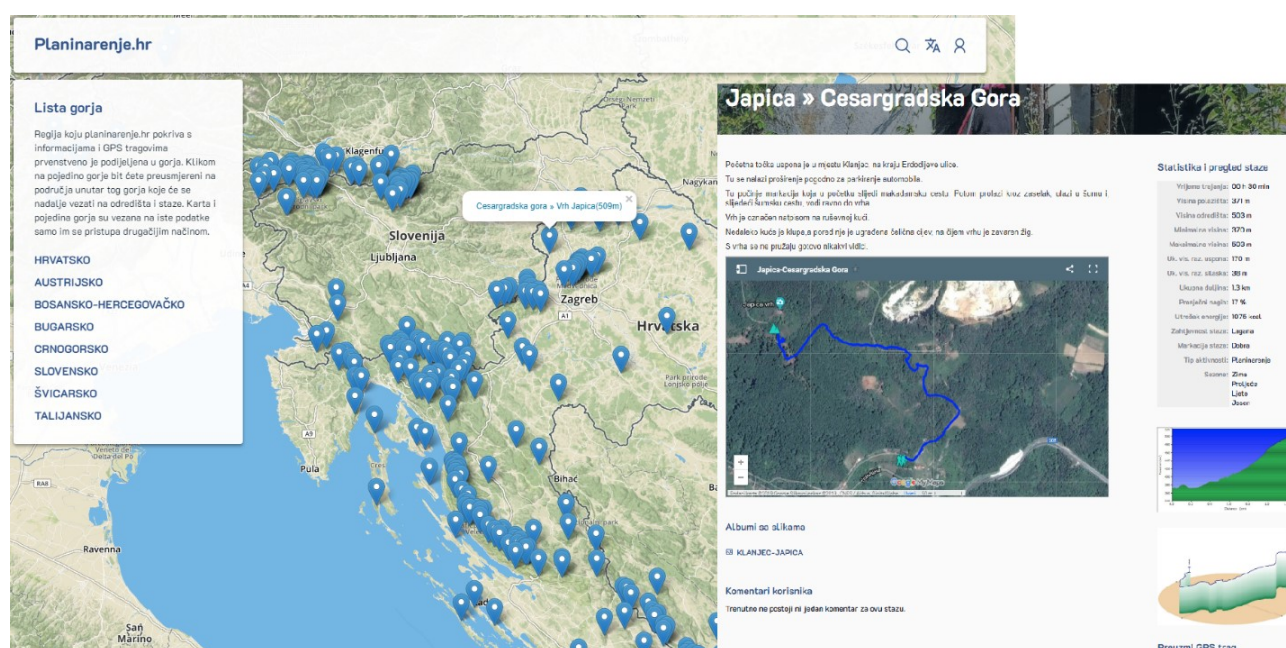

Fig. 2 Interface of hiking section on planinarenje.hr portal (Portal planinarenje.hr 2019)

registered users who have collected thematic data (crowdsourcing) during hiking can participate in filling of the GIS content of the application, which contributes to its promptness (Mountaineering Portal 2019). The map interface has been developed so that all the tools are placed within the toolbar at the top of the page while the map window is intended for the visualization only. For the more transparent and easier search of objects on the map the data is organized into layers. Layers on the map are divided into background layers that, along with the default OpenStreetMap, include a choice of 6 other cartographic base maps, and overlay layers that encompass mountaineering facilities, checkpoints and GNSS traces. Different mountain objects are differentiated on the map with different icons, so in the basic view there are icons that show the position of checkpoints, houses, shelters and huts, and line objects that display GNSS traces. Moving the mouse over the icons of a particular object basic information about this object is shown (Fig. 3), and by clicking on the icon of the individual shelter, hut or home and selecting the »Opis doma« (Home Description), a detailed description will appear with information about contact, infrastructure, number of places to sleep and more. Below this information is also a photo gallery with illustrations of the interior and exterior of the ob-

