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ANNOUNCEMENTS

Teledyne Geospatial announced the sale of its next-generation bathymetric CZMIL SuperNova to leading professional services firm Dewberry. Dewberry is the first private North American company to purchase the CZMIL SuperNova, adding this unique capability in support of state and federal coastal zone mapping programs, surveying of wetlands, lacustrine and riverine systems, submerged habitat detection and offshore mapping for renewable energy governance.

The CZMIL SuperNova’s ability to deliver Quality Level 1 (QL1) data from altitudes greater than 1,200 feet and its Secchi depth penetration range (down to 70 meters in optimal conditions) will allow Dewberry to deliver the quality data required for their projects. Leveraging advanced artificial intelligence and machine learning (AI/ML) techniques for automated land/water discrimination and noise classification, the CZMIL SuperNova bathymetric solution also sets a new standard in processing workflow efficiency through automation in the CARIS software suite without compromising quality.

USGS Landsat 9 Collection 2 Level-1 and Level-2 data will be made available for download from EarthExplorer, Machine to Machine (M2M), and LandsatLook. Initially, USGS will provide only full-bundle downloads. USGS will provide single band downloads and browse images, and Landsat 9 Collection 2 U.S. Analysis Ready Data shortly thereafter. Commercial cloud data distribution will take 3-5 days to reach full capacity.

The recently deployed Landsat 9 satellite passed its post-launch assessment review and is now operational. This milestone marks the beginning of the satellite’s mission to extend Landsat’s unparalleled, 50-year record of imaging Earth’s land surfaces, surface waters, and coastal regions from space. Landsat 9 launched September 27, 2021, from Vandenberg Space Force Base in California. The satellite carries two science instruments, the Operational Land Imager 2 (OLI-2) and the Thermal Infrared Sensor 2 (TIRS-2). The OLI–2 captures observations of the Earth’s surface in visible, near-infrared, and shortwave-infrared bands, and TIRS-2 measures thermal infrared radiation, or heat, emitted from the Earth’s surface.

Landsat 9 improvements include higher radiometric resolution for OLI-2 (14-bit quantization increased from 12-bits for Landsat 8), enabling sensors to detect more subtle differences, especially over darker areas such as water or dense forests. With this higher radiometric resolution, Landsat 9 can differentiate 16,384 shades of a given wavelength. In comparison, Landsat 8 provides 12-bit data and 4,096 shades, and Landsat 7 detects only 256 shades with its 8-bit resolution. In addition to the OLI-2 improvement, TIRS-2 has significantly reduced stray light compared to the Landsat 8 TIRS, which enables improved atmospheric correction and more accurate surface temperature measurements.

All commissioning and calibration activities show Landsat 9 performing just as well, if not better, than Landsat 8. In addition to routine calibration methods (i.e., on-board calibration sources, lunar observations, pseudo invariant calibration sites (PICS), and direct field in situ measurements), an underfly of Landsat 9 with Landsat 8 in mid-November 2021 provided cross-calibration between the two satellites’ onboard instruments, ensuring data consistency across the Landsat Collection 2 archive.

Working in tandem with Landsat 8, Landsat 9 will provide major improvements to the nation’s land imaging, sustainable resource management, and climate science capabilities. Landsat’s imagery provides a landscape-level view of the land surface, surface waters (inland lakes and rivers) and coastal zones, and the changes that occur from both natural processes and human-induced activity.

“Landsat 9 is distinctive among Earth observation missions because it carries the honor to extend the 50-year Landsat observational record into the next 50 years,” said Chris Crawford, USGS Landsat 9 Project Scientist. Partnered in orbit with Landsat 8, Landsat 9 will ensure continued eight-day global land and near-shore revisit.”

Since October 31, 2021, Landsat 9 has collected over 57,000 images of the planet and will collect approximately 750 images of Earth each day. These images will be processed, archived, and distributed from the USGS Earth Resources Observation and Science (EROS) Center in Sioux Falls, South Dakota. Since 2008, the USGS Landsat Archive has provided more than 100 million images to data users around the world, free of charge.

Landsat 9 is a joint mission between the USGS and NASA and is the latest in the Landsat series of remote sensing satellites. The Landsat Program has been providing global coverage of landscape change since 1972. Landsat’s unique long-term data record provides the basis for a critical understanding of environmental and climate changes occurring in the United States and around the world.

TECHNOLOGY

Applanix, a Trimble Company announced the Trimble® AP+ Land GNSS-inertial OEM solution for accurate and robust position and orientation for georeferencing sensors and position-
ference solution for advanced driver-assistance systems (ADAS) testing, even in the most challenging GNSS environments.

The Trimble AP+ Land is a comprehensive solution for land vehicle applications that is small enough to easily integrate into the most compact mobile mapping systems. It is also compatible with virtually any type of mapping sensor, including single or multi-lidar systems, video cameras, photogrammetric and panoramic cameras and other similar sensors.

Configurable to meet the mapping, positioning and direct georeferencing (DG) accuracy demands of mapping and positioning applications in challenging GNSS signal environments.

The Trimble AP+ Land OEM solution is fully supported by the industry-leading Applanix POSPac MMS post-processing software, which features Trimble CenterPoint RTX post-processing for centimeter-level positioning globally without the need for base stations. These capabilities make it an ideal solution for integrators to produce a highly efficient land mobile mapping system.

For lidar integrators, the Trimble AP+ Land OEM is compatible with the POSPac MMS LiDAR QC tools. SLAM technology computes the IMU to lidar boresight misalignment angles and also adjusts the trajectory to achieve the highest level of georeferencing accuracy in the generated point cloud.

The Trimble AP+ Land OEM solution and POSPac MMS are available through Applanix sales channels. For more information visit: mobilemapping.applanix.com.

Phase One, a leading developer of digital imaging technologies, announced the iXM-GS120 aerial camera built to meet the demanding needs of national security and geo-intelligence gathering projects. Designed for use on unmanned aerial vehicles (UAVs), fixed-wing aircraft, and helicopters, the iXM-GS120 is the first wide-area, 120MP resolution camera designed around advanced global shutter sensor technology.

The iXM-GS120 underscores the Phase One commitment to pioneering development of reliable and innovative aerial imaging solutions. The single-sensor design combined with 120MP resolution guarantees fast collection of detailed information over a wide area of interest in every frame, reducing flight times and enhancing effectiveness. With regards to processing, this design also eliminates the time-consuming stitching together of image scenes from multi-sensor camera systems.

The new camera is the most productive airborne system ever developed by Phase One. Integrating a CMOS global shutter sensor, the iXM-GS120 boasts a remarkable seven frame-second capture rate and broad dynamic range. The high-sensitivity, low-noise technology gives the camera an ability to collect data in low-light conditions, thereby expanding its operating window by several hours per day.

Available in RGB color and monochrome versions, the iXM-GS120’s range of applications is further broadened by an expansive selection of Fields of View for operation at numerous different aircraft altitudes and speeds. Compatible fields of view include a range of lenses from 35mm to 300mm.

Weighing just 630 grams, the compact camera body mounts easily on a wide range of platforms, including Group 3 tactical unmanned aircraft for long enduance operation.

Learn more at: https://phaseone.ws/security_and_space.

EVENTS

The 22nd William T. Pecora Memorial Remote Sensing Symposium (Pecora 22) will convene in Denver, Colorado, USA from October 23 – 28, 2022, and will focus on all aspects of Earth observation, spanning scientific discoveries to operational applications, and from sensors to decisions. Continuous monitoring of the Earth involves the integration and analysis of both historical and contemporary remotely sensed imagery. It occurs across spatial and temporal scales, measurement objectives, and embraces a broad range of remote sensing and analytical methodologies.

The Pecora 22 conference will also celebrate the 50th anniversary of the launch of the first Landsat satellite and the accomplishments that followed. The conference theme, Opening the Aperture to Innovation: Expanding Our Collective Understanding of a Changing Earth, embraces both the innovations and discoveries that resulted from 50 years of Landsat Earth observations, and also current and future innovations in science and technology that are contributing to our ability to improve our understanding and better manage the Earth’s environment.

