



# 17th International Conference Geoinformation and Cartography

23–25 September 2021  
Zagreb

**Organizers**

**Under the Auspices of**



hrvatsko kartografsko društvo  
croatian cartographic society

**Croatian Cartographic  
Society**



**Faculty of Geodesy  
University of Zagreb**



**International  
Cartographic Association**



**University of Zagreb**

By organizing this conference the Croatian Cartographic Society and the Faculty of Geodesy of the University of Zagreb wish to contribute to the development of geoinformatics, cartography, geodesy, geography and associated fields with special emphasis on new achievements. A wide range of themes offered and renowned invited lecturers guarantee interesting lectures and a contemporary approach.

Conference themes include climate changes and risk management, Covid-19, AI, geoinformation and cartography in education, map projections, maritime, military, and topographic cartography, and many more.

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17th International Conference on  
Geoinformation and Cartography  
Zagreb, 23-25 September 2021



Croatian Cartographic Society



University of Zagreb, Faculty of Geodesy



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## **Program and Abstracts**

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## **Under the Auspices of**

International Cartographic Association

## **Supported by**

State Geodetic Administration of the Republic of Croatia

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## Introduction

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## Suggested Themes

- AI, machine learning and robotics
- Big data visualization
- Climate changes and risk management
- Covid-19
- Geodiversity
- Geoheritage and cartoheritage
- Geoinformation and cartography in education
- Geospatial technologies for local and regional development
- GIS and ecology
- Location-based services and web mapping
- Map projections
- Maps for autonomous vehicles
- Maritime, military and topographic cartography
- Remote sensing and cartography
- Satellite technologies in cartography
- Spatial data visualization and analysis
- St. Isidore of Sevilla
- UAV – unmanned aerial vehicles

The Organizing Committee is going to consider proposals of other themes from fields connecting cartography, geography, geodesy, geology, geoinformatics and associated professions.

Conference program, lecture abstracts and presentations are going to be published at the Croatian Cartographic Society website. Papers received by the organizer prior to 15 October 2021 are going to be reviewed and published in *Cartography and Geoinformation*, issue 36.



## Keynote Speakers



Dr. Tao Wang is an associate professor and the associate dean of education with College of Geospatial Information Science and Technology at the Capital Normal University of China. His research areas include geospatial data analysis and visualization with applications in smart cities and flood simulation. He is the chair of Commission of Education and Training of the ICA.



Stephan Winter is Professor in Spatial Information Science at the University of Melbourne, specializing in human spatial cognition, navigation, and intelligent transportation. He is pioneering formal and stochastic models of urban environments, and does research in intelligent spatial systems, computational transportation science, and probabilistic time geography. He holds a PhD from the University of Bonn, and a habilitation from the Technical University Vienna.





## 17th International Conference on Geoinformation and Cartography

### First day program, Thursday, 23 September 2021

Location: University of Zagreb, Faculty of Geodesy, Kačićeva 26, Room 119, Zagreb  
or online with Zoom platform

The history of the University of Zagreb began on 23 September 1669, when the Holy Roman Emperor and the King of Hungary and Croatia Leopold I gave the Jesuit Academy in the free royal city of Zagreb a diploma, granting it the status and privileges of a university institution. The recognition was adopted by the Parliament of the Kingdom of Croatia on 3 November 1671.

The Faculty of Geodesy of the University of Zagreb was established in 1962 as an independent faculty. However, the education of surveyors and geodesists in Croatia has a long history. The basic activities of the Faculty of Geodesy are teaching, and scientific and research work in the field of geodesy and geoinformatics.







8:30–9:30 Registration

9:30–10:00 Opening Ceremony

10:00–10:30 Keynote Lecture

Tao WANG	Cartographic Education Progress and Reflections: A Bibliometric Analysis of ICCs Literature in Last 20 Years
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10:30–11:00 Coffee Break

11:00–13:00 Lectures

Damir MEDAK, Mario MILER, Ante MARENDIĆ	LABIRINT – Towards the Improvement of Study Programmes in Geodesy and Geoinformation
Dalibor GERNHARDT	Overview of Web Map Services
Marina VILIČIĆ, Ana KUVEŽDIĆ DIVJAK, Saška MARČETA	Available Systems for Earth Observation Data Management and Remote Processing: Opportunities and Challenge
Đeni DMINIĆ VAROVIĆ, Mile PRŠA, Bojan BLAŽONA, Marta HAMZIĆ	3D Infrastructure Cadastre: Current Situation and Needs in the Republic of Croatia
Marija BRAJKOVIĆ, Zoran BRAJKOVIĆ	Why Do We Create 1 m <sup>2</sup> Cadastral Parcels?
Igor VILUS, Vladimir BARIČEVIĆ	Establishment of Official Topographic-Cartographic Information System of Republic of Croatia

13:00–13:30 Promotion of Sponsors

13:30–14:30 Lunch Time

14:30–16:00 Map Projections Session

E. Lynn USERY	Map Projections Knowledge and Semantic Technology
Krisztián KERKOVITS	A Raster Reprojection Method Based on Direct Formulae of Map Projections
Miljenko LAPAINE	Conic Projections with Three Standard Parallels

The end of the conference first day.



## Second day program, Friday, 24 September 2021

Location: University of Zagreb, Faculty of Geodesy, Kačićeva 26, Room 119, Zagreb  
or online with Zoom platform

### 10:00–10:30 Keynote Lecture

Stephan WINTER	Place in Mobility Research
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### 10:30–11:00 Coffee Break

### 11:00–13:00 Lectures

Dominik MILETIĆ, Ivan BRKIĆ, Dino DOBRINIĆ, Mario MILER	Change Detection Based on a Convolutional Neural Network for Remote Sensing Imagery
Martina KIČIĆ, Sebastian SCHEUER, Silvija KRAJTER OSTOIĆ, Dagmar HAASE	MyDynamicCity – Highly Customizable Open-source PPGIS Software Employed for Participatory Mapping in the city of Zagreb
Damir MEDAK, Mario MILER	Web-based geoinformation system “Potres” (Earthquake): from Emergency Mapping to a Geospatial Hub
Lovro KLARIĆ, Lucija BRAJKOVIĆ, Almin ĐAPO, Boško PRIBIČEVIĆ	Modern Geodetic Methods of Documenting Cultural Heritage Buildings for the Purpose of Building Condition Assessment and Comprehensive Reconstruction After Destructive Earthquakes
Karlo KEVIĆ, Ivan BRKIĆ	Spatial-temporal Analysis of Using Public Bike Service in the City of Split Based on Open Data
Klaudija MOLNAR	Sky Maps
Jurica JAGETIĆ, Ivka KLJAJIĆ	An Analysis of Gornji/Donji (Upper/Lower) Adjectives in Oikonyms in Northern Croatia