ject. By the same principle, moving the mouse over an icon or by clicking on the checkpoint icon, numerous information about them with detailed descriptions and photographs are shown (Pašić & Špoljarić 2018). Unlike mountaineering facilities, GNSS traces do not have so many attributes and most of the information about them are displayed in the window at the bottom of the screen that appears by moving the mouse across the trace. By clicking on the trail, the user is offered to download the trace in .gpx format. Along with searching and browsing data about objects and GNSS traces, there are also several tools that enable greater map interactivity with the user. These are for example geolocation (determination of the current position of the user using a GPS sensor in mobile phone or triangulation depending on the signal of the mobile network), map distance measurement and data filtering by different attributes. In order to filter the information about hiking objects more easily, it is also possible to set GIS queries related to the data on the map. Query can be set based on several attributes: area (within mountaineering objects are located), category (type) of a mountaineering object, altitude, number of places to sleep, and availability of water, electricity and roads to access by vehicle to the facility itself. The GIS query options are shown in Fig. 3.
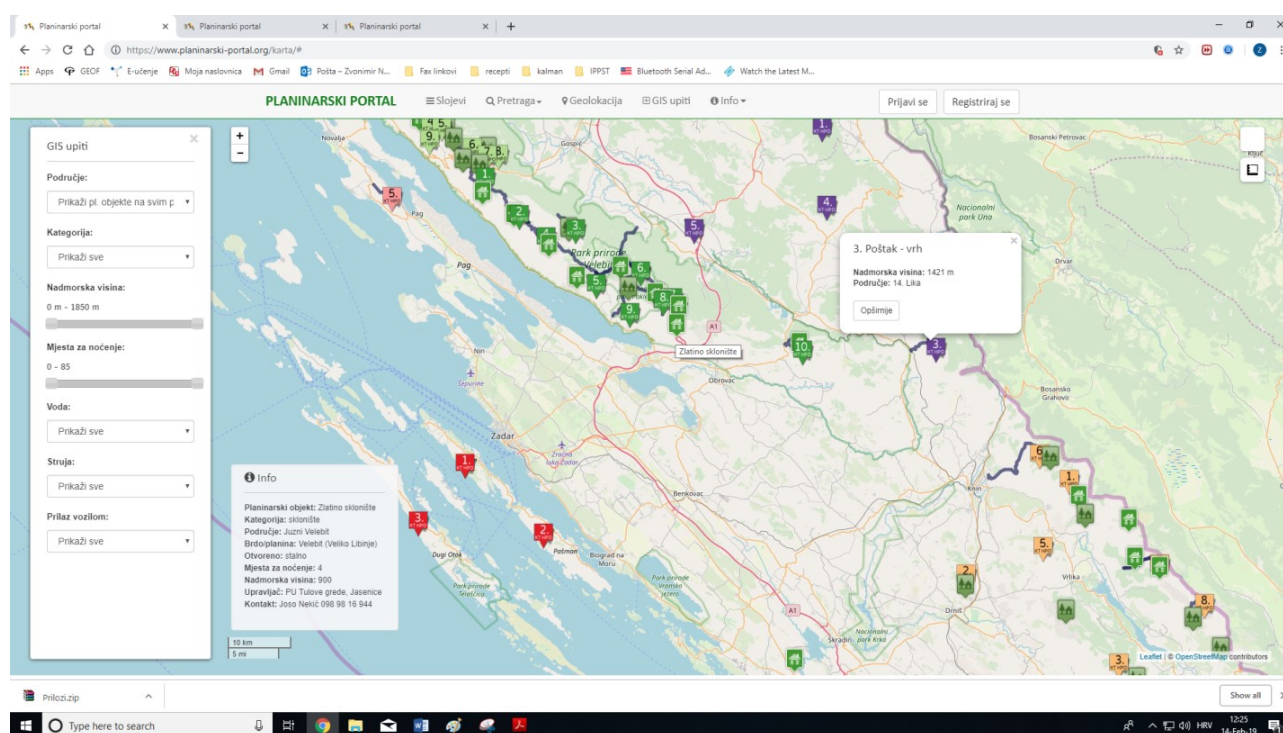

Fig. 3 Map of the Mountaineering portal (Mountaineering Portal 2019)

In addition to uploading GNSS traces and photos of mountaineering objects, registered users are also able to access to number of other features through the portal, such as commenting and evaluating the existing map content and changes of the HPO checkpoints. Thus, registered portal users can view, download, upload and control the entered data, because checked (reliable) and updated spatial and attribute data on mountaineering facilities, hiking trails and HPO checkpoint will facilitate the planning of excursions and enhance the safety of domestic and foreign visitors to Croatian natural beauties (Mountaineering Portal 2019). The interactive web application interface is customized for most mobile and tablet devices, making it easier to use applications on smaller devices such as smartphones.

