Selected Topics in Geoinformatics

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Topic 1#: Living Atlas

Introduction

The topic of this lecture is an introduction to the Esri Living Atlas, a comprehensive collection of geographic information, including maps, apps, and data layers to support our work. Prof. Strobl have provided us with the clear steps on how to use these online maps.

Thoughts

The lecture introduced me with the concept of the Living Atlas, which served as a valuable resource from visualization and cartography to spatial analysis. In my point of view, it can act as an inspiration for my future research directions while viewing others' approaches on resolving problems.

One of the key takeaways was learning how to access the Living Atlas, and the app launcher is the gateway to this valuable resource. Living Atlas covers topics such as base maps, imagery, boundaries, demographics and so on. I was particularly impressed by the availability of high-resolution satellite imagery and datasets, like the population data down to 100-meter resolution, which can help us to do precise analysis combined with dataset such as the Nightlight Imagery, Mobile Signaling data and Taxi Moving data. This reminds me with a research group in East China Normal University, who has done quantities of work on the combination research related to nighttime light remote sensing and population estimation, rebuilding, and analyzing population raster based on various datasets. Furthermore, the Living Atlas offers data from authoritative sources, so this platform is a one-stop shop for geospatial data, which simplifies the process of finding and accessing the right data for various projects.

Another interesting aspect of the lecture was the emphasis on the quality and reliability of the datasets. In Living Atlas, each dataset is tagged with labels, indicating its source and credibility, which is essential for us to conduct geospatial analysis or research. Generally, whether data is suitable for experimental research is far more important than the quality of the data itself.

Apart from Living Atlas, GIS training is also a vital part on our way to an excellent GISer, which can be easily accessed via URL https://www.esri.com/training/. This platform offers us thousands of courses covering many basic or advanced GIS skills we need to learn, such as the ability to do spatial analysis and develop related apps, which really helps us to teach ourselves.

Overall, my experience in the introduction has opened my eyes to the wealth of geospatial data and tools available through the Esri Living Atlas. This lecture has been a valuable journey into a new world of geospatial data through ArcGIS online, and I look forward to applying this knowledge in my future research and projects.

Discussion

While using the search engine in Browse, the search parameters can be combined with some built-in parameters to limit the search range. This can not only give us the precise result we need, but also offers the information about the related research groups.

Topic 2#: Creating and sharing web maps

Introduction

The topic of this lecture is about creating and sharing web maps in the ArcGIS online platform, which is an insightful exploration into the diverse applications and significance of web maps in digital landscape. Prof. Manukyan set the stage for an in-depth exploration of the fundamentals of web maps for us.

Thoughts

This lecture provided me with an introduction to using the Map app in ArcGIS online and its workflows. It was useful to learn about how web maps were more than static representations but actually serving as interactive platforms for engagement and how online maps transformed into tools for communication and public participation.

Moreover, the discussion on the types of informative products that can be created with web maps, like static maps, 2D and 3D visualizations, animations and charts emphasized the versatility of web based spatial data representations. Prof. Manukyan explained these formats with visual examples, which really helped me to understand the various applications of web mapping. With the help of ArcGIS online platform, thousands of base maps and feature map resources can be available in different sharing levels, which can be referenced by our own map project conveniently.

Another interesting session in this lecture is a demonstration about creating a web map using public datasets, in type like .csv, which contains data collecting, preprocessing and visualization. During the demonstration, I gained knowledge about how to prepare a web map and convert it into an interactive web application. In practice this required organization of data adding relevant information and designing good interface. Informed by Prof. Manukyan, I also realize the significance of descriptions and proper annotations attached to the map, which plays a vital role in conveying related details effectively and facilitating information sharing.

Overall, my experience in the introduction this week has shown me the endless possibilities of online maps. This lecture combined with the practical demonstration part, was a comprehensive overview of web mapping applications, which enlightened me to take advantage of the power of spatial representations in my current research related to the soil erosion simulation, flood area prediction and other research direction in Geo-informatics. I also learned to concentrate on the necessity of organizing GIS information sensibly through this lecture.