### 13:00–13:30 The Day of the Faculty of Geodesy – Video Presentation

### 13:30–14:30 Lunch Time



#### 14:30–16:00 Lectures

Neža Ema KOMEL, Dušan PETROVIĆ	Cartographic Documentation of Remains of the Isonzo Front on Mrzli Vrh Based on UAV Data
Andraž HRIBAR	Hydro-geomorphological Changes of the Mura River in Slovenia Due to River Engineering Measures
Tome MARELIĆ, Josip FARIČIĆ	Reflection of the Perception of Spherical Coordinates for the Adriatic Sea Area on the Accuracy of Early Modern Nautical Charts and Geographical Maps
Goran BAROVIĆ, Duško VUJAČIĆ	Analysis of Map Elements and Methods of Representation of the Territory of Montenegro in Coronelli's Atlas
Miljenko LAPAINE	St. Isidore of Seville – Saint Patron of Cartographers

The end of the conference second day.



## Third day program, Saturday, 25 September 2021

### Medvednica Guided Tour

On 25 September 2021, the **Croatian Cartographic Society** is organising an excursion to Medvednica, getting to know its basic geographical and geological characteristics and a presentation of GPS application in mountaineering and cartography. Departure from the church in Šestine is at 10 AM. Next to the St. Rocco Chapel and the Šestinski lagvić restaurant, we will follow the marked trail no. 12 to Medvedgrad. Unfortunately, Medvedgrad is closed, so we will not be able to climb to the top of the tower where the GPS point is located. The marked path leads further to the Grafičar lodge where a mountaineering lunch awaits us. The Zrinski mine is located in the immediate vicinity, and those who are interested can visit it with an expert guide.

We will return around 2 PM, passing by St. Jacob's Chapel (trigonometer), Kraljčin Zdenac (the Queen's Well), and then along the Miroslavec educational trail to Šestinski Lagvić and Šestine. The descent takes about an hour and a half.

**Šestine** (291 m), once a village known for its picturesque Šestine folk costume, is today a sub-Sljeme area of the city of Zagreb. The Kulmer castle (331 m) used to be above the village. It was built 400 years ago by Stjepko Gregorijanec, the owner of Medvedgrad, and was later owned by the Zrinski, Čikulin, Sermage and Kulmer families. It burned down in 1944, and its last owner was Miroslav Kulmer, who was the president of the Croatian Mountaineering Association for a record long time (29 years). The mausoleum of the Counts Kulmer family is attached to the church. The tomb of the aforementioned Miroslav Kulmer (1861-1943) is also found here. Behind the parish church is the cemetery where the grave of Ante Starčević is located with the famous monument by sculptor Ivan Rendić. Šestine is a good starting point for excursions around Medvednica.

**Medvedgrad.** The ruins of this typical medieval castle are located on a pointed peak 593 m high. It was surrounded by a double ring of thick defensive walls and two defensive towers, north and south. The towers were entered through a door on the first floor. There were two residential palaces and several economic buildings in the city.

Conservation works strengthened its walls; the southern defensive tower was restored, partly the western and eastern palaces, as well as the entire octagonal chapel of St. Philip and James with stone corners, rosettes and a three-meter high Romanesque portal. To the north of it, in slate stone, there was a 5×4 m water tank, over 4 m deep. The city was entered from the north through a narrow funnel-



shaped passage between the inner and outer walls. Medvedgrad was built by Bishop Filip of Zagreb and the Zagreb Kaptol in the period from 1249 to 1254. It frequently changed hands. Apart from kings and the bishops of Zagreb, its lords were the canon Toristi, the Babonić family, the Counts of Celje, the Weysfriath brothers, Stjepan Frankopan, Juraj Brandenburški, Ivan Karlović, the Counts Zrinski and the Gregorijanec family. During the time of the Gregorijanec family, the castle was so damaged by an earthquake in 1590 that it had to be abandoned and has been mentioned as a ruin as early as 1642. For more on the history of Medvedgrad, see Nada Klaić: "Medvedgrad i njegovi gospodari" (Medvedgrad and its Lords) (Globus, Zagreb, 1987). Under the defensive tower, the Altar of the Croatian Homeland, the work of sculptor Kuzma Kovačić, was built in 1994, as a place to pay tribute to Croatian sovereignty and the great figures in its history. This monument consists of large stone cubes of various types and sizes with carved Croatian motifs from the time of Duke Branimir, a large cross and verses of the Croatian anthem arranged next to the Croatian coat of arms. The renovated economic building in the west wing hosts the "Medvedgrad" restaurant. Medvedgrad can be reached by car, on a 4 km asphalt road that turns off in Lukšić, ascending up to the parking lot at the Glog pass.

**Lodge of the "Grafičar" Mountaineering Association.** It is located on mound Rudarsko sedlo, at the foot of Malo Sljeme, at an altitude of 864 m, with a clearing surrounded by forest. It is built of wood and stone in the Alpine style. The ground floor has a large dining room and kitchen, while the first floor has bedrooms with a total of 32 beds. The lodge has telephone, plumbing, electricity and is constantly open and stocked. It is managed by the "Grafičar" Mountaineering Association from Zagreb. Notice the small mountaineering collection displayed in the window to the left of the entrance. In the vicinity there are benches and tables for about 200 hikers.

The lodge is also accessible by motor vehicles along the Sljeme Road. Interesting remains of the mines of the Counts Zrinski are located three minutes (200 m) southwest of the lodge in the forest, in the so-called Rudarski vrt (Miner's Garden).

**Zrinski Mines.** At an altitude of about 830 m are the remains of an old galena mine after which the Miner's Garden was named. These are the remains of mining trenches and galleries where even today one can find lead glance crystals sprayed into the stone. The mine was exploited by the Counts Zrinski in the 17th century (it is mentioned as early as 1609) due to the silver that galena contained (0.049%). In 1993, the trenches were cleaned and restored thanks to the "Zagreb" Forestry Office. They are interesting not only as an excursion site, but also as an educational facility for mining students.

**St. Jacob's Chapel.** It was first mentioned in 1746 as a wooden chapel probably built by miners from the nearby Zrinski mine. The present masonry chapel in the Gothic style, which falls under the parish



of Šestine, was built in 1847, and was thoroughly renovated in 1935 according to the design by architect Denzler, who also built the Sljeme Chapel. The new sanctuary is decorated with old Croatian ornaments. The chapel offers a beautiful view of Zagreb and Posavina.