We are currently accepting proposals for conference sessions and abstracts.

The deadline for both is now March 15, 2022.

For more information see the conference website at http://pecora22.org

Questions? Contact the Pecora 22 Technical Program Committee at pecora@usgs.gov.

CALENDAR

- 3-6 October, GIS-PRO 2022, Boise, Idaho. For more information, visit https://www.urisa.org/gis-pro.
- 23-27 October, Pecora 22, Denver, Colorado. For more information, visit https://pecora22.org/.
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SectorInsights.org—RCMRD/SERVIR Eastern & Southern Africa Collaborate with Kenya Wildlife Conservancy Association (KWCA) to Train Conservancy Managers in the use of GIS and Satellite Data for Conservation

By Edward Ouko and Robinson Mugo

155 Potential of Open Source Remote Sensing Data for Improved Spatiotemporal Monitoring of Inland Water Quality in India: Case Study of Gujarat

Neetu Singh, Shivanand Mallikarjun Naligire, Meeta Gupta, and Pennan Chinnasamy

Unison of in situ data with satellite remote sensing data has been widely used for water body quality monitoring; however, the developed synergized model is unique and thus needs to be recalibrated and revalidated before applying to other water bodies. In some Indian locations, water quality monitoring is conducted only once a year due to associated costs and time. To aid such instances, in this article, stepwise linear regression models were developed using in situ (annual) and Landsat 7 (biweekly) remote sensing data and validated for two inland water bodies (Sursagar and Nalsarovar lakes) in Gujarat state for dissolved oxygen, biochemical oxygen demand, electrical conductivity, pH, and nitrate.

165 Automated 3D Reconstruction of LoD2 and LoD1 Models for All 10 Million Buildings of the Netherlands

Ravi Peters, Baldaz Dukai, Stelios Vitalis, Jordi van Liempt, and Jantien Stoter

In this article, we present our workflow to automatically reconstruct three-dimensional (3D) building models based on two-dimensional building polygons and a lidar point cloud.


Muhammad Nasar Ahmad, Qimin Cheng, Fang Luo, and Yewen Fan

This article proposes an estimation method for assessing urban sprawl using multispectral remote sensing data: SNPP-VIIRS, DMSP/OLS, Landsat 5-TM, and Landsat 8-OLI. This study focuses on the impacts of human activities, in terms of increased electrical-power consumption (EPC) due to urbanization.

181 An Optimal GeoAI Workflow for Pan-Arctic Permafrost Feature Detection from High-Resolution Satellite Imagery

Mahendra R. Udawalpola, Amit Hasan, Anna Liljedahl, Aiman Soliman, Jeffrey Terstriep, and Chandni Witharana

High-spatial-resolution satellite imagery enables transformative opportunities to observe, map, and document the micro-topographic transitions occurring in Arctic polygonal tundra at multiple spatial and temporal frequencies. Knowledge discovery through artificial intelligence, big imagery, and high-performance computing (HPC) resources is just starting to be realized in Arctic permafrost science. We have developed a novel high-performance image-analysis framework—Mapping Application for Arctic Permafrost Land Environment (MAPLE)—that enables the integration of operational-scale GeoAI capabilities into Arctic permafrost modeling. Interoperability across heterogeneous HPC systems and optimal usage of computational resources are key design goals of MAPLE.

189 Assessing the Impact of Land Use Changes on Net Primary Productivity in Wuhan, China

Yan Gu, Zhenfeng Shao, Xiaoning Huang, Yuanhao Fu, Jiyan Gao, and Yewen Fan

Since 2000, major changes have taken place in Wuhan city. Land use and land cover (LULC) has changed significantly, characterized by increased construction land, reducing farmland, grassland, and forest land due to the rapid urbanization process. Taking advantage of LULC data and Moderate Resolution Imaging Spectroradiometer Net Primary Production (MODIS NPP) data from 2000 to 2020, we analyze the impact of LULC type transformation on NPP, reveal the relationship between LULC type and NPP, and quantify the impact of urban expansion on NPP by taking Wuhan, China as a study case.

199 Information Extraction from High-Resolution Remote Sensing Images Based on Multi-Scale Segmentation and Case-Based Reasoning

Jun Xu, Jiansong Li, Hao Peng, Yanjun He, and Bin Wu

In object-oriented information extraction from high-resolution remote sensing images, the segmentation and classification of images involves considerable manual participation, which limits the development of automation and intelligence for these purposes. Based on the multi-scale segmentation strategy and case-based reasoning, a new method for extracting high-resolution remote sensing image information by fully using the image and nonimage features of the case object is proposed.

See the Cover Description on Page 144
While Inuit people have lived in the Foxe Basin for thousands of years, English mariner William Baffin was among the first Europeans to explore this shallow, icy basin north of Hudson Bay. Among the details he noted in his 1615 log: the tan color of the sea ice.

More than 400 years later, the phenomenon continues to stand out, even in satellite imagery. The Operational Land Imager (OLI) on Landsat 8 captured this image of beige ice drifting south of Prince Charles Island on June 22, 2016. The color is likely due to staining from silt and sediment—particles of eroded rock and soil that accumulate on the ocean floor.

Land surrounds most of the Foxe Basin, so sediment sources are not far away. Since the basin is shallow, winds and waves often stir up sediment from the ocean floor. Particles circulate throughout the water column, sometimes reaching the surface and becoming embedded directly within sea ice. Over time, these sediments can become concentrated in ice at the surface because of sublimation and the melting of the ice. In some areas, the water is shallow enough that sea ice rubs directly against the ocean floor and picks up sediment that way.

Some of the color could also be caused by algae, which can grow under the ice and wash up onto the surface during storms.

For more information, visit https://landsat.visibleearth.nasa.gov/view.php?id=149283

You May Not Be The Only One Confused About Python Formatting

One of the continuing theses of this column is that with GIS software, there are always multiple ways to accomplish the same end goal. With Python scripting, it is even more true, but with a twist. When scripting there are 101 additional things to think about. Does the function have the right inheritance hierarchy? Are there too many comments? Was that fourth IF-statement indented properly? And then there is an entire additional list of items when geographic information system (GIS) software is thrown into the mix. What worked perfectly fine in the code editor you are using for your development environment suddenly doesn’t cooperate when bringing it into another GIS interface. Then, a major factor to keep in mind when developing scripts is identifying what version of Python your software is using and what format a script needs to be written in for the software to understand a particular command. For this month’s Tip & Trick, we will focus on formatting strings with the F-String function.

In Python, there are three methods of formatted strings (f-strings) that can be used to format syntax and change display expressions. Each method was developed as new versions of Python were released; the intent was to make formatting simpler, but of course, with different versions, new issues and confusion can arise.

### For Python version 1.0
In Python 1.0, the f-string method involves using %formatting. The percent (%) operator acts as a placeholder in a statement while the variable being formatted is then added after the %. (Example 1). If there is more than one variable needed in a statement, then the variables are included after the % operator using parenthesis and commas to separate each variable (Example 2).

**Example 1.** Basic use of %formatting where variable “baker” is being incorporated into a print statement.
```python
baker = "cleo"
print("Welcome to %s’s bakery"%baker)
```
Result: Welcome to Cleo’s bakery

**Example 2.** Formatting with more than one variable.
```python
food = "donuts"
um = 73
baker = "Cleo"
print("Welcome to %s’s bakery! There are %s %s in stock."%(baker, num, food))
```
Result: Welcome to Cleo’s bakery! There are 73 donuts in stock.

### For Python version 2.0
In Python 2.0, the f-string method involves using the string format; where curly brackets “{}” are used to contain a string variable (otherwise known as “str.format()”). The {} act as a placeholder for the variable while .format() follows after; the variable is contained within the parenthesis (Example 3). As many variables as needed can be added within the parenthesis, where even variables in a dictionary (Example 4) can be called and formatted in a statement.