3.4   Geodetic mountaineering portal

Since the most of trigonometrical points (trigonometers) of the 1st order on the territory of the Croatia are on mountain peaks, they represent a great interest for hikers. Trigonometers placed on mountain peaks are mostly stabilized as pillars or pyramids, and most of them are located on grassy or rocky peaks which provides wide-open views. For the purpose of popularizing the peaks with trigonometers, a new hiking tour − *Geodetic Mountain Tour* (GPO), whose checkpoints are those trigonometers, was designed at the Faculty of Geodesy in Zagreb. The largest and most beautiful national hiking tour Croatian hiking tour has 152 checkpoints of which only 26 are on the peaks which contains trigonometers (of 75 in total), so, 49 of them are unknown to the public. The development and realization of the tour started in 2017, and the *Geodetic mountaineering portal* (https://geopp.planinarski-portal.org/) was developed in parallel as a functional, content-confident and rich informatics support of the tour. It is realized as a web GIS application that serves as a database of checkpoints of the tour and provides to future hikers numerous information and various IT tools for preparation and successful visit of GPO checkpoints (Jagetić & Špoljarić 2018). The application contains an interactive map that allows you to choose between 10 different base maps, with OpenStreetMap been selected as the default. The content that can be displayed on the map includes the trigonometric point of the 1st order marked with different icons depending on the stabilization method and the condition of trigonometer, the trigonometric network of the first order, GNSS traces of access to trigonometric points, checkpoints of HPO and 14 differ-

ent areas that are composed of geographic units within checkpoints are divided. Clicking on a particular trigonometer, floating window displays whit its name and tag, and clicking on the window opens a new page where detailed description for each point is given. Description contains stabilization and signalization method, photo gallery, interactive map with hiking trails to the point and spatial and attribute data of geodetic and mountaineering content. For each point you can find a detailed description of the hiking trail and the GNSS trace in the .gpx format that can be downloaded. Clicking on the icon of the HPO checkpoint opens a window that represents the link to the Mountaineering portal, i.e. the sub-page of the portal where the selected point is described in detail. With search and review of checkpoints and GNSS traces, there are also several tools that allow greater interactivity of the map with the user. These are for example geolocation, map distance measurement, and map data filtering (GIS queries). GIS queries can be made by selecting areas, trigonometric points, stabilization method, and altitude or ellipsoid height of the points. Additional parameters of checkpoint queries were also set, and they allow user to select a point, depending on whether it is in the settlement, military or mine suspected area and is the point at the same time a part of the HPO. The map of the *Geodetic Mountaineering Portal* with checkpoints of the *Geodetic Mountain Tour* is shown in Fig. 4. Apart from cartographic content, the portal also contains additional information on geodesy and the thematic dictionary. There is also a historical overview of trigonometric measurements with the topographic maps created based on the first, second and third topographic surveys.