The **Queen's Well** is located at an altitude of 529 m and is one of the strongest springs of the Kraljevec stream, which is called Medveščak in its lower course. The water temperature in the spring is 10°C. Its name comes from the legendary Black Queen, probably Barbara of Celje, the second wife of King Sigismund, who, according to folk legend, had her estate here under Medvedgrad (first half of the 15th century). Before World War I, next to the spring, Count Kulmer from Šestine raised a forestry lodge, and below it a trout farm. About ten years ago, the building fell into disrepair and in its place, the "Zagreb" Forestry Office arranged a new excursion site, with benches and tables for tourists (the building is privately leased and provides hospitality services). A century ago, the spring was the most popular Zagreb excursion site. Members of the Croatian Mountaineering Association built it as early as 1881. The following year they built a wooden shelter next to the spring and marked the access trails. In 1894 they placed a memorial plaque above the spring, and in 1898 they extended the trail from the Well to Sljeme. In 1980, a completely new, very comfortable walking path was cleared uphill from the Well to the lodge of the "Grafičar" Mountaineering Association. Because it was built by youth through volunteer work, it was called the Youth Trail.

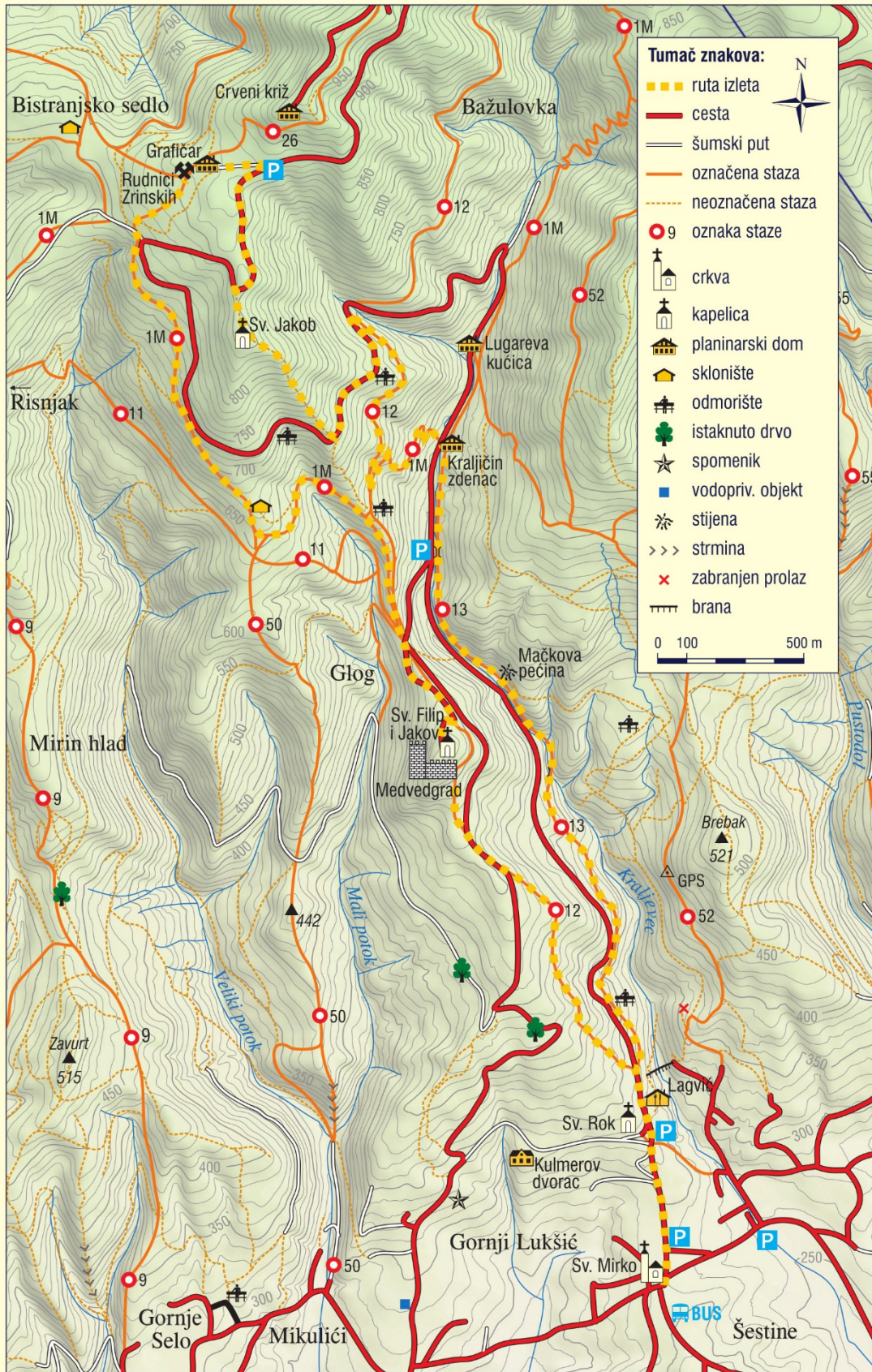
**"Miroslavec" Educational Trail.** About 150 m behind the "Šestinski Lagvić" restaurant, a well executed hiking trail separates at the shelter to the right of the road. It has an easy 3 km ascent through the forest along the Kraljevec stream. The end of the trail forks, left over the bridge on the stream to the Queen's Well, and straight further uphill to Sljeme (1M marking). The "Zagreb" Forestry Office arranged this path as an educational trail. At the most important places, signs have been placed bringing attention to various natural features along the trail, to rest areas and drinking water springs, as well as to proper behaviour in a forest.

Compiled by M. Lapaine according to Ž. Poljak: Hrvatske planine, Golden marketing, Zagreb, 2001.  
Translated by Ivana Amerl.





# Medvednica 25. 9. 2021.





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# 17th International Conference on Geoinformation and Cartography

## **Abstracts**



## **Cartographic Education Progress and Reflections: A Bibliometric Analysis of ICCs Literature in Last 20 Years**

Tao WANG

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### **Abstract**

Cartography and geospatial information education and talent training are the cornerstones of the development of cartography and geographic information science, as a discipline and a profession. In the new normal era of post-Covid19, summaries and reflections of the progress of experience and theories can help to design sustainable and resilient education practice and new model of talent training.

The conference papers and abstracts on educational topics of the International Cartography Conferences in the past two decades, the last ten International Cartographic Conferences, are to be re-investigated with bibliometric analysis methods to produce a thorough overview of cartographic and geospatial education. A domain term knowledge map is drawn together with education topics, authors, and regions. The results show that the number of publications on education in the International Cartography Conferences has been increasing. In general European countries contribute about 50% publications. Authors from Brazil, the United States, Germany, Russia and Switzerland are the top five countries contributing about 40% publications in this field. The research topics are mainly focused on undergraduate and graduate education in cartographic and geographic information systems, secondary education, education atlas, learning theories, learning environmental design, online education, etc. Pedagogies and experience of distance learning and online education developed in the last 20 years have been well applied as a new normal of education in many countries.