**Example 3.** Basic use of string format where baker, number, and food variables are applied to the print statement.
```python
food = "donuts"
num = 73
baker = "Cleo"
print("Welcome to {}’s bakery! There are {} {} in stock.".format(baker, num, food))
```
Result: Welcome to Cleo’s bakery! There are 73 donuts in stock.

**Example 4.** Accessing a dictionary with string format for the print statement.
```python
bakery = {"baker":"Daniel","food":"danishes"}
print("Welcome to {baker}’s bakery! We sell {food}.")
```
Result: Welcome to Daniel’s bakery! We sell danishes.

### For Python version 3.0
In Python version 3.0, the f-string method is similar to str.format() but now it is written out as f "{}". By using lowercase f or uppercase F in the beginning of the statement, the curly brackets containing the variable can be placed more easily (Example 5). This method makes editing syntax more efficient and easier to follow.

**Example 5.** Basic use of f"{}" where variables are placed throughout the print statement.
```python
baker = "Cleo"
rival = "Daniel"
b1 = "donuts"
b2 = "danishes"
print(f"{rival}’s bakery is {baker}’s rival. But their {b2} can’t compare to our {b1}.")
```
Result: Daniel’s bakery is Cleo’s rival. But their danishes can’t compare to our donuts!
Understanding the different methods of f-strings is not only useful for formatting scripts, but also significant to formatting tools for different GIS software systems. Not all GIS systems may have Python incorporated into their back-end code; while some GIS software may use older versions of Python. The trick to formatting lines of code with f-strings is knowing what version of Python the software uses.

Every update to a piece of software is going to come with its own positives and negatives. One update may solve developing needs and make work much easier. On the other hand, an update may have the most up to date version of Python, but may take away a feature the last version had that was needed for a special kind of analysis or cartographic work. Table 1 summarizes popular GIS software and Python versions, there are a variety of packages that come in certain software versions.

Knowing how to adapt code for frameworks is part of an application and script’s life cycle. Not every project requires legacy code to function, but having a basis of what formatting is required makes the adaptation and troubleshooting process run smoother.

It is important to note that there is no wrong way to write scripts and tools; there is always more than one way to accomplish the end-goal. Rather, it is a matter of how clear they are to users and developers that determines their usability. If a project is dependent on features of one system version over another, developing code that’s understandable for that specific system is essential. But where there are limits, there also lies creative bounds. Once a system’s syntax limits are understood, it becomes easier to adapt code for the best use of a project or task.

Below are some additional sources for help with Python scripting.

**Sources**


Send your questions, comments, and tips to GISTT@ASPRS.org.

YoLani Martin is a Geospatial Analyst with Dewberry’s Fairfax, VA office. She is a resource for open source tools and Python scripting. Al Karlin, Ph.D., CMS-L, GISP is with Dewberry’s Geospatial and Technology Services group in Tampa, FL. As a senior geospatial scientist, Al works with all aspects of Lidar, remote sensing, photogrammetry, and GIS-related projects.
RCMRD/SERVIR Eastern & Southern Africa Collaborate with Kenya Wildlife Conservancy Association (KWCA) to Train Conservancy Managers in the use of GIS and Satellite Data for Conservation

The Maasai Mara Wildlife Conservation Association (MMWCA) and Amboseli Ecosystem Trust (AET) are two key biodiversity hotspots in Kenya, and whose wildlife corridors extend into neighbouring Tanzania. The two ecosystems constitute habitats for very important wildlife species (keystones such as Elephants). The Mara ecosystem accounts for 25% of Kenya’s wildlife (Figure 1) and nearly three quarters of the protected area population. On the other hand, the Amboseli ecosystem is one of Kenya’s premier parks both in terms of biodiversity conservation and tourist visitation. The MMWCA manages 15 conservancies covering an area of 347,011 acres (about 1400 square kilometres), supporting 14,528 land-owners and 280 community rangers, while the AET has current membership of 20 conservancies covering approximately 394,834 acres (about 1597 square kilometres) supporting 65,881 households and close to 500 community rangers.

The Mara and Amboseli ecosystems are valuable national and community assets, whose conservation and sustainability will greatly enhance the wealth and resilience of the local communities to climate change and economic shocks. Unfortunately, the impact of environmental degradation due to human activities and the effects of climate change are apparent in both ecosystems, which calls for prudent and data driven conservation efforts. However, given the vast areas, and a myriad of threats to natural ecosystems and wildlife, conservation managers must improve their skills in data collection, analysis and synthesis for prompt decision making. As a result, conservation managers, policymakers and others are increasingly relying on geospatial information and analysis to monitor and assess pressures on habitats, understand species status, vulnerability and distribution patterns. Geographic information science (GIS) is therefore critical in monitoring external threats, planning of conservation actions and response.

The SERVIR Eastern and Southern Africa (E&SA) project is a joint initiative of the National Aeronautics and Space Administration (NASA), the United States Agency for International Development (USAID), and the Regional Centre for Mapping of Resources for Development (RCMRD). SERVIR partners with countries and organizations in eastern and southern Africa to address critical challenges in climate change, food security, water and related disasters, land use, and air quality. Using satellite data and geospatial technology, SERVIR co-develops innovative solutions through a network of regional hubs to improve resilience and sustainable resource management at local, national and regional scales. In Kenya, SERVIR is collaborating with KWCA to build a GIS portal for managing conservation data, and also training conservancy managers in the use of GIS and satellite imagery derived from NASA and Copernicus hubs to improve decisions in conservation. Recently, SERVIR E&SA and

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1 https://maraconservancies.org/
2 https://amboseliwatershed.org/
3 https://servirglobal.net/Regions/ESAfrica
4 https://www.nasa.gov/
KWCA brought together 30 conservancy managers from the MMWCA and AET for training in the application of geospatial tools in conservation management and monitoring. The managers were taken through the use of GPS devices, open-source GIS and remote sensing software (QGIS), data use and manipulation in a GIS environment and map creation of key natural resources. The training models were built on open-source tools to facilitate access to and manipulation of GIS and remote sensing (satellite) data and products within the conservation networks.

The collaboration between the RCMRD and KWCA fulfils SERVIR’s strategic goal to empower regional and national actors in the use of Earth observation information for development decision making. KWCA works with landowners and communities through 167 conservancies in Kenya to sustainably conserve and manage wildlife and their habitat outside formal protected areas for the benefit of the people of Kenya. At the same time RCMRD and SERVIR bridge the skills gap in use of geospatial tools for better decision making. The partnership is built around a Memorandum of Understanding covering collaboration in the areas of data, tools co-development and capacity enhancement in the application of geospatial tools in conservation management. The SERVIR project believes improved capacity in the use of geospatial tools and technologies among the conservation practitioners will be important in strengthening conservation efforts on the ground and enhance citizen science led data collection among the conservation community. This would enable the various conservation actors like KWCA and communities to play key roles in defining future spatial data and products which serve local conservation and ecological needs. On the gender lens, KWCA did a remarkable job of identifying a number of women to participate in the training, making up approximately 25% of the participants Figure 2.

Following the successful training, the conservancy managers expressed confidence that the skills acquired during the engagement will be vital in their daily conservation monitoring activities. According to Daniel Kaaka, the Amboseli Ecosystem Coordinator, “The remote sensing and GIS training was a hands-on opportunity for Amboseli Ecosystem conservancy managers to interrogate and inform decision making by the click of a button.” Sarah Omusala, of Gamewatchers Safaris Conservation and Porini Camps, observed that “the training empowered the conservancy managers in collecting data on flora and fauna, thus adding to their skills and tools for managing protected areas, and also monitoring habitat health, identifying the wild animals and livestock movements, illegal activities, and grazing areas based on land use and landcover types”.

**References**

https://www.rcmrd.org/about-us/about-rcmrd
https://kwcakenya.com/
https://www.servirglobal.net/

**Authors**

Edward Ouko is a Thematic Lead for the Ecosystem and Modelling Service Area of the SERVIR Eastern & Southern Africa Project at the Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya. He holds a double Master of Science in GIS and Remote Sensing with bias to Global Environment Modelling from Lund University, Sweden and University of Twente, in the Netherlands. His research interests include ecosystem modelling, biostatistics, species distribution modelling, forestry, and system modelling. He is passionate about application of remote sensing (Optical and SAR) to monitor ecosystems and landscapes across the globe.