4   Discussion: cross-country comparison and prospects for Web GIS

4.1   Mountaineering portals in Slovenia, Switzerland and Slovakia

There are several neighboring countries that have a long tradition in mountaineering and have developed mountaineering web GIS applications / portals for hikers and other excursionists. In this paper we will describe and analyze the thematic portals of the Slovenian Mountaineering Association (https://en.pzs.si/), the Slovak mountaineering portal (http://www.slovak-republic.org/hik-
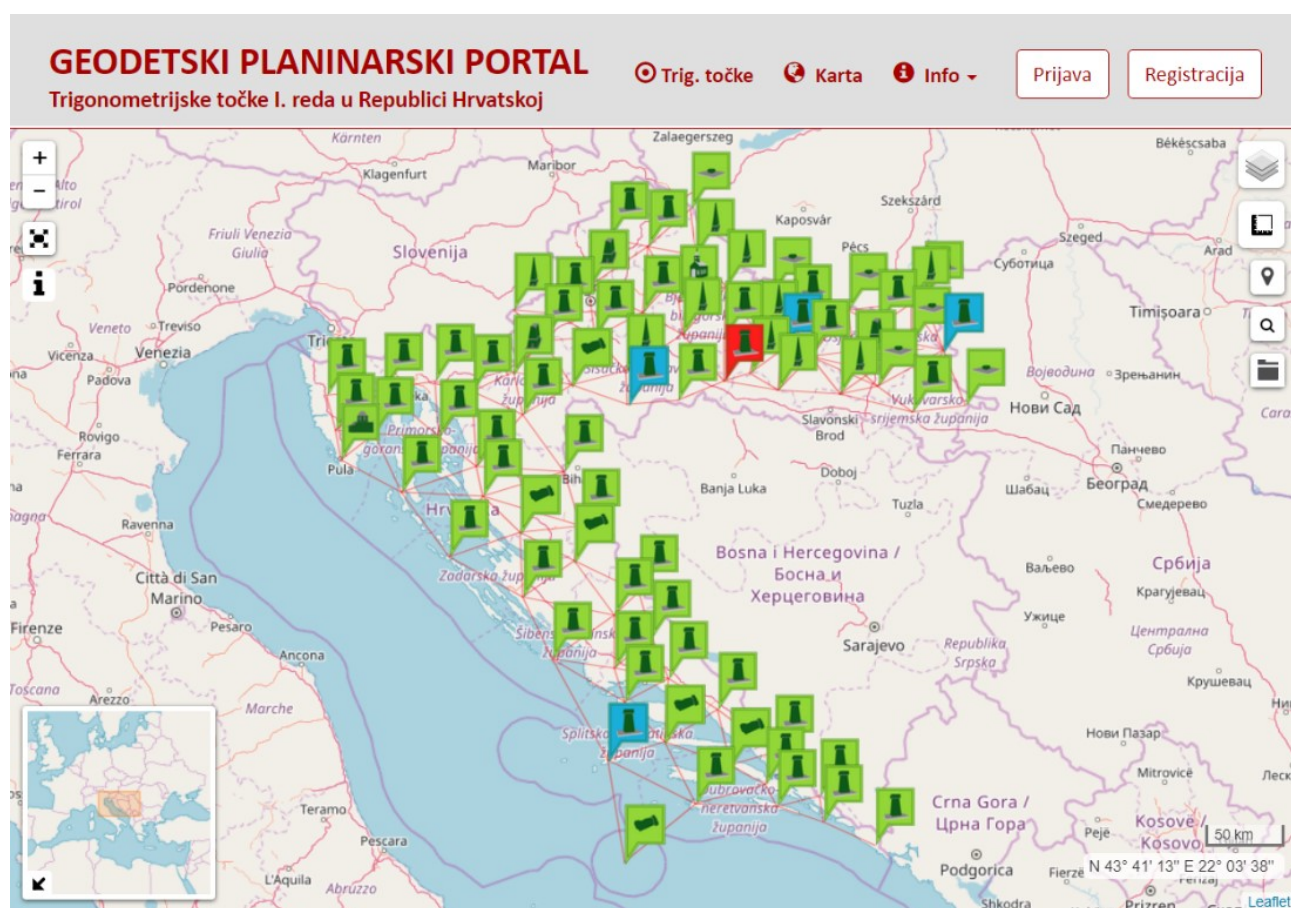
Fig. 4 Map of the Geodetic Mountaineering portal (Geodetic Mountaineering Portal 2019)

ing/hiking) and one Swiss Mountaineering Portal (https://www.schweizmobil.ch/en/summer.html).
The portal of the Slovenian Mountaineering Association and the mentioned Swiss portal contain numerous information on mountain peaks, objects and trails, and Slovak much less. For example, on the portal of the Slovenian Mountaineering Association, on three separate interactive maps can be found numerous information about checkpoints, trials and mountain facilities. On first map, clicking on checkpoint/peak gives information about the name, height, area and mountaineering society which is responsible fort that point. On the map with trails and objects, can be found a wealth of information, but detailed descriptions, photos and other illustrations are missing. On the Swiss portal, on one map we can find numerous spatial, attribute and other useful information with detailed descriptions and photos of hiking trails. Furthermore, 3D view of all trails, objects along the trails, as well as signaling and marking of the trails are also provided. For hiking facilities there is no detailed attribute information but only a link to Facebook or the web page of the facility.