With fast development of geospatial data acquisition technologies and growing revolutionized demands of geospatial analytics, cartographic educators are expected to incorporate and adopt new contents and pedagogies, which can well support cartographic graduates to the changing world of work.

**Keywords:** cartographic education, bibliometric analysis, International Cartographic Conference





## **LABIRINT – Towards the Improvement of Study Programmes in Geodesy and Geoinformation**

Damir MEDAK, Mario MILER, Ante MARENDIĆ

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### **Abstract**

The project „Development and improvement of curricula based on occupational standards and qualification standards in fields of geodesy and geoinformation – LABIRINT“ has been funded by European Social Fund for the period between February 2019 to February 2022. During the project, Faculty of Geodesy of University of Zagreb (with Faculty of Civil Engineering, Architecture and Geodesy of University of Split and Institute for Development of Education as partners) developed 10 new occupational standards and 3 qualification standards for the fields of geodesy and geoinformation. The process has been defined by Croatian Qualification Framework and it involves academic institutions, employers and employees in private, state and public sector. Both academic partners shall benefit both from the improvement of educational facilities (new instruments and computer labs) and from the feedback of stakeholders about the competences needed for Bachelors and Masters of the future. The goal of this presentation is to show the project results obtained so far, related to qualification standards at Master and Bachelor level. In addition, we introduce the third stage of the project: study programmes.

**Keywords:** qualification standards, qualifications framework, geodesy and geoinformation



## Overview of Web Map Services

Dalibor GERNHARDT

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### Abstract

Geospatial data can take many forms, ranging from printed sheets to digital imagery or vector data. In the early days of computers these were scanned maps and later digital maps or imagery stored on a local hard drive, followed by network drives. As the amount and complexity of the data grew, it became impractical to store this data locally and the need arose to find a standardized way to transfer this data over the network. Base maps are often enriched with additional content, requiring the merging of multiple layers. To provide a standardized way to transmit and process geospatial data over the network, the Open Geospatial Consortium (OGC) organization has developed several international standards. All of these standards are somewhat similar names, but are developed with different purpose in mind. Some standards are intended for the transmission of raw raster geospatial data, others for use on devices with limited processing capability, meaning that all rendering must be done on the server side, some serve as base maps, while others are for dynamic content. To clarify difference between the international standards and their intended use cases, in this work we examine the following OGC standards: Web Map Service (WMS) for displaying custom maps, Web Map Tiled Service (WMTS) for distribution of pre-rendered static map tiles, Web Feature Service (WFS) for two-way transfer of vector data, Web Coverage Service (WCS) for transfer of raw imagery formats, and Web Processing Service (WPS) for tasking a server with geoprocessing tasks. We clarify the intent of each service and explain the principles of operation at a technical level, which may not be visible to the end user. This paper provides guidance for organizations which have necessity for transferring geospatial data over a network on which technology is best suited for their use case.

Keywords: Open Geospatial Consortium (OGC); Web Maps Service (WMS); Web Map Tiled Service (WMTS); Web Feature Service (WFS); Web Coverage Service (WCS); Web Processing Service (WPS)





## **Available Systems for Earth Observation Data Management and Remote Processing: Opportunities and Challenge**

Marina VILIČIĆ, Ana KUVEŽDIĆ DIVJAK, Saška MARČETA

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### **Abstract**

Earth observation satellite data provide highly useful information on natural events around the world including the most isolated parts of the Earth. From prediction, monitoring and mitigating Earth changes to helping to strengthen the capabilities in maritime surveillance and providing information in all phases of crisis management, Earth observation satellite data enable to obtain sustainable societies and environment.

Free and open access to Earth observation satellite data makes those data available to a wide range of users. In 2008 NASA and the USGS released a new Landsat Data Distribution Policy by which they provide free Landsat imagery since 1972. Also, the Copernicus programme enables free, full and open data access for the Sentinel data products.

Online download portals, such as Copernicus Sentinel Hub, USGS Earth Explorer and GEOSS portal, provide data for download but often the user's computer does not have enough capacity to handle big data volumes and this requires a high degree of human interaction. However, the traditional way of information production where the complete dataset is downloaded, analysed locally, and transformed into a map, faces obstacles due to the amount of data, the complexity of preparing, storing and processing this data. Therefore, analytically oriented solutions such as computer systems for managing and analyzing big Earth observation data are increasingly being developed and used.

In this study, we examine five existing and operational systems (Google Earth Engine, Open Data Cube, Sentinel Hub, SEPAL and CREODIAS) that provide the highest degree of interactivity (e.g. online processing, uploading, and downloading of data). To examine the characteristics of the Earth observation satellite data that are accessible within the system and their open data policies and to better understand their opportunities and challenges for performing some typical spatial analysis tasks, we provide a comparison based on selected criteria that represent the interests of the Earth Observation community (such as: data filtration, algorithms and data extensibility, collaborative work, data access interoperability, portability, usability, data access, target groups for open data, technical standards, metadata availability, data quality, data licence, data available without registration, and data ownership).

Looking ahead, we hope that this comparative analysis of the five operational systems could inspire interested experts and non-expert users to explore the new paradigm of Web-based systems for Earth observation data.

**Keywords:** Earth Observation, Open Satellite Data, Computing Platforms, Analysis, Remote Processing



### **3D Infrastructure Cadastre: Current Situation and Needs in the Republic of Croatia**

Deni DMINIĆ VAROVIĆ, Mile PRŠA, Bojan BLAŽONA, Marta HAMZIĆ

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#### **Abstract**

This paper analyses the current situation and needs in the Republic of Croatia related to the 3D infrastructure cadastre. An analysis was conducted of the selected available relevant literature and data of the 3D infrastructure cadastre related to the territory of the Republic of Croatia. Furthermore, an analysis was conducted of the material available so far, as part of a new innovative project - the 4DII (4D Intelligent Infrastructure) system, which is being developed by several companies and institutions as part of the scientific-research project “Competence Center for Smart Cities” (CEKOM). The innovation of the 4DII system consists of several segments, such as the new ways of processing, recording, inventory, monitoring, and analysis of communal infrastructure in the space-time dimension (4D), as well as the simulation of the future state of facilities, etc. In August 2021, the Infrastructure Cadastre System (Sustav katastra infrastrukture - SKI) and the Joint Access Point (Jedinstvena informacijska točka - JIT) were launched into operation for the Sisak-Moslavina and Bjelovar-Bilogora County. The infrastructure cadastre records the lines (and other objects) of the infrastructure regarding electric power, electronic communication, heating pipeline, gas pipeline, oil pipeline, water pipeline and sewage. Currently, the system’s base has recorded 48,000 km of lines, and the base will be updated, until the entire infrastructure in the Republic of Croatia becomes the part of the system. This paper describes the way in which a large number of unstructured and unrelated data, still stored as analogue and/or digital data by the manager/owner of the infrastructure and local authorities, connect, structure and update with additional useful information within the 4DII system. In this way, a modernization of the Croatia’s infrastructure cadastre existing system can be achieved, with the purpose of further developing digital public services and business that will enable the equal participation of the Republic of Croatia in the EU Single Market.