Robinson Mugo is the Project Manager of the SERVIR Eastern & Southern Africa Project at the Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya. SERVIR is a partnership with USAID and NASA which fosters the use of Earth observation (EO) data and geospatial tools for development decision making in various societal benefit areas. He also serves as a board member of the Kenya Education Network Trust (KENET), the National Research and Education Network (NREN) of Kenya. He holds a PhD in Satellite Oceanography and GIS from Hokkaido University, Japan, with research interests in ecological informatics, species distribution modeling using machine learning models, and water quality monitoring using EO data.
Paleolithic remains have been found in the region, but the oldest dwelling in Kiev is from the 25th century B.C., about 4,500 years ago. “Ukraine was the center of the first Slavic state, Kievan Rus, which during the 10th and 11th centuries was the largest and most powerful state in Europe. Weakened by internecine quarrels and Mongol invasions, Kievan Rus was incorporated into the Grand Duchy of Lithuania and eventually into the Polish-Lithuanian Commonwealth. The cultural and religious legacy of Kievan Rus laid the foundation for Ukrainian nationalism through subsequent centuries. A new Ukrainian state, the Cossack Hetmanate, was established during the mid-17th century after an uprising against the Poles. Despite continuous Muscovite pressure, the Hetmanate managed to remain autonomous for well over 100 years. During the latter part of the 18th century, most Ukrainian ethnographic territory was absorbed by the Russian Empire. Following the collapse of czarist Russia in 1917, Ukraine was able to bring about a short-lived period of independence (1917-1920) but was reconquered and forced to endure a brutal Soviet rule that engineered two artificial famines (1921-22 and 1932-33) in which over 8 million died. In World War II, German and Soviet armies were responsible for some 7 to 8 million more deaths.” (World Factbook, 2004). The republic achieved independence in 1991.

Ukraine is slightly smaller than Texas and borders Belarus (891 km), Hungary (103 km), Moldova (939 km), Poland (526 km), România (169 km), Russia (1,576 km), and Slovakia (97 km). The coastline is 2,782 km along the Black Sea and the Sea of Azov. The climate is temperate continental, and most of Ukraine is steppes and plateaus, with the Carpathian Mountains in the west and the southeastern coast of the Crimea from Sevastopol through Yalta and north to Feodosiya. The lowest point is the Black Sea (0 m), and the highest point is Hora Hoverla (2,061 m). The capital is Kiev, and according to legend, the city was founded in 482 A.D. by a royal family of three brothers and one sister.

The czarist Russians performed surveys and topographic mapping of Ukraine in the 19th and early 20th centuries, but these works were for military purposes only. They did nothing with respect to individual land ownership registration, and they preferred the sazhen for their unit of measurement. (Paraphrased from Poland, PE&RS, September 2000). The existing classical triangulation net is a dense mesh to the west along the border with Poland, Hungary, România, and Moldova, primarily in the mountainous region and extending as far east as Rivne, Ternopil’, and Chernivtsi. A southern chain of figures reaches from the western city of

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Izmayil, through Odessa and Kherson to the Crimea where it includes Feodosiya and Kerch. There are seven other meridional arcs that are connected by three more-or-less continuous east-west chains. Although some first-order work is evident around Kiev, there is a very dense network about Yalta in the Crimea. There are a number of high-order local surveys evident in Ukraine, and I suspect that some of these locations may be coincident with now-empty underground silos; a once-favorite area for ICBM sites when the USSR had control of Ukraine.

The observations for the Horizontal State Geodetic Network (HSGN) of Ukraine began in 1923-25, but it took over 30 years to complete both horizontal and vertical leveling work. Completed in 1970, the first-order network has been maintained while densification has continued for third and fourth-order control. The HSGN consists of 19,538 points that include 547 first-order and 5,386 second-order points. The HSGN is on the “System 42” datum established (in 1942) by the USSR where the origin point is at Pulkovo Observatory where: $\Phi_0 = 59^{\circ} 46^{'} 18.55^{\prime\prime}$ North, $\Lambda_0 = 30^{\circ} 19^{'} 42.09^{\prime\prime}$ East of Greenwich. The defining azimuth at the point of origin to Signal A is $\alpha_0 = 317^{\circ} 02^{'} 50.62^{\prime\prime}$. System 42 is referenced to the Krassovsky 1940 ellipsoid where $a = 6,378,245.0$ meters, and $1/f = 298.3$. The previously mentioned dense and continuous western network is entirely first-order in quality. The remainder of the first-order network of the Ukraine

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is comprised of polygons: the lengths of each section being less than 200-250 km. There are 250 LaPlace (astronomic) stations in the HSGN which are located at each end of the first-order triangulation polygons and in the middle of each section. In continuous first-order chains, the LaPlace stations are spaced every 10 triangles, and the accuracy of the azimuths is ±1.2°. In second-order chains, LaPlace stations are located at baseline terminals. The accuracy of baseline distance measurements is not less than 4×10⁻⁶. In general, a single Ukraine map sheet at a scale of 1:1,000,000 will contain about 35-70 LaPlace station points and about 20-30 baselines. The average density of HSGN points is 1 point in 30 km², but this varies in different regions. For instance, in the industrial region around Donbass, the density goes up to 1 point in 5-10 km², while in the rural region around Polissia the density goes down to about 1 point in 40-50 km². The grid system associated with the Ukraine HSGN is the same as with all former countries of the Soviet Union – the Russia Belts which are identical to the UTM grid except that the scale factor at origin \((m_o) = \text{unity. For large-scale mapping, the width of the belts reduces to 3° rather than the standard 6° belt.}

The Vertical State Geodetic Network (VSGN) consists of almost 11,000 km of first-order leveling, plus 12,600 km of second-order leveling, 6,000 km of third-order leveling, and about 300,000 km of ordinary leveling. The average distance from any site in Ukraine to a first- or second-order level line does not exceed 40 km. The first-order VSGN is tied to the vertical networks of Poland, Slovakia, România, Hungary, Russia, and Belarus. The vertical datum is referenced to the Kronstadt tide gauge located at the Baltic Sea, near St. Petersburg (Russia). Benchmark spacing in Ukraine is not in my files. The State Gravimetric Network is comprised of 80 first-order points and 20 second-order points with the fundamental point located in Poltava.

The NGA does not list datum transformation parameters from System 42 to WGS84 for Ukraine. My guess is that the parameters are pretty close to what they are for Moscow since the strategic importance of the country was so enormous to the USSR. Ukraine has now passed legislation that denotes WGS84 as the national datum of the republic.

Years ago, I sat in a hotel room in South America and watched “The Wall” being torn down. I was working on a U.S. A.I.D. project for land titelization in which I designed the geodetic and photogrammetric aspects of the project for a canton in Ecuador. That process is a major project now in Ukraine, and GPS technology is an integral component of the social transformation. Those that read my columns are aware that I often grouse on “La Ley” – “The Law” as it exists in much of Latin America in which a branch of the federal government is given the exclusive monopoly for geodetic surveying and topographic mapping of a country. That is a custom derived from the European way of doing things back in the 19th century. I don’t care for the concept because it frustrates private commercial mapping in favor of some federal groups, usually the military. Such an idea seems to be the current state of affairs in Ukraine, and their federal government appears to have passed a similar 19th-century-era-type law. This may be a result of sociological/economic phenomena more than anything else, but it’s disappointing to see such developments in new republics striving for excellence in a worldwide capitalistic environment. I wish them success in their endeavors to provide farmers with a title to the soil their forefathers have tilled for so many centuries; the geodetic and photogrammetric sciences will allow the technical aspects to flow smoothly.

I have to thank Dr. Momchil Minchev of Sofia, Bulgaria for his generous assistance in locating geodetic publications in English on the Ukraine for me. The reports of Dr. Michael Cheremshynsky of the Ukraine Main Administration of Geodesy, Cartography, and Cadastre of Ukraine in Kiev have made the technical details of the geodetic history possible for this article. Once again, Dr. Minchev has helped me unravel an enigma.