Discussion

In my point of view, while the process of creating a web map and quality assurance are crucial, it's essential to remember that the a map is something to be used by people. Therefore, we should pay attention to good interactivity and user-friendliness in map applications. However, we acknowledge that online web maps do have their limitations. While viewing the Filters and the Item Type, I noticed that the imported layers support not only Feature layers but also raster data, like Imagery layers, and some larger layers may take longer to render, where optimization works may become necessary.

Topic 3#: Graffiti as spatial information

Introduction

The topic of this lecture is about exploring the spatial distribution and broader implications of graffiti within urban environment, which offers a perspective on graffiti beyond its conventional portrayal as vandalism or illegal activity embedded within their visual expressions. Prof. Trzepacz provided insights into the evolution of graffiti, examining its significance as a socio-cultural phenomenon and a source of spatial data.

Thoughts

As for me, I am enthusiastic about collecting, so the ubiquitous wall graffiti in European cities has aroused my interest every time when I was wondering. This lecture mainly concentrated on the preferences of graffiti artists, delineations among specific groups, and the potential socioeconomic impacts of these graffiti artworks.

I think graffiti is rich in content. In the provided images, I managed to understand some of the symbols and texts used in graffiti, which represented specific ideologies or tell stories about society. With the rich content, visitors can think deeply about the complexities and underlying socio-economic factors of urban spaces.

This lecture resonated with me a lot as it explored graffiti's evolution, from a form of territorial marking among gangs in American cities encompassing football supporters' inscriptions, cultural representations, and political statements. As a sports lover, I am surprised that graffiti has convey specific messages within football supporter groups, which potentially reflecting boundaries and conflicts between different supporter factions. Another interesting idea shared by the lecturer focusing on the socio-cultural significance of graffiti, which was the paradoxical relationship between authorities cracking down on graffiti as vandalism while also using it to beautify certain areas. In my point of view, this conflict highlighted the tensions in society regarding how graffiti was perceived, whether as urban protest or illegal behavior. This session really made me rethink what I thought about graffiti. I now view it as a way that society expresses itself and, as a way to understand urban spaces, which also helped me realize how street art changes within communities.

Apart from the characteristics above, I think graffiti involves the construction and interpretation of urban images, which can evoke varied interpretations among people with different culture backgrounds. Prof. Trzepacz also provided detailed methods and principles for collecting graffiti and mapping it out. This involves using bicycles to systematically document graffiti along streets and the subsequent steps and techniques for processing this data, which made it possible for us to reproduce the procedures and analyze our own data.

Discussion

This research may lead to a reevaluation of art as an important tool for understanding the society and history. So, I think it is a good idea to explore unconventional data sources for geographical analysis and uncovering the potential stories woven into urban landscapes.

Topic 4#: Lidar point cloud registration methods for outdoor

Introduction

The topic of this lecture is exploring Lidar point in outdoor environment and algorithms and data processing related to. Prof. Procházková provided insights into the concepts and practical use of these Lidar technologies, mainly focusing on the registration methods of the point cloud.

Thoughts

As someone with a background in mathematics and point cloud, I was particularly attracted by the practical applications of Lidar data when working with. Prof. Procházková explained the differences between mobile and static Lidar systems, and I really agreed with her explanation on how mobile are were utilized for outdoors while static Lidar is more suitable for indoor measurements.

In the demonstration of Ouster Studio, we had a chance to participate in the audience poll through Menti.com. At the beginning, some concepts like Time of Flight (ToF) puzzled us a lot, so our lecturer provided a detailed explanation the operation of Ouster by using ToF principles to measure distances, which was based on the integration of Lidar technology with cameras and GPS systems for data collection. Additionally, point ground detection combined with morphological operation were introduced.

Another substantial session is the methodologies for point cloud registration. Some data driven techniques were mentioned, like PCA, SVD, ICP and statistical methods such as the normal distribution transform. During this session, my understanding of registration expanded. I gained insights into the significance of PCA in determining directions but also acknowledged its limitations on the sensitivity to data noise. ICP algorithm also plays a role in refining registration iteratively and addressing initial inaccuracies.