**Keywords:** infrastructure cadastre, 3D infrastructure cadastre, 4DII system, Republic of Croatia



## Why Do We Create 1 m<sup>2</sup> Cadastral Parcels?

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### Abstract

The cadastral parcel is a basic spatial unit and is part of a cadastral municipality, whose boundaries are defined by breaking points with determined coordinates. The cadastral parcel area in the official planar projection mapping is presented in square meters. Cadastral parcels are subdivided for different purposes and in the process of cadastral municipal documentation maintenance. In the Republic of Croatia territory, there is a small number of cadastral parcels with an area of 1 m<sup>2</sup> (data from the State Geodetic Administration of the Republic of Croatia). Cadastral parcels with an area of 1 m<sup>2</sup> are in an unequal position with other cadastral parcels whose areas are larger than 1 m<sup>2</sup> because by subdividing a cadastral parcel of 1 m<sup>2</sup> into two cadastral parcels, you get two cadastral parcels with an area of 1 m<sup>2</sup> and 0 m<sup>2</sup> or two cadastral parcels of 1 m<sup>2</sup> and 1 m<sup>2</sup>. If, due to the division, we get two 1 m<sup>2</sup> parcels, then mathematically, the entry area does not correspond with the output area. Therefore, it may be impossible to subdivide them without registering the actual areas. Why are 1 m<sup>2</sup> parcels even created if there is no possibility for their subdivision and if it is not possible to present areas per 1 m<sup>2</sup> for newly created parcels? The current regulations do not recognise the area of the cadastral parcel less than 1 m<sup>2</sup>. The area of the cadastral parcel of 1 m<sup>2</sup> is not unambiguously determined, and it depends on the accuracy of geodetic measurements. There is a small number of cadastral parcels with an area of 1 m<sup>2</sup> in Croatian cadastral municipalities, and current regulations do not allow their subdivision. Hence, it is proposed to prohibit the formation of new 1 m<sup>2</sup> cadastral parcels as long as cadastral parcels will not be presented at 1 dm<sup>2</sup>, 1 cm<sup>2</sup>, etc.

Keywords: cadastre, parcel, size problem



## **Establishment of Official Topographic-Cartographic Information System of Republic of Croatia**

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### **Abstract**

Initial project STOKIS (1995) has laid out the plan to design and establish the Official topographic-cartographic information system of Republic of Croatia dealing with issues of topographic measurements and production of state maps. The establishing of the base topographic database was started following the standards that were defined in CROTIS project - that had a goal to define the standards for topographic data, define the basic and detailed solutions for topographic information system in terms of the data model, data collection, processing, precision, terms of presentation and topological relations. With the help of EU funds STOKIS system was realized in a period of 2 years and business processes, rules, documentation were created. Topographic and cartographic databases were established for all official scales which are the basis of the STOKIS system.

Keywords: STOKIS, CROTIS, official mapping



## Map Projections Knowledge and Semantic Technology

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### Abstract

Map projections knowledge consists of multiple facets including basic mathematics of projections transformations, distortion characteristics, preservation characteristics, classification of similar projections, and representation, methods of construction, and others. To represent this knowledge semantically requires translation of these many facets into semantic language. Commonly, this is accomplished through an ontology and semantic representation with the many facets and characteristics represented as triples of subject, predicate, and object, usually in Resource Description Framework (RDF) format. Tools for the development of these ontologies and creation of the triples are available in the open-source environment, one example used in this work is Protégé. In this work the various facets of map projections are represented as classes with sub classes as needed. Specific map projections become individuals under the various subclasses and then possess properties including those for objects, annotation, and data. Additional classes such as creator and history are included. The RDF structure and ontology allow connections to other Web sites and thus the semantic representation can harvest information from the Web.

This research applies these concepts and is developing an ontology of map projections knowledge. The emphasis is on knowledge about projections that can be used as a part of a general cartographic body of knowledge. This current work includes an RDF representation that supports direct queries to the ontology and data and is being made available on the Map Projections Website as an RDF triple store and endpoint currently in development.

Keywords: Map projections, semantic technology, knowledge representation, RDF



## **A Raster Reprojection Method Based on Direct Formulae of Map Projections**

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### **Abstract**

When changing the map projection of a raster layer, it is necessary to resample the image. Current software (e.g. the open-source GDAL) do this based on inverse equations of map projection. However, inverse equations are often cumbersome to obtain, and some mappings may even lack an analytic inverse. Furthermore, these simple methods fail to consider the discontinuities of map projections, and output unusable results for world maps, for example, near meridian  $180^\circ$ . To tackle this problem, the author created an algorithm using only the direct mapping equations that can provide satisfying images. Some example usages are shown to demonstrate the robustness and reliability of the method proposed.

Keywords: Raster GIS, reprojection, forward formulae





## Conic Projections with Three Standard Parallels

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### Abstract

The term "conic projection" refers to any projection in which meridians are mapped to equally spaced lines radiating out from the apex and circles of latitude (parallels) are mapped to circular arcs centred on the apex.

When making a conic map, the map maker arbitrarily picks two standard parallels. Those standard parallels may be visualized as secant lines where the cone intersects the globe – or, if the map maker chooses the same parallel twice, as the tangent line where the cone is tangent to the globe. The resulting conic map has low distortion in scale, shape, and area near those standard parallels. Distances along the parallels to the north of both standard parallels or to the south of both standard parallels are stretched; distances along parallels between the standard parallels are compressed. When a single standard parallel is used, distances along all other parallels are stretched.

Two statements in previous sentences are invalid. One is that standard parallels can be visualized as cross-sectional parallels in which the cone intersects the globe. It has been explained several times that it is not the case. Another claim is that in conic projections there are (at most) two standard parallels. This is not true either since conic projections can have more than two standard parallels. This will be discussed in more detail in the paper.