**Ukraine Update**

“2020 can be considered as the year of geospatial data in Ukraine with the Ukrainian geospatial community facing a historic moment of digitalization. We have introduced a ‘single window’ for natural resource management, which will help to save budget funds and develop territories, strengthen public control over the activities of state bodies and increase public confidence in the government.

“In April 2020, Ukraine’s law on the National Spatial Data Infrastructure (NSDI) was finally adopted by the Ukrainian Parliament after more than 10 years and 4 attempts. Although Ukraine is not an EU Member State, the law is fully in line with INSPIRE and also reflects the main principles of EU open data policy” (State Service of Ukraine for Geodesy, Cartography and Cadastre (StateGeoCadastre) 2022).

The Ukrainian government’s geodetic website (https://dgm.gki.com.ua/pererahunok-po-gelmertu-(po-kljuchna-ploschini) offers a Helmert-style datum conversion tool and appears to have a completely open access portal to the nation’s geodetic network, as typical for a free republic. The website pages are in Ukrainian and in English.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for Geoinformatics (C’G).

This column was previously published in PE&RS.
ASPRS SAC GIS DAY CELEBRATIONS

To celebrate GIS Day, the ASPRS Student Advisory Council (SAC) hosted an online Map Cartography Contest!

Maps were welcomed in any format including hand-drawn. Entries were limited to one map per ASPRS member. The submission deadline was November 17, 2021 and online voting was held on November 18th. There were a variety of entries, all beautiful in their own form. Submissions can be viewed online at https://sites.google.com/pdx.edu/asprs-sac-map-contest.

“It is difficult to pick only 5. All of them are amazing!” voiced numerous voters. This was something we were ecstatic to hear.

Originally 5 prizes were decided but we extended the prizes to six participants when voting resulted in a tie. The prizes included a free one year “ArcGIS for Personal Use license” and the opportunity to have their map displayed in the Poster Gallery at the ASPRS Annual Conference at Geo Week this past February. Winners were also offered a position as a Student Volunteer at the Annual Conference.

The winners, a short biography, and their corresponding maps are mentioned below.

**Street Guide of a Section of Ado-Ekiti, Ekiti State, Nigeria**

Andy Egogo-Stanley is a recent graduate in Surveying and Geoinformatics with interest in spatial data science and machine learning, from the University of Lagos, Nigeria. He served as the General Secretary of the Nigerian Institution of Surveying and Geoinformatics Students (NISGS), 2019 – 2020.

**Deforestation of the Amazon Rainforest in Rondônia, Brazil**

Akinnusi Samuel completed his BSc in Surveying and Geoinformatics from the University of Lagos. His BSc research was on air pollution and its relationship with land cover change in Nigeria. He is also a member of several geospatial organizations and through volunteering is working towards achievement of the SDGs.

**Dzaleka Refugee Camp Watershed**

Gbiri Joshua is an undergraduate student of Surveying and Geoinformatics at the University of Lagos, Nigeria with research interest in machine learning and GIS. He is a member of several geospatial communities and holds a Remote Pilot license from AUVSI. In addition, he loves teaching, playing guitar, and debating.

**Rocky Mountain Way: Best Markets for Live Music in the Rockies**

Marty Marquis is a graduate student of GIS at Portland State University. He also spent over a decade studying “applied geography,” touring and performing in a band. His interests include architecture, analog synthesis, and American football. Marty lives in Scappoose, Oregon with his wife and children.

**A GIS Based Drastic Model for Assessing Groundwater Vulnerability**

Rabia Munsaf Khan is a Fulbright PhD scholar at SUNY ESF with research interest in water quality monitoring using machine learning techniques. She is also serving as Communications Councilor at ASPRS SAC. As a quintessential altruist she has moderated over 100 students in the past years on multiple platforms.

**Glacial Lake Kalapuya**

Peter Samson is a lifelong cartophile, now retired, whose career took him through geology; science education; project and event management; and consulting to nonprofits on strategic planning, finance, grant-writing, and fundraising. He also enjoys outdoor activities, pie baking, and volunteering.

If you are interested in participating in SAC activities:

- Join us every other Thursday from 10-11 am PST!
- Join us via this zoom link, https://tinyurl.com/SACASPRSMeeting
CONGRATULATIONS TO ASPRS’S NEWLY ELECTED BOARD MEMBERS!

We are extremely fortunate to have such a strong group of dedicated professionals express their desire to help lead the future direction of ASPRS. I am very excited to see what Jin, Matt, Hank and Bahram will do to craft the future of their respective Divisions. As I close out my tenure, I know that the future of ASPRS is in good hands with the election of Dr. Kar as well. I look forward to watching the Society benefit from her leadership.”

-ASPRS President, Jason Stoker

ASPRS Vice President – Bandana Kar
GIS Assistant Division Director – Jin Lee
Lidar Assistant Division Director – Mat Bethel
PAD Assistant Division Director – Hank Theiss
UAS Assistant Division Director – Bahram Salehi

ASPRS ANNOUNCES THE 2022 GEOBYTE SERIES

Visit https://www.asprs.org/geobytes.html for more information and to register.

NEW ASPRS MEMBERS

ASPRS would like to welcome the following new members!

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Abena Boatmama Asare-Ansah
Quest Besing
Jon Blickwede, Sr.
Rachael Brady
Benjamin Bush
David Cakalic
Dave J. Cook
Stuart Gibson
Rupert Dujon Green
Tim Haynie
Jon Loder
Alex Martin
Joseph McNichols
Katherine Milla, PhD

Adam Mochenwa
David C. Newkirk
James Rego Nicolau, IV
Ismaila Abiola Olaniyi
Constantine Papadakis
Mark Paulson, PLS
Maya Price
Charles Robison
Brian Scott
Johnathan Paul Smeh
Timothy Tallmadge
Ewoud Van Der Cruyssen
Kara Leigh Wayman
Kevin R. Winslow
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Call for *PE&RS* Special Issue Submissions

**Multimodal Remote Sensing Data Processing and Analysis for Earth Observation**

Earth observation, by providing critical information on natural resources, hazardous areas, and climate change, among others, is a powerful tool in all aspects of life. The observations come primarily from space-based sensors such as satellites, but they highly depend on ground-based remote sensing devices. Multimodal remote sensing systems integrate optical and passive microwave radiometers to improve the quality of observations. The versatility of multimodal RS offers enormous potential to monitor diverse target phenomena in all climate system components with high spatial, temporal, or spectral resolution. It provides innovative methods for processing multispectral, hyperspectral, and polarimetric remote sensing data for different vegetation, geophysical, and atmospheric applications to understand the earth better. However, there are still challenges to achieving maximum exploitation of multimodal data. At the same time, the combination of multimodal remote sensing technologies is a powerful approach that can yield significant advantages compared to traditional single-modal sensors.

The techniques such as image processing is typically used to adjust and refine data derived from remote sensing. Its capabilities are also useful for merging data sources. Image processing techniques, such as filtering and feature extraction, are well suited for dealing with the high-dimensionality of spatially distributed systems. The input data may come from different sensors, each with a different spatial resolution and measurement scale (‘multimodal’). It provides approaches for the extraction of relevant non-topographic information from remote sensing data, such as demographic indicators from satellite images of urban areas, which could assist in future spatial modelling of these areas. It helps to analyze shape, topography, and texture phenomena for soil and vegetation data and various methods for image fusion and analysis of the optical, radar, and gravity data. It covers a wide range of geospatial applications, including land and water resources management, urban planning, environmental monitoring, natural hazards and climate change, oceanography, engineering design, and national security and intelligence. It processes multispectral, thematic-mapping, thermal-infrared (TIR), hyperspectral data acquired from optical, SAR or lidar platforms with advanced techniques in the areas of scene characterization and feature extraction.