I think this lecture has sparked my current research. Actually, I've been using accurate point cloud data (with a sub-meter precision level) from small watersheds in my ongoing study. This data was transformed into DEM with a resolution of 0.1 m, which forms the basis for analyzing soil erosion in small watersheds. However, I hadn't fully realized the challenges and algorithms involved in point cloud data registration before this lecture. It has motivated me to explore Lidar technology and other sources of point cloud based research as they could potentially be vital areas, for my future studies.

Discussion

What caught my attention during the lecture was the discussion about feature-based methods that identify points based on changes in shape or RGB information. The lecture also covered the use of Lidar data with pretrained neural networks(NN) for clustering and generating 3D features followed by image analysis using this approach. These characters are related to deep learning, which is particularly a debated topic in the development and application of high-quality neural networks. In a nutshell, there is still a pressing need for research, in registering and extracting information from point cloud data combined with advanced techniques.

Topic 5#: Patterns of individual mobility using spatial graphs

Introduction

The topic of this lecture is exploring individual mobility patterns using spatial graphs based on multiple datasets. During the lecture, Prof. Long shared his findings on how tracking data can be used to gain insights into the movement behaviors of both humans and animals, mainly focusing on outdoor recreation, home-based work, and the impact of COVID-19 on mobility changes.

Thoughts

The lecture provided an insight into the integrated science of movement, including various dimensions of movement patterns like connectivity, quantity, stability, and clustering. I was really impressed by the techniques used in the course. They focused on constructing move graphs using GPS data to group stops together and analyze graph properties. So, I think the idea is similar to simplifying the real world into conceptual models in the design of data models.

Another interesting session in this lecture is the application of graph theory metrics. Prof. Long explained the relationship between graph measures (like degree centrality) and mobility dimensions that offering a new way to understand the significance of specific nodes in movement graphs. Additionally, the transition from human to animal mobility patterns was introduced, combining with Hidden Markov Model to explore the stops or moves of some species like Wild Pigs in USA. By reading relevant literature, I think current research on animal migration is mainly qualitative, however, by integrating Markov models and network theory, spatial graph can support the acquisition of more precise quantitative results in the research related to animal migration.

In conclusion, what really inspired me in this lecture was the lecturer's comprehensive and well-structured approach in conducting research. I summarize the research story and draw a flowchart as follows.
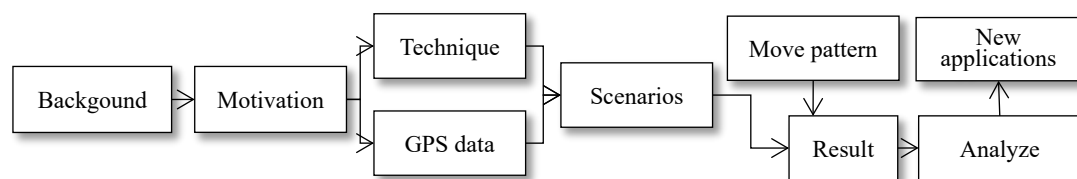
For me, the research process was akin to a story. The lecture started with real-life scenarios and diving into the significance of studying human activity patterns. Then, the research methodologies, spatial networks and graph models, was introduced, simplifying and abstracting human activities into graph models. Following this, it explored the application scenarios and acquired GPS tracking data to generate Activity Graph. Finally, the research findings were analyzed by correlation coefficient between graph parameters and spatial dimensions of movement. In the discussion section, the lecturer explored the potential application of graph models to other life scenarios and even animal migration, broadening the research's scope of application.

Topic 6#: Measuring Rural Accessibility: Case Study of Armenia

Introduction

The topic of this lecture is about the GIS techniques on measuring rural accessibility, which was conducted within the project named *Impacts of Roads on Poverty and Access*. Dr. Piloyan shared his research works on characterizing road accessibility and identifying constraints to service in Armenia based on indices including Rural Accessibility Index (RAI), Market Accessibility Index (MAI) and Service Accessibility Index (SAI).