Let us recall that a few years ago a paper was published on azimuthal projections with several standard parallels. According to this work, "This paper shows that relating the projection plane to a projecting sphere does not make much sense. In fact, it can be demonstrated that an azimuthal projection with two, three and more standard parallels exists. How does one explain a plane intersecting a sphere in three concentric circles? Obviously, this is not possible. Of course, such an azimuthal projection is unlikely to be applied widely. It was developed only to show how awkward and unnecessary it is to relate the projection plane to the sphere so that projection distortions can be explained. Furthermore, conic projections with any number of standard parallels can be created in the same way."

The basic property of all map projections is the distribution of inevitable distortions. Conic projections with one or two standard parallels are mentioned in the literature. These are parallels with the property that the distortion of length, area and angles equals zero at each of their points. It turns out that there are conic projections with no standard parallels, as well as those with more than two standard parallels. Such projections exist not only in theory, but examples of such projections can be constructed as well.

Keywords: map projection, conic projection, standard parallel



## Place in Mobility Research

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### Abstract

Mobility needs, as well as mobility services, are typically represented as point-to-point. I will challenge this traditional view as too strict even from a mathematical perspective and call for a more flexible notion of “place-to-place”. This challenge, and the use of an uncommon concept, requires me (a) to clarify what I mean by “place” – a notoriously difficult concept for geography, let alone a formal geographic information science –, (b) to show that using this term brings a flexibility superior to the traditional “point”, and (c) to draw some needs for further research in order to profit from using “place” in mobility needs and services.

Keywords: place, point, mobility



## Change Detection Based on a Convolutional Neural Network for Remote Sensing Imagery

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### Abstract

Change detection (e.g., detection of illegal buildings, water area supervision, natural disaster assessment, urban planning expansion research, etc) in remote sensing imagery is a critical and challenging task. It consists of comparing a registered pair of images of the same region and identifying the parts where a change has occurred. In recent years, image processing methods based on Convolutional Neural Networks (CNNs) have achieved very good results. In the field of semantic segmentation, CNNs are widely used due to its high efficiency and accuracy. Therefore, in this paper, UNet-based architecture is proposed for change detection (CD) between pairs of satellite images. The PlanetScope satellite imagery including four spectral bands (i.e., red, green, blue, and near infra-red) and a spatial resolution of 3.7m was used for CD. After manually labelling of training samples has been done, both sets of images have been divided into 512x512 pixel raster tiles and they have been concatenated to create an image with 8 bands which will be used as an input to UNet network. Gathered dataset has also been augmented by combining mirroring and rotating each raster input as well as its respective label. UNet network has been trained on both augmented and non-augmented datasets. The main contributions of this paper are twofold. The first contribution which is presented in this paper is that UNet CNN can detect changes between co-registered image pairs which were acquired with a same sensor at a different dates. The second contribution presented in this paper is that through data augmentation it is possible to improve the F1-score for a small dataset.

Keywords: change detection, PlanetScope, convolutional neural networks, UNet, data augmentation



## **MyDynamicCity – Highly Customizable Open-source PPGIS Software Employed for Participatory Mapping in the city of Zagreb**

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### Abstract

Today, Public participation GIS (PPGIS) are successfully employed in different spatial contexts and for a variety of purposes. PPGIS methods integrate collecting non-expert spatial and aspatial information in a participative process. Usually, results gathered using PPGIS are used to represent public opinion on a particular topic, e.g., to inform spatial planning and decision-making. Currently, there are various commercial and non-commercial – often open-source – PPGIS software packages available on the market. Here, we present the motivation for applying PPGIS methods, and introduce MyDynamicCity, a highly customizable, adaptive, and re-usable open-source PPGIS software. MyDynamicCity was used for collecting data in a PPGIS survey conducted for the city of Zagreb, Croatia, focusing on the mapping of selected cultural ecosystem services and ecosystem disservices related to the city's urban green infrastructure, as perceived by the respondents. Furthermore, the survey sought to elicit contextual information, e.g., using open and close-ended questions, multiple choice, or Likert-scale items. The integration of open-source extensions, e.g., enabled as elements as part of a fully customizable front page, implements heatmaps of so far collected spatial data to inform other participants and provide preliminary results to the interested public.

The high customization of MyDynamicCity helped designing and tailoring the PPGIS survey to the local context of Zagreb. While the survey is still open to participation, at this moment more than 200 people took part, ensuring richness of collected data and confirmation of software usability. MyDynamicCity could therefore find its application in diversity of projects for the benefit of research and society.

Keywords: PPGIS, open-source, MyDynamicCity, Zagreb, software



## **Web-based Geoinformation System “Potres” (Earthquake): from Emergency Mapping to a Geospatial Hub**

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### **Abstract**

On 29th December 2020, an earthquake of magnitude 6.4 Mw hit central Croatia, with an epicenter located roughly 3 km west-southwest of Petrinja. The spatial and demographic data about the area hit by severe damage were neither complete nor updated. With help of State Geodetic Administration and Central State Office for the Development of the Digital Society, Faculty of Geodesy of University of Zagreb developed the web-based geoinformation system within the Central Government Cloud. The system integrated spatial and demographic data with live update about inspection of damaged on buildings. The results of numerous spatial analyses were used for emergency mapping, humanitarian aid and for the assessment of damage coordinated by the Office of the World Bank. Web-GIS “Potres” (Croatian word for earthquake) has been continuously used by numerous government agencies for coordinating relief efforts supported by European Union Solidarity Fund. The design of the interoperable web-GIS proved the concept of a long-term Geospatial Hub as a necessary precondition for emergency response to similar disasters.

Keywords: web-GIS, emergency mapping, geospatial analysis



## **Modern Geodetic Methods of Documenting Cultural Heritage Buildings for the Purpose of Building Condition Assessment and Comprehensive Reconstruction After Destructive Earthquakes**

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### Abstract

Devastating earthquakes that hit the area of the City of Zagreb on October 22, 2020, and the area of Petrinja, Sisak and Glina on December 29, 2020, have caused great damage to numerous cultural and historical heritage sites. For most of the earthquake-affected buildings, documentation was insufficient or non-existent. Expediently applying modern geodetic methods and instruments, the Faculty of Geodesy has established a detailed approach for the protection and preservation of cultural heritage in a crisis. Applying modern methods of documentation and instruments; terrestrial laser scanners, digital SLR cameras and drones were used to capture the existing condition of the buildings. Based on the collected data of terrestrial and aerial photogrammetry, 3D realistic models of individual objects were made for easier visualization or damage detection, and based on the collected TLS data, high-resolution point clouds were made which were used to create floor plans and damage detection. The advantage of collecting a large amount of data in a short period of time is seen in the level of recorded details. Architects and civil engineers can draw detailed floor plans of the building floors and model individual elements from the point cloud without extensive and demanding fieldwork. All point clouds and 3D models are georeferenced and on a 1:1 scale which makes them suitable for determining the actual dimensions of objects and calculating areas. This approach enables collecting a large amount of data in an abbreviated period of time which is crucial for a crisis such as destructive earthquakes.