This special issue is intended for remote sensing scientists, engineers, and researchers involved in its application for earth observation. Innovative techniques dealing with climate monitoring; environmental monitoring, including pollution monitoring and deforestation detection; geographical information system (GIS) applications; maps generation, land cover classification and change detection; mineral exploration industries; hydrology and water resources management; based on multimodal remote sensing data are most invited for submission.

List of Topics (include, but not limited to the following):
- Deep learning and computer vision for earth observation and multimodal remote sensing
- Semantic and instance segmentation of the multimodal remote sensing data for earth observation and analysis
- Multimodal remote sensing data fusion, interpretation and analysis for earth observation
- Hyperspectral remote sensing and image processing for earth observation
- Light weight deep neural network algorithms for earth surveillance
- Earth object classification and recognition using multimodal remote sensing approaches
- Multi-resolution and multi-modal remote sensing for enhancing the earth observation processes
- Novel applications of multi-modal remote sensing in earth monitoring and surveillance processes
- Spatio-temporal data analysis for efficient earth observation
- Multimodal data reconstruction and restoration for efficient classification process
- Benchmarking multimodal datasets for earth observation
- New algorithms and frameworks for efficient analysis of multimodal remote sensing data

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**Guest Editors**

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Potential of Open Source Remote Sensing Data for Improved Spatiotemporal Monitoring of Inland Water Quality in India: Case Study of Gujarat

Neetu Singh, Shivanand Mallikarjun Nalgire, Meeta Gupta, and Pennan Chinnasamy

Abstract
Unison of in situ data with satellite remote sensing data has been widely used for water body quality monitoring; however, the developed synergized model is unique and thus needs to be recalibrated and revalidated before applying to other water bodies. In some Indian locations, water quality monitoring is conducted only once a year due to associated costs and time. To aid such instances, in this study, stepwise linear regression models were developed using in situ (annual) and Landsat 7 (biweekly) remote sensing data and validated for two inland water bodies (Sursagar and Nalsarovar lakes) in Gujarat state for dissolved oxygen, biochemical oxygen demand, electrical conductivity, pH, and nitrate. Results indicated that all models showed good to excellent performance metrics based on an r value (p < 0.01) ranging from 0.86 to 0.98 and 0.72 to 0.99 for Sursagar and Nalsarovar lakes, respectively. All models had root mean square errors less than 0.3, and residual predictive deviations greater than 2, which depicted good predictability. The models were able to increase the water quality assessment from annual resolution to biweekly resolution and provided insights on the dynamics of water quality parameters, improved understanding on key drivers for the change, and identified peak pollution leading to unfit conditions for domestic or agricultural consumption.

Introduction
Access to clean water has become a critical issue worldwide due to growing population, industrialization and increasing pollutant loads due to climate and land-use changes into freshwater ecosystems (Chinnasamy et al. 2021, Sagan et al. 2020). Over the past ten decades, half of the natural wetlands and a significant number of freshwater bodies have vanished due to water pollution and growing economic activities (UN Water 2020). In India, river and lake pollution has been a crucial problem over the past few decades (Kumar et al. 2017). It is estimated that around 70% of the surface water bodies in India are polluted by biological, toxic, organic, and inorganic pollutants (Sengupta 2018). Every day, rivers and other water bodies receive around 40 million liters of wastewater, with a negligible fraction adequately treated (Hirani and Dimble 2019). Traditionally, surface water bodies have been a significant source of water supply for drinking and domestic purposes. However, with widespread urbanization and industrialization becoming predominant, these water sources have been contaminated severely and are considered unfit for human consumption and other activities, such as irrigation and recreation (Kumar et al. 2017). Also, polluted water supplies increase the cost of water treatment and minimize water oxygenation by limiting sunlight transfer.

The surface water quality (SWQ) is estimated based on different physical, chemical, and biological parameters (Sagan et al. 2020). The conventional methods adopted to determine the water quality involve in situ and in-field measurements or collecting water samples from the field and performing analysis in the nearest laboratories. Although the in situ measurement delivers accurate results, the entire exercise is time consuming, labor intensive, and costly (Ali-Shaibah et al. 2021). In addition, due to the low spatial and temporal resolution, the existing sampling methods adopted do not capture either the spatial or the temporal extent required for the accurate assessment and management of the water bodies (Mushtaq and Nee Lala 2017). Therefore, there is a constant need to update and upgrade methods for inland water quality assessments and frequent monitoring.

With the advancement and growing role of remote sensing (Chinnasamy and Parikh 2021) and geographic information systems (GIS), new techniques have emerged for assessing water quality using satellite data to reduce time and cost and increase accuracy (Ali-Shaibah et al. 2021). The widely used approach to estimate SWQ parameter concentration using remote sensing data involves fitting a linear regression between spectral bands/band combinations and temporally coincident in situ SWQ observations, called empirical modeling (González-Márquez et al. 2018). This approach has a limitation of nongeneralizability across large spatial and temporal scales, though it can be outweighed by its capability to provide model transparency, cost-effectiveness, simplicity, and minimal computational requirements (Topp et al. 2020). On this note, satellite images have been widely used to develop synergized models with in situ data to assess the quality of water bodies globally. For example, Al Din and Zhang (2017) developed linear regression models using Landsat 8 data to estimate optical parameters, such as turbidity, total suspended solids (TSS), and concentration of nonoptical parameters, such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), and dissolved oxygen (DO), in Saint John River, Canada. In another study, González-Márquez et al. (2018) used Landsat 8 data to assess spatial and temporal variation of phosphates (PO4), electrical conductivity (EC), TSS, turbidity, and pH in Playa Colorado Bay. The developed water quality models had coefficients of determination (R2) in the range of 0.637–0.955. Zhang et al. (2017) used Landsat images along with the linear stepwise regression method to estimate total nitrogen (TN), total phosphorus (TP), permanganate index (CODMn), and 5-day biochemical oxygen demand (BOD5) in Danjiangkou Reservoir, China, which indicated a water quality deterioration trend between May 2006 and May 2014. The application of multitemporal Landsat images in the aforementioned studies has established their potential to estimate the spatial and temporal variation of SWQ parameters. Such an application is needed for Indian inland waters, as some water bodies are monitored only once a year for water quality parameters. This low monitoring frequency impedes the understanding of water quality changes and the insights on what causes these changes.

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Modelling, Representation, and Visualization of the Remote Sensing Data for Forestry Management

Remote sensing data includes aerial photography, videography data, multispectral scanner (MSS), Radar, and laser to map and understand various forest cover types and features. An accurate digital model of a selected forest type is developed using forest inventory data in educational and experimental forestry and extensive databases. It includes the formalization and compilation of methods for integrating forest inventory databases and remote sensing data with three-dimensional models for a dynamic display of forest changes.

Big data technology employs vast amounts of forestry data for forestry applications that require real-time inquiry and calculation. The techniques and strategies of forestry data analysis are integrated into the Big data forestry framework, enabling interfaces that other Programmes may call. Virtual Reality addresses constraints in forest management such as temporal dependence, irreversibility of decisions, spatial-quantitative change of characteristics, and numerous objectives. Virtual representations integrate various computer graphics systems with display and interface devices to create a spatial presence in an interactive 3D environment. Visualization of plant species’ growth patterns, changes in species and their composition, and other morphological properties of forests are enhanced using machine learning and regression analysis methods as part of a digital model. In modelling, deep learning (DL) replicates expert observations on hundreds or thousands of hectares of trees.

Remote sensing is being used to map the distribution of forest resources, global changes in flora with the seasonal variations, and the 3D structure of forests. Graphic Information System (GIS) based visualizations depict dynamics through animations and 3D geo model visualizations and allow advanced spatial analytics and modelling in geographical phenomena for forest management. Digital forest modelling includes integrating forest inventory data, forest inventory database formation, graphics objects of forest inventory allocations with a digital forest model, and technology for visualizing forest inventory data. It helps forecast changes and visualizes situational phenomena occurring in forests using data and models involving spatial-temporal linkages.