Thoughts

This lecture provided a detailed procedure for calculating the RAI index, including road data acquisition using RoadLabPro and Mapillary, field surveys, and RAI computation using the ArcGIS tool. I was truly impressed by the dedication of the researchers when I learned that they collected around 9200 km of road quality data in just 4 months. It made me reflect on some limitations of my own project during my undergraduate studies, where I also conducted an accessibility assessment of intercity railway passenger in the Shandong Peninsula Urban Agglomeration in China. In that study, I focused on gathering travel durations between cities in Shandong Province and economic indicators to calculate accessibility using a weighted average travel time model. The result allowed me to classify cities based on their accessibility within the railway network.

$$A_i = \sum_{j=1}^{n} \left(T_{ij} * M_j \right) / \sum_{j=1}^{n} M_j$$

where i,j stands for the index of city, A_i stands for the accessibility, T_{ij} stands for shortest travel time between city i and j, M_j stands for urban development assessment indicator. Under the inspiration of his research, I started to reconsider my previous research with the help of this lecture. Firstly, railway travel duration only represents one aspect of railway capacity while the calculation of the RAI index considers multiple factors related to road quality, so I need to add factors. Secondly, I used GDP in my research as a substitute for overall city strength without considering other important factors such as population, health and education which are considered when calculating MAI and SAI factors in the lecturer's research. Therefore, it is important for me to develop an index system that can be used to evaluate the overall strength of a city.

Discussion

I have a small piece of advice regarding the lecture. While explaining the usage of the RAI tool in ArcGIS, Dr. Piloyan only provided the fields involved in the calculation but did not offer the formula used by this tool for calculating RAI, making the result map somewhat puzzling. So, I suggest attaching relevant links in the slide. By searching relevant web pages, I got the source code and introduction of RAI plugin for ArcMap at https://github.com/sdsna/rai and learned about the RAI distribution map 2022 calculated at country scale in the ArcGIS online platform.

Topic 7#: Development of a doc. prototype for wildlife management

Introduction

The topic of this lecture is creating a prototype for digitally documenting wildlife management in the Berchtesgaden National Park, which contains the introduction, solutions and lessons learned in this meaningful project.

Thoughts

Before the lecture started, I had some brainstorms about the task of this project. So, what is a prototype? Based on my previous programming experience, I realized that the term 'prototype' is very common in JavaScript, which acts as a property of an object used to specify the prototype or parent object, containing all the basic attributes and methods waiting to be inherited through the prototype chain. So 'creating a prototype' for the national park may refers to a preliminary model or version of the digital documentation system for wildlife management.

During the lecture, I gained knowledge about the Berchtesgaden National Park and its collaborative efforts with various research projects. This has significantly enhanced the level of digitalization and automation in ecological conservation and biological management within the park. However, there are still several challenges faced by the management team in this park. For instance, managing a complex structure of information due to multiple personnel involvement and delays in digitizing historical records. So, it is crucial to establish a reference prototype for digital documents.

This reminds me of the course named *Design of Geospatial Data Models* in this semester, where I gain knowledge about the logical and physical model of data. So, I assumed that the challenges they met in the project mainly fall into 3 categories, which are standardization, structuring and digitization of wildlife management data. The target is to bring together data generated in various formats or at different times into a unified and standardized database for consistent and sustainable management. To achieve this goal, software such as Esri ArcGIS (Field App) and Oracle are necessary to be used.

In my point of view, the user roles and the design of schema may take the top priority in the implementation. While designing the documenting system, the team needs to incorporate different user roles with different rights, and in order to make the most of the existing software, the new system should build on already proven software to reduce costs.

And when it comes to the schema design of multi-dimensional and data type models, I think it's crucial for the team to consider how data tables are logically structured from top to bottom. By doing so, they can minimize data duplication while ensuring the integrity of the data. It's also important to have a clear understanding of the different types, structures and sources (which might sometimes be more than one) of each data field. In addition, they should consider creating views for the data to present any post processing results effectively. From my past experience with PostgreSQL and pgAdmin, I know that designing a schema can be quite challenging in relational databases.