Keywords: earthquake, cultural heritage, point clouds, 3D reality mesh, TLS, photogrammetry





## **Spatial-temporal Analysis of Using Public Bike Service in the City of Split Based on Open Data**

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### **Abstract**

Public bike service in the City of Split is relatively new public service available for city's inhabitants. Since its introduction few years ago, it has increased number of stations and available bicycles showing positive trends in public using the service. So far, there has been limited research concerning the impact of the service to everyday migration and therefore this paper provides an analysis of the usage of the service on spatiotemporal basis. Methodology used in this work identifies bicycle as data transmitter moving information from one station to another. Data on bicycles and stations needed for the analysis are obtained from service's web site where are available as open data. They are collected in a seven-days period with five-minute resolution. The amount of data gathered was considered to be enough for the purposes of the work. The research resulted with several valuable information. First of them are the most frequent distances in the city showing pattern of citizen's daily migrations. This is followed by most loaded stations pointing to the most interesting parts of the city for the users (population). Finally, trends of the usage across the day reveal possible purposes why people use the service. Results of this analysis are highly valuable for the provider of the service, research community and citizens themselves as they contain information on behaviour of the users of the service.

**Keywords:** bike service, public transport, open data, spatial-temporal analysis



## Sky Maps

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### Abstract

Sky maps have undergone a major change throughout the history. The large globes that we now see in museums used to serve a great role, being later replaced by large atlases. Today, mobile applications are ready at our fingertips to be downloaded, installed and used, showing us in real time the details about the part of the sky that we're looking at.

In this presentation an overview of the archives of the Zagreb Observatory was made and different types of maps were combined. Comparison was made between the same parts of the sky displayed in different cartographic projections. The area around the celestial equator is usually displayed in Mercator projection, while mobile applications typically use stereographic projection. Overview of the maps is given according to the purpose of the maps, analyzing the usage of colors. The rotating sky map used usually at night at the observation point has a black background, with the stars displayed typically in nuances yellow and cream colour.

Apart from the fact that the stars can be displayed in the same colors, they can be displayed according to the classification of the star. Star names are usually not shown on many maps. When stars are shown it is mostly in Bayer's catalogue where the brightest star in the constellation is marked as alpha, the second brightest as beta and so on. Another common type of the naming is Flamsteed cataloguing, where stars are named after the growing right ascension in the constellation.

Keywords: sky map, sky atlas, astronomy, cartographic projections



## **An Analysis of Gornji/Donji (Upper/Lower) Adjectives in Oikonyms in Northern Croatia**

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### **Abstract**

The Republic of Croatia has several levels of administrative subdivision. The first level of subdivision is into 20 counties and the City of Zagreb. Each county is divided into towns and municipalities, with a total of 128 towns and 428 municipalities. Each city and municipality are further divided into settlements. There are 6757 settlements in Croatia. Every settlement has its own name - an oikonym. Some of them have Upper or Lower adjectives in their name. The focus of this work is to analyse the elevation data of settlement pairs that contain Upper and Lower. The sample for this analysis will be the settlements in four northern Counties of Croatia – Krapina-Zagorje, Koprivnica-Križevci, Međimurje and Varaždin. Only the urban area of a settlement will be analysed, since the topography of unsettled hilly areas can greatly skew the results, especially in the areas surrounding the Ivančica mountain. Primary problem is determining the Upper/Lower pairs of settlements (e.g. Gornja Voća and Donja Voća); finding the borders of the examined settlements; determining their urban areas; and determining the elevation data of the urban areas. Administrative data is provided by the State Geodetic Administration of the Republic of Croatia. Elevation data used in this analysis is the SRTM digital elevation model. The hypothesis is that the settlement containing Upper in their oikonyms have a greater elevation than those containing Lower.

**Keywords:** northern Croatia, settlements, Gornji/Donji (Upper/Lower), oikonyms, elevation, analysis



## **Cartographic Documentation of Remains of the Isonzo Front on Mrzli Vrh Based on UAV Data**

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### **Abstract**

Many man-made disasters have left a mark on the surface of Europe. But the destroyed landscape after the First World War must have been one of the worst catastrophes. The war began on 28 July 1814 after Austro-Hungary declared war on Serbia. Approximately a year later, after Italy signed the Treaty of London, the south-west front between Italy and Austro-Hungary was opened. The south section along the river Soča (ital. Isonzo) was one of the largest battle fields in the high mountain area in the world. The Isonzo front ended in October 1917 (Simčič, 2006).

Nowadays many traces of the war can be found in uninhabited and hardly accessible territory along the river Soča (Simčič, 2006). Mrzli vrh (1359 m), where one of the bloodiest battles in the area happened, lies near Kobarid in the Julian Alps (in north-west of Slovenia). The open-air museum Mrzli vrh was established in 2007 and it is part of the tourist path Pot Miru (the Walk of Peace), which takes the visitors from the Alps to the Adriatic. However, no useful map of the trenches on Mrzli vrh has ever been made. The aim of our research was visualization of the remains on Mrzli vrh using lidar data and UAV photography.

The students from the elective subject from the master study programmes in Geodesy and Geoinformation at University of Ljubljana, Faculty of Civil and Geodetic Engineering were involved in the research. The positions of the trenches and the path were mostly gained from airborne laser scanning (ALS). The source of data was Laser Scanning of Slovenia, which was carried out between 2011 and 2015. In June 2021 we went to the area which is presented on the map and we gathered the information about the positions of the objects, such as caverns, trenches and fences using GNSS tracking, field photography and UAV survey.

Due to the fact that the area is mostly covered by forest, we used a UAV on open and semi-open areas on the ridge of the mountain and in the smaller area near mountain Lapoč. We created 3D models from the images which had additional useful information about the location of trenches.

A thematic map of the remains of the Isonzo front on Mrzli vrh and points of tourist interest was designed as a final product. We are hoping that it will help tourists to orient themselves in the area.

### **References:**

- Fundacija Poti miru v Posočju. Stories from the land along the Soča. <http://www.potmiru.si/pdf/izleti-eng.pdf>  
Simčič, M. 2006. 888 dni na soški fronti. Orbis, Ljubljana.

**Keywords:** lidar, UAV, Isonzo front, 3D model, thematic map



## **Hydro-geomorphological Changes of the Mura River in Slovenia Due to River Engineering Measures**

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### Abstract

The author analyses the quantitative and qualitative changing of geomorphological forms at two sections of the Mura River in Slovenia from 1824 to 2006 using data from the Francis I cadastre from 19th century and cartographic material from 1968 until today. The changes are ascribed to the human activities taking place in and along the river. It has been ascertained that virtually no valuable geomorphological forms still exist there and that the process of their disappearance will certainly not stop in a natural way.