Standard aerial shots capture images that view unseen components to the naked eye, such as the Earth’s surface’s physical structure and chemical composition. The challenges in remote sensing models include insufficient Remote Sensing (RS), spatial, spectral, and temporal resolution to detect degradation accurately. High costs of RS, the gap between operational and scientific uses, and lack of information sharing are some of the challenges of RS for forest management. The list of topics of interest include but are not limited to the following:

- Advancement of forest surveillance through Geographical Information Systems
- State of the art and perspectives of modelling and visualization framework for Forest type mapping and assessment of distribution
- Futuristic Satellite data analysis for stock maps and forest inventory analysis
- Big data-enabled GIS framework for forest management information
- Al-based Space Remote Sensing For Forest Ecosystem Assessment
- Enhanced visualization through deep learning for forest management solutions
- Novel approaches of multi-temporal satellite data using digital image analysis for forest management
- Advance representation of discrete objects and continuous fields in virtual environments through VR framework
- Database framework for regional and plot-based forest allotment data for model representation and visualization
- Development of scalable models for area-based metrics from Light Detection and Ranging (lidar) devices and photographic structure-for-motion (SFM)

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Guest Editors
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Dr. Yan Pei, peiyan@u-aizu.ac.jp, Computer Science Division, The University of Aizu, Japan.
Automated 3D Reconstruction of LoD2 and LoD1 Models for All 10 Million Buildings of the Netherlands

Ravi Peters, Balázs Dukai, Stelios Vitalis, Jordi van Liempt, and Jantien Stoter

Abstract

In this paper, we present our workflow to automatically reconstruct three-dimensional (3D) building models based on two-dimensional building polygons and a lidar point cloud. The workflow generates models at different levels of detail (LoDs) to support data requirements of different applications from one consistent source. Specific attention has been paid to make the workflow robust to quickly run a new iteration in case of improvements in an algorithm or in case new input data become available. The quality of the reconstructed data highly depends on the quality of the input data and is monitored in several steps of the process. A 3D viewer has been developed to view and download the openly available 3D data at different LoDs in different formats. The workflow has been applied to all 10 million buildings of the Netherlands. The 3D service will be updated after new input data becomes available.

Introduction

Three-dimensional (3D) city models are widely used in urban applications. The outcomes of such applications serve as input for planning and decision-making processes that aim at making cities cooler, sustainable, more accessible, greener, carbon dioxide-neutral, etc. (Biljecki et al. 2016; Deren et al. 2021). Models of buildings are prominent objects in these models. The building models can be generated at different levels of detail (LoDs). Taking the terminology of CityGML, a building can be modeled at four main levels of detail for the outer shell of the building, i.e., LoD0, LoD1, LoD2, and LoD3, and at LoD4 for the interior of the building (OGC 2012; Kutzner et al. 2020). Each of these four CityGML LoDs can be further refined (Biljecki et al. 2016; Sun et al. 2019).

A higher level of detail is often preferred over a lower one, since building models at higher LoDs look closer to reality. However, higher levels of detail are more complicated (and therefore more expensive) to acquire because it is harder to reconstruct them in an automated manner from available source data. In addition, using models at higher levels of detail in spatial analysis does not automatically lead to better results (Biljecki et al. 2018), while at the same time too much detail may have a negative impact on performance. Therefore, for some applications it is better to avoid too much irrelevant detail.

The LoD of a 3D city model is therefore driven by the specific data requirements of the urban application for which it is built (see also the section “LoD in Relation to Urban Applications”). However, the highest achievable LoD is also restricted by the available source data and the reconstruction method used (see also the section “LoD in Relation to Reconstruction Method”).

While many 3D city models exist for various parts of the Netherlands, they are often generated for relatively small areas, are using different reconstruction methods, and are based on different source data. Furthermore, the update cycles are different, and the level of detail is also different because it is collected for different applications. This can result in inconsistencies between 3D city models of the same area. There may be discrepancies between the geometries of building models like the geometry or height of the footprint. Also, the reference heights for the same building might differ over data sets since the heights may represent different references (e.g., gutter, ridge, maximum) or the reference heights are based on different statistical calculations. In addition, buildings (or building parts) available in one data set might be missing in another data set. There may also be temporal differences because the input data sets that were used for the reconstruction come from another date. Typically, there is no plan to maintain and update the once generated 3D data. This may be another source for discrepancies.

All these differences have profound influences in practice, such as affecting the applications for which an existing 3D model can be used, the processing that is necessary to use it, and the likely errors that will be present in the end result.

In this research, we demonstrate how to create a consistent country-wide 3D city model in LoD1.2, LoD1.3, and LoD2.2. In order to achieve this, we look at three main aspects.

First, to ensure consistency between 3D city models of the same area and different LoDs, to improve efficiency, and to serve the 3D data needs of different urban applications, we investigate how to reconstruct building models for large areas at different LoDs in one reconstruction process, based on the same reconstruction principles and based on the same source data. For the block models, we provide the user with several reference heights, so that the user can select the appropriate reference height to extrude building blocks for the specific application.

Second, our objective is to develop a fully automated reconstruction method. Our focus is on 3D city models covering large areas to support countrywide urban applications. This requires a fully automated reconstruction method. Automated reconstruction also enables standardization of the output data resulting in consistent geometries, semantics, and temporal aspects of the data. This consistency is also ensured when new models are reconstructed in the future with the same automated procedure based on updated source data.

Third, we investigate how to monitor and assess the quality of the building models that are automatically generated on such a large scale. This is essential for users to assess if models are fit for a specific use.

Finally, we also investigate the visualization and dissemination of such a big data set so that the city model is accessible and usable in an efficient manner.

Structure of this Paper

In this paper, we present our methodology to reconstruct LoD1.2, LoD1.3, and LoD2.2 models of all buildings in the Netherlands in one process. The section “Scope of the Research and Previous

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Contributed by Zhenfeng Shao, June 7, 2021 (sent for review September 9, 2021; reviewed by Nan Yang, Hongping Zhang).
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Muhammad Nasar Ahmad, Qimin Cheng, and Fang Luo

Abstract
This article proposes an estimation method for assessing urban sprawl using multispectral remote sensing data: SNPP-VIIRS, DMSP/OLS, Landsat 5-TM, and Landsat 8-OLI. This study focuses on the impacts of human activities, in terms of increased electrical-power consumption (EPC) due to urbanization. For this purpose, nighttime light data are used to measure the EPC growth from 2000 to 2020. We also perform a suitability analysis using geographic information-systems techniques to propose a new urban town in Lahore to mitigate urbanization and EPC increase. We found an overall increase of 33% in urban area and an EPC increase of 21.6% in the last two decades. We also find that the best proposed site for the new urban town is in the northwest of Lahore.

Introduction
Urbanization is an emerging problem worldwide. It mainly affects socioeconomic factors and the demographic composition of locations, leading to many environmental and ecological problems such as urban heat islands and waterlogging. These complications are increasing as time goes on, due to rapid urbanization all over the world.

According to Q. Zhang and Seto (2011), a United States survey stated that by 2050 the global population will increase by 2.7 billion. For the most part, people readily move from rural to urban zones to seek better living and work opportunities and to enhance their earnings, which leads to an increase in population density and urbanization. Ding et al. (2016) concluded that most agricultural farmland is converted into urban areas, which will have negative effects on regional climate change. Imhoff et al. (1997) note that when analyzing urban sprawl and its dynamics, it is necessary to identify factors and the effects of urbanization on society and the environment.

Urban expansion is a reflection of urban growth patterns, which can be either scattered or fragmented. An abrupt increase in urbanization also results in the loss of vegetation, biological diversity, freshwater resources, and energy production sources. Dowall and Ellis (2009) explain that most of the growth in urban sprawl occurred in Asia over the past few decades. According to Sutton (1997), urbanization has negative impacts that are typically observed in underdeveloped countries. There is a need to control the outcomes of urbanization. The health of the environment and food security in densely populated regions are the main reasons for monitoring urban settings, because they address public health issues as well as fiscal concerns.