Topic 8#: Designing an App with Experience Builder

Introduction

The topic of this lecture is an experience sharing on how to use Experience Builder combined with other tools in ArcGIS online to design an App.

Thoughts

The course provided us with a case study named Salzapp.at based on Experience Builder. I was really impressed by the powerful functionality of this tool which can create immersive web apps by combining various data types and integrating existing apps and external web sites, similar to some Low-Code Development Platform (LCDP), free us from getting stuck in numerous bugs in coding practice and concentrate on achieve our target. This experience sharing lecture is valuable for me, because I'm involved in the Digital Earth Citizens course this semester and is still worried about how to design an online app that addresses a scientific question with creativity and public engagement. Luckily, Maciej gave us a very detailed description of his project structure and related technics, which inspired me a lot. An essential part of this web app was designing the responsive user interface, which made it possible to adapt to the different sizes or screen resolutions of the user's devices to ensure the best user experience in all situations. At the same time, the Experience Builder should not only provide spaces for the user data collected by Map or Survey123, but also contain Survey123 on the web app implicitly.
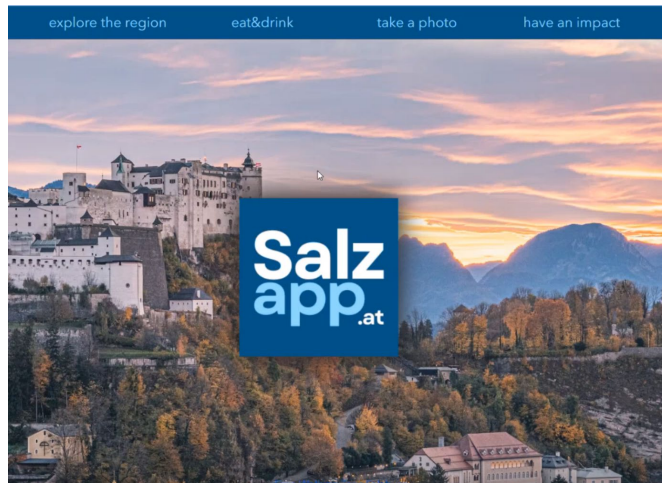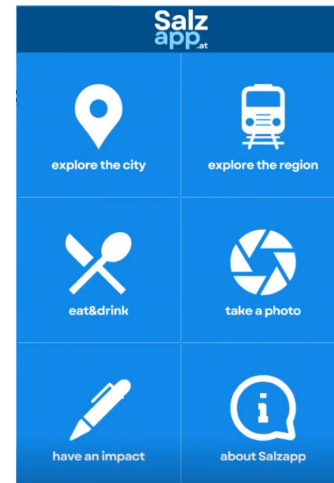

Fig 1. Full window size   Fig 2. Minimum window size

This made me reflect on my own project based on Quickcapture and Survey123. I realized that, though I don't need to do size adjustment, I ought to consider the friendliness of the user Interface like what Maciej do, rather than designing the app without any feedbacks. For example, I post many fill-in-the-blank questions in the questionnaire before, but actually, some of the answers can be converted to fixed options, in form of MCQ, to make it easier for the participants to answer. Moreover, after the participant finishing one part of my survey, I think some guidance for the next step should be added to the page.

Topic 9#: Living geography connecting space and time

Introduction

The topic of this lecture is about the living geography, especially concerning with the timeline and the real-time geographical information.

Thoughts

For me, I think the most essential concepts in this lecture are 'Digital' and 'Time'. The digital twin is currently an important research field related to geographic information science, and technological solutions for building digital twin cities and even a digital earth are being explored around the world. But in fact, as mentioned in the article *Don't confuse digital with digitiztion* quoted in the lecture, 'a digital transformation involves rethinking...', which suggests that simply creating a virtual replica of the real world based on mathematical and physical theory is definitely not the focus of this research direction. Although it is important to automate mapping based on the large amount of geographic data available, we should pay more attention to the interaction and information flow between geographic features. Researchers have already proposed some idea of the third law of geography, which is based on Scenario modelling, exploring the interactions of the objects in a generic scenario, so that computer-simulated geographic entities can go beyond the mere 'existence' of themselves.