On the same portal we can find a lot of information about nearby cycling and skiing routes. The Slovak Mountaineering Portal offers only brief textual descriptions of how to reach a particular peak with few illustrations and a static map (no interactivity) and is based more on descriptions of peaks and natural features.

4.2   Possibilities and future plans

By comparing mentioned mountaineering portals with each other, it was analyzed what individual portals provide to users, and how they differ in content. Thematic content of all portals was also analyzed by comparing the positional and attribute data of identical mountaineering objects and checkpoints. For example, the GNSS traces, descriptions and markings of trails, condition of stamps at checkpoints and more were compared with information on the websites of individual mountaineering societies and data from the Croatian Mountain Rescue Service (HGSS). Numerous data on mountaineering facilities and their representation on a particular portal were also compared and analyzed.

Each of the described portals offers users reliable and up-to-date spatial and attribute information about mountaineering facilities with the purpose of facilitating the excursions planning and staying in nature and to enhance the security of Croatian and foreign visitors to Croatian mountains. All portals allow users to view the mountaineering content on a dynamic digital map with the ability to search the contents of the map while on the Mountaineering Portal and the Geodetic Mountaineering Portal GIS queries are also provided to users. GIS queries further facilitate the search of map content, which is an advantage of these two portals over the others. The lack of these two portals is incompleteness of information for about 20% of mountaineering facilities and checkpoints. Content incompleteness is present on portals because small group of authors, who started and editing the portal, on its own visit object and checkpoints, take their photos and describe them, measure GNSS traces and finally, the collected data entering into the application database. For all objects on the portal, basic information can be found, and additional attributes, descriptions and photos are still in the collection phase. Unlike the Mountaineering Portal that contains information about homes, huts, shelters, checkpoints of HPO and hiking trails, Geodetic Mountaineering Portal is thematically oriented to a future hiking tour − the Geodetic Mountaineering Tour. Another advantage of these portals is the ability to comment and thus filling the content by registered users what is a form of crowdsourcing. All user updates and data are verified by the system administrator.

An Interactive Mountaineering Map of Croatia has been developed by the Croatian Mountaineering Association (HPS) which makes her, as the official HPS application, content richest especially with the network of hiking trails and their GNSS traces. However, information about individual objects is currently not detailed as on other portals, especially about mountaineering facilities. The descriptions of mountaineering facilities are most detailed on the Mountaineering Portal, while the most detailed overview and description of hiking trails can be found on the *portal planinarenje.hr*. In fact, this portal is mostly oriented to hiking trails to numerous destinations (mostly mountain peaks), while the remaining content is poor with information. For example, for homes and other facilities, we can find just a position coordinate and / or a photo. Furthermore, unlike the remaining three portals, it does not offer additional tools on the map, such as distance measurements, geolocation, change of the base map and GIS queries.

All the portals contain information about the checkpoints of the Croatian Hiking Tour. But only on the Mountaineering Portal and the Geodetic Mountaineering Portal the thematic E-logs are connected, which are also developed at the Faculty of Geodesy. E-log of HPO and HPK (Croatian Mountain Huts) on Mountaineering Portal and E-log of GPO on Geodetic Mountaineering Portal (Tomac et al. 2018).

Currently, applications, such as viewing position and attribute information about hiking facilities and checkpoints or geolocation, can only be used in online mode (with Internet access and mobile network). For some applications, the ability to download content to mobile phones or handheld GNSS devices for off-line operation mode is currently developing. All the features of applications through web browsers on desktops are identical to the capabilities on mobile phones. On mobile phones, geolocation tool is particularly important, which has often proved to be significant when hiking, especially when approaching some peaks that are not marked by hiking trails.

Described mountain hiking portals are a great source of useful information for hikers and other visitors, but the basic disadvantage is the dispersion and partial incompleteness of provided information. Each of the analyzed portals has its advantages and disadvantages. For example, when planning a trip, we will combine data from all portals because each one contains more detailed and up-to-date information on a particular topic (object, trails, etc.). The advantages and disadvantages of the portals are mutually complementary, and they complement each other's content because the advantages of a one portal are the disadvantages of the other and vice versa. Therefore, the solution that is imposed for the future, is that all data from portals, as well as information about all hiking tours and access to all E-logs, must be merged into one content complete and rich portal with reliable and up-to-date data. This will allow users instant access to the required mountaineering information.