Keywords: geodiversity, geoheritage, hydromorphologic assessment, water management measures



## Reflection of the Perception of Spherical Coordinates for the Adriatic Sea Area on the Accuracy of Early Modern Nautical Charts and Geographical Maps

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### Abstract

During the last three centuries of the Middle Ages, portolan charts were made in the Mediterranean. Their mathematical basis can be directly determined from linear scale bars and, conditionally, from the rhumb network, as in the first centuries of their production the graticule grid was not plotted on them. The display of a graticule grid, the appearance of which depends on the applied map projection, is a legacy of Hellenistic cartography. However, the awareness of the possibility of making maps in such a way that their mathematical basis rests on the spherical coordinates of points on the Earth projected into the plane, reached Western Europe at the beginning of the Modern Age, primarily through Claudius Ptolemy's *Geographic Hyphegesis*: the fundamental work about the spatial interrelations perceived in this manner. Since the early modern period, the display of the graticule network became a standard in the production of geographical maps, and, later, nautical charts. This research sought to determine the accuracy of the representation of the Adriatic Sea on early modern nautical charts and geographical maps, taking into account the values of the spherical coordinates displayed therein. On the selected charts and maps, a sample of points standardized among them was determined, for which the average error of spherical coordinates in relation to their actual values was calculated. In addition, the average error of the spherical coordinates was calculated for the selected geographical maps in comparison with coordinates extracted from the *Geographike Hyphegesis*. Nautical charts and maps were then georeferenced over a modern map projected in three selected map projections in two different scenarios: a) by using the selected points' actual coordinates as reference values and b) by using the points' coordinates extracted directly from maps and charts themselves as reference values. Our results showed that the coordinates on the selected maps are more accurate in comparison with their actual values than in comparison with the values extracted from Ptolemy's work, whose influence on the production of these maps is manifested in their relatively high longitudinal errors. On the other hand, the range of longitude and latitude degrees on nautical charts shows more significant deviations from analogous values found on maps, and according to the spatial composition of the selected points they appear to be geometrically more similar to portolan charts. On the basis of this, it was assumed that the longitudinal values on charts containing a graticule grid, in comparison with selected maps, were additionally corrected in such a way that their authors had plotted the graticule over the spatial display typical for the portolan charts, which had, by then, already been in use. According to the point coordinates values that were extracted directly from the maps and charts sample, it was found that selected maps were mainly projected in a normal equidistant cylindrical projection with latitude  $36^\circ$  used as a standard parallel, while selected charts were, for the most part, projected in normal conformal cylindrical (Mercator) projection. Considerably high geometric accuracy for both maps and nautical charts was determined, in terms of their particular cartographic projections, when the values of spherical coordinates are taken into account in the way they were perceived by their authors. Our research results also indicate that compilation was one of the basic methods of the composition of geographical content on these maps and charts and that, for the most part, the geographical and nautical cartography of that period behaved as two parallel and relatively separated systems in the context of the perception of spatial interrelationships, with geographical cartography relying on the preserved opus of Claudius Ptolemy, and nautical cartography on the geometry of portolan charts coastline renderings.

Keywords: early modern charts and maps, spherical coordinates accuracy, mapping accuracy, Adriatic Sea





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## **Analysis of Map Elements and Methods of Representation of the Territory of Montenegro in Coronelli's Atlas**

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### Abstract

Unfortunately, for quite some time, we found reviews of the territory of Montenegro with foreign authors and publishers, because it never had an institution that dealt exclusively with mapping its territory. The most common representations of the entire territory, or individual parts of it, which have been obtained by previous research, are maps that show its area on its peripheral parts.

One of the very high-quality cartographic representations, especially considering the time it was made, can be found in the atlas of the world made by Vincenzo Maria Coronelli in the 17th century. He is one of the most famous Italian cartographers from the period of the Venetian Republic. In addition to the numerous maps he left behind, he is known as the author of numerous globes. His geographical society "Accademia degli Argonauta" was the organization through which he made his works known. The mentioned society gathered numerous members who were map drawers. Coronelli made numerous, and according to researchers, best Venetian atlases, of which "Atlante Veneto" ("Isolario dell 'Atlante Veneto") is important for our research, in which Montenegro is also shown.

The authors analyze the mathematical elements of the map and the methods of presenting the content used to show the area of Montenegro. Knowing the cartographic knowledge of that time and considering the depiction of Montenegro, it can be concluded that this is a quality edition that gave its users a sufficient amount of information.

Keywords: map, atlas, map elements, display methods, Coronelli, Montenegro



## St. Isidore of Seville – Saint Patron of Cartographers

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### Abstract

A *mappa mundi* is any medieval European map of the world. The term derives from the Medieval Latin words *mappa* (cloth or chart) and *mundus* (world). Such maps range in size and complexity from simple schematic maps 25 millimetres or less across to elaborate wall maps, the largest of which to survive to modern times, the Ebstorf map, was around 3.5 m.

Extant *mappae mundi* come in several distinct varieties, including zonal maps, tripartite or "T-O" maps, quadripartite maps, and complex maps. T-O maps, illustrate only the habitable portion of the world known to medieval Europeans, limiting their perspective to a relatively small portion of the Earth's Northern Hemisphere. The landmass was illustrated as a circle (an "O") divided into three portions by a "T". These three divisions were the continents of Asia, Africa and Europe.

A T–O map also known as an *Isidoran map*, is a type of early world map that represents the world as first described by the 7th-century scholar Isidore of Seville in his *De Natura Rerum* and later his *Etymologiae*. St. Isidore of Sevilla, also spelled Saint Isidore of Seville, Latin Isidorus Hispalensis, (c. 560 – 636), canonized 1598, feast day April 4, theologian, archbishop, and encyclopaedist. Pope Innocent XIII formally declared him a doctor of the church in 1722. His *Etymologies*, an encyclopaedia of human and divine subjects, was one of the chief landmarks in glossography (the compilation of glossaries) and was for many centuries one of the most important reference books.

Pope St. John Paul II named St. Isidore of Seville the patron on the internet, which is interesting because St. Isidore was bishop of Seville in 600 AD – many years before the internet came to be. Furthermore, St. Isidore of Seville is Patron Saint of Spanish topographers, cartographers, and geodesists. I propose that St. Isidore of Seville be the patron saint of Croatian cartographers.

Keywords: *mappa mundi*, T-O map, Isidore of Sevilla, patron saint



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