'Time' is another import concept in building live geography. In GIS studies, there is a need to consider changes of geographic entities on the timeline of past, present and future, particularly focuses on the prediction of future status. I strongly agree with the point in this lecture, 'people as sensors, collective sensing', because fixed sensors such as satellites and observation stations are able to observe geographic data averaged over larger scales, but humans, as intelligences, are social scenarios that are in a state of flux over time of micro-individuals in a social scene that changes over time. Therefore, data acquired based on public participation will be more suitable for time series-based modelling or forecasting studies. Over the past year, I have been involved in the geomorphology group of the Deep-Time Digital Earth (DDE) project. DDE aims to harmonize global deep-time earth data and share global geoscience knowledge, but the actual research work goes beyond that. Take the work on geomorphological classification as an example, based on the production and sharing of global landform classification results, the study of geomorphological developmental processes will also be conducted, which will go much deeper, addressing the mechanisms of landform evolution over time.

Topic 10#: How soil sealing silently affects our daily lives

Introduction

This lecture explores the impact of soil sealing on our lives. Soil sealing is a common type of soil artificialization which refers to the process by which the natural soil surface is covered by impervious materials like asphalt or concrete.

Thoughts

In this lecture, what impressed me most was not the description of the ecological impact of soil sealing, but the development of our lecturer's research ideas. During the PhD., the lecturer has come up with the idea of studying the effects of artificial impermeable surfaces on the climate and disaster incidence in urban areas, mainly concerning the relationship between soil sealing and heavy rainfall or flooding. However, he did not limit himself to this. Further studies are conducted to measure the reliability of sealed surface detection using new data source, and build models in GEE to automate the multi-temporal detection of soil sealing and also the temperature pattern influenced by soil sealing. His research journey of soil sealing was not limited to a single perspective, but expanded with the development of new data sources and technics, which has inspired me reflecting on my ongoing research related to soil erosion and artificial landforms.

Actually, while facing difficulties in my research, I may feel frustrated sometimes and unable to find good solutions, thus getting stuck in the current problem. After listening to this talk, I realized that a change of mindset is often necessary to find innovative solutions. For the research topic of soil erosion, besides the ongoing quantitative simulation study, can I also try to approach it from the perspective of data input and model sensitivity? For artificial landforms, apart from extracting geographic entities using machine learning or deep learning methods, can I also include the evaluation of the differences in model-based extraction effects between different data sources, or evaluate the different benefits of different artificial landforms on soil conservation? In a nutshell, never confine the mindset, this is the most important thing I learn from the lecture.

Topic 11#: A geospatial analysis of rural-urban fringe

Introduction

The topic of this lecture is the dynamics of transition zones between urban and rural areas, with detailed approaches for rural-urban fringe recognition and result analysis.

Thoughts

In my opinion, the lecture highlighted the variations in how urban and rural areas are defined. Recognizing these disparities in definitions among countries added complexity to comparisons and statistical analyses, which prompted me to concentrate on the importance of definitions in studies related to urban planning. I also learned methods used for defining clusters and centers. By examining indicators concerned with population, questions about the applicability of established threshold values were raised, which really needed to take regional variations into account considering the spatial heterogeneity of countries. It was quite a creative approach to consider a continuum between rural and urban classifications instead of rigid binary distinctions. I think this really enhances precision in capturing variations, in population density and total population.

The latter part of the lecture focused on applying classification methods in practical ways using a study conducted in the Czech Republic as an example. Logic was used to determine rural areas and applied it to analyze the spread of COVID 19 and assess vaccination accessibility, in both settings. These examples demonstrated how accurate urban classifications can greatly impact decision making in fields like public health and quality of life assessments.

To summarize, this lecture didn't only provide an understanding of the characteristics found in rural transition zones, but also enlighten us to change the scale of analysis and our stereotypes towards the urban morphology.

Discussion

Current quantitative analysis related to urban models tend to use the building height raster as the base data and the individual building footprint as the analysis unit, but is it possible to extend the scale of analysis to the block?