Analyzing portals in three neighboring countries we can conclude:

1. the Slovenian portal, have numerous information classified by categories (trails, peaks / checkpoints and objects), but attribute descriptions and illustrations are missing;

2. the Swiss portal contains the most information about trails and peaks, but attribute descriptions of the objects along the trails are missing, and the significant advantage of the Swiss portal is the additional 3D visual-

ization and detailed overview of trail signaling and marking;

3. according to the information, the Slovak portal is by far the poorest.

From all the above, we can conclude that the Croatian, Slovenian and Swiss portals are the richest in content and that they differ in detail. For example, the Swiss portal provides the most information on hiking trails, and Croatian portals are not far behind, but on them you can find the most information with detailed descriptions and photos of mountain objects and peaks, all visualized on a one web map with a simple search tool. Mountaineering content on the Slovenian portal is sorted and visualized individually (by category) on three web maps, which is sometimes an advantage in planning excursions or hikes.

The Croatian Mountaineering Association, as the head organization of Croatian mountaineering, operates in the field of sports, recreation and nature protection and is engaged in the development and promotion of mountaineering, sport climbing and mountain skiing, and promoting and expanding these activities. In addition to being a member of the Croatian Olympic Committee, the International Federation of Alpine Climbing and Mountaineering, the International Climbing Federation is also a member of the European Hiking Association and the Regional Balkan Mountaineering Union (BMU). BMU was founded in Vranje in 2006 as an informal organization with headquarters in Skopje. BMU consists of mountaineering associations of Serbia, Albania, Bosnia and Herzegovina, Bulgaria, Montenegro, Greece, Croatia, Macedonia, Slovenia, Turkey and as an country observer, Czech Republic. Through effective cooperation between the mountaineering associations affiliated to BMU, an interactive map was created showing all the mountain facilities (lodges, houses, huts and shelters) in the national territory of the Union Member States. Cooperation has continued through other projects, such as the publication of BMU Magazine, "Climbing for All" (EU co-funded), mountaineering orientation championships and more (HPS).

5   Conclusions

Web GIS applications provide new opportunities for excursion planning and safe stay in nature because they greatly facilitate access to reliable mountaineering information. Data on Croatian mountains are now much more accessible to anyone with an Internet connection, either through a computer, tablet or mobile phone. Applications are easy to use, and they provide users with numerous information with their sub-pages and additional links. Portal users can view, download, add and control entered data, and verified and updated spatial data on hiking facilities, trails and control points of Croatian mountain tours will facilitate the planning of excursions and improve the safety of domestic and foreign visitors of Croatian natural beauties. They also contribute to the promotion of mountain tourism, because they enable visitors to be informed about numerous hiking destinations. There is no doubt that these applications (although they are currently in the Croatian language only) will be used by mountaineers from other countries who visit Croatian mountains more and more. The value of the described applications is primarily in numerous reliable and up-to-date data about mountaineering facilities, checkpoints of Croatian tours and GNSS traces of hiking trails, and the disadvantage is the dispersion of information to several URLs and content (descriptions) in the Croatian language only. Therefore, it is a solution to merge data from all the portals into one content complete, rich and bilingual portal with reliable and up-to-date data at a single URL address.

From the analysis of the three thematic portals of neighboring countries (the Slovenian Mountaineering Association portal, the Slovak mountaineering portal and one Swiss mountain portal) and the comparisons with the Croatian portals, we can conclude that the Slovenian, Swiss and Croatian portals are the richest in content and that they differ in detail. For example, the Swiss portal provides the most information on hiking trails, while the Croatian portals contain the most descriptions and photographs of mountain objects and peaks / checkpoints, all visualized on one web map. Mountaineering content on the Slovenian portal is sorted and visualized individually (by category) on three web maps, which is sometimes an advantage in planning mountain excursions.

It is indisputable that mountaineering portals and associated applications based on the web GIS are important for expanding the tourist offer and generally for the development of tourism and therefore the development of mountaineering tourism. The ecological culture and the sustainability of the mountaineering environment, as well as going to nature with minimal damage to it and the overall environment, is a task not only of the national mountaineering associations but also of every hiker.

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