Globally, the main factor is people who migrate to enhance their livelihoods and earnings and secure their future. In the past, statistical data and conventional methods were used to analyze changes in urbanization. But these methods are slightly complicated and require considerable time for data collection and surveying. Taubenböck et al. (2012) described limitations of these conventional methods. Researchers are now using remote sensing technology to speed up analysis and identify changes in land cover/land use.

Remote sensing is a dynamic tool that is used to acquire accurate, prompt, and up-to-date spatial information on urban growth patterns across the globe. However, mapping of urban clusters is quite difficult, because of mixed land use, which includes buildup, rivers, vegetation, and barren land. Many satellite products are available which incorporate different sensors and image characteristics, for mapping built-up areas and urban clusters. However, this also depends on the available spectral and spatial resolution of the satellite imagery.

In past, multiple satellite images were used, such as MODIS, Spot, and Ikonos, but these satellite products were acquired only during daytime (Zhao et al. 2018). But nighttime light (NTL) data have a particular characteristic that allows a sensor to acquire data in the absence of sunlight. Because light-source detection is strongly correlated with urban activities at any given location at night, researchers in the past considered emission of light as an indicator of electrical-power consumption, human activities, population expansion, and urban sprawl (Yi et al. 2014; Zhou et al. 2014).

Thus, the use of NTL data is quite practical for analyzing the distribution of urban expansion using image-processing techniques combined with multi-source data. Small et al. (2005) determined that electrical-power consumption is a major factor for countries in terms of energy production. As discussed by Letu et al. (2010) and Mellander et al. (2015), NTL data can also be used to predict future economic growth and reliability, with respect to available energy resources. According to Kiran Chand et al. (2009), mostly solar power, wind power, and coal are used to produce electricity on a global scale.

Nighttime light data typically capture artificial light emitted from the earth’s surface at night. NTL products including DMSP/OLS and NPP-Visible Infrared Imaging Radiometer Suite (VIIRS) data can be used to assess large areas, because they have a resolution of 750 m to 1 km. Nighttime light data (NTLD) are also convenient for determining time-series change over the globe, because there are many freely available products. According to Huang et al. (2014), NTLD have been used more since the launch of version 4 and VIIRS products.

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Natural and human disasters are increasingly affecting global communities worldwide in recent decades. With the increasing human population and urbanization, the earth is inevitably more susceptible to manmade hazards. Global warming and its associated environmental instability increase the frequency and severity of the disaster. Rapid climate change is linked with meteorological events with a high degree of risk probability causing flood disasters. Implementation of proper hazard management such as disaster prevention, disaster preparedness, and adequate disaster relief would reduce the impact of natural disasters. Usage of the conventional earth observation model helps in hazard management with a reliable solution but cannot provide early prediction of disaster occurrence, saving people’s lives. However, using remote sensing techniques would enable warning systems by building futuristic codes that predict the hazards and warn people on time with greater accuracy. Remote sensing imagery provides a quick method for assessing the variation of hazard impacts, coastal inundation, erosion, and majority affected flood plains using intelligent, visionary technology. The data gathered from sensors provide valuable insights about the spatial phenomena that aid scientists in making accurate decisions about the forecast patterns. Above all satellites, remote sensing is used to detect global environmental problems, explore resources, and monitor disasters by capturing the earth’s surface during altered weather conditions. This helps in the early detection of disaster patterns with futuristic mitigation procedures.

The sensors technology captures images of fires, flooding, and volcanic eruption can create a visual impact during the response phase that aids in readiness actions when people are viable to disaster risk. Earth observation systems and GIS helps professionals to make effective project planning with more accurate analysis. The utilization of various spectral bands such as Visible, infrared, thermal infrared, and synthetic aperture radar provides adequate coverage of environmental patterns and allows technology enhancement to analyze data. Meteorological satellites use High-resolution transmission sensors for cyclone monitoring, intensity assessment, and storm surges. Geo-stationary satellites use global coverage sensors for flood and drought management by collections of multi-date imaginary data for rainfall and river stages. Using its unique spectral signature, it identifies the water standing areas, the sand casting of agricultural lands, and marooned villages to enable hazard recovery plans. SAR sensing system is used to detect forest fires and forest monitoring using microwave techniques to acquire sensory images. There are some challenges about using sensors for hazard prediction where research prospects are needed. As smart sensors use advanced technologies and complex data for prediction, data breaches would lead to misinterpretation of results, increasing the risk to human lives. An adequate skilled workforce is required to analyze the collected sensor data. In the future, integrating IoT and artificial intelligence would create autonomous drones that aid in inspecting the geographical patterns in multi-dimensional views to accelerate high definitions imagery for efficient prediction of results. This special issue enumerates the role of remote sensors for earth hazard predictions and future advancements. We welcome scholars and practitioners of this platform to emphasize this topic and present submissions that fall within the scope of remote sensing techniques for the accurate prediction of environmental hazards.

The topics of interest include:
- Role of Artificial intelligence in generating patterns in sensor data
- Disaster management cycle and it’s important in hazard mitigation
- Advantages of geometrics in disaster risk management
- Usage and applications of GIS in flood forecasting
- Advanced Earth observation system tools for project planning
- RadarSat and use cases in detecting oil seeps
- Big data and its uses for accurate data collection in sensors
- Role of climate change in creating environmental risk
- Advancement in satellite sensors for earth’s behavioral prediction
- Role of autonomous drones in capturing multispectral images

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An Optimal GeoAI Workflow for Pan-Arctic Permafrost Feature Detection from High-Resolution Satellite Imagery

Mahendra R. Udawalpola, Amit Hasan, Anna Liljedahl, Aiman Soliman, Jeffrey Terstried, and Chandi Witharana

Abstract
High-resolution satellite imagery enables transformational opportunities to observe, map, and document the micro-topographic transitions occurring in Arctic polygonal tundra at multiple spatial and temporal frequencies. Knowledge discovery through artificial intelligence, big imagery, and high-performance computing (HPC) resources is just starting to be realized in Arctic permafrost science. We have developed a novel high-performance image-analysis framework—Mapping Application for Arctic Permafrost Land Environment (MAPLE)—that enables the integration of operational-scale GeoAI capabilities into Arctic permafrost modeling. Interoperability across heterogeneous HPC systems and optimal usage of computational resources are key design goals of MAPLE. We systematically compared the performances of four different MAPLE workflow designs on two HPC systems. Our experimental results on resource utilization, total time to completion, and overhead of the candidate designs suggest that the design of an optimal workflow largely depends on the HPC system architecture and underlying service-unit accounting model.

Introduction
Big image-data analysis has become essential in an array of scientific applications, such as computer vision (Kucuk et al. 2017), medical imaging (El-Baz and Suri 2020), materials science (Okunev et al. 2020), and astronomy (Kremer et al. 2017). The advancements of satellite sensor technology, coupled with the ever-increasing spatial resolution and temporal frequency of image acquisitions, ideally position remote sensing applications in the big-data landscape (Wang et al. 2015; Liu et al. 2018). Satellite imagery archives are being radically transformed from terabyte to petabyte scale (Witharana et al. 2021). The sheer volumes of imagery pose new challenges in storage, analysis, and visualization techniques (Liu 2015; Y. Ma et al. 2015), and the requirements exceed the capabilities of existing general-purpose computing resources. Therefore, highly efficient workflows with high-performance computing resources are required for implementing big-imagery applications.

High-throughput computing (HTC) and high-performance computing (HPC) are both important in high-resolution imagery analysis on a petabyte scale. HTC is used for workloads that consist of tasks that are independent of each other and can start or complete in any order (e.g., automated feature extraction from thousands of satellite images in repeated mapping applications). Therefore, there is a lot of flexibility in scheduling these HTC jobs in HPC systems. In contrast, an HPC workload is characterized by its scalability or running time. Typically, an HPC workload consists of a single job that coordinates multiple processes which run at the same time. When running these jobs, input-output requirements are important. Usually, HTC tasks operate on a small volume of data and HPC workloads operate on large volumes of data. But in running many HTC jobs, the limitations of input–output bandwidth become significant. Usually, most supercomputers are designed for HPC workloads. Huerta et al. (2019) argue that new applications require a paradigm shift in computing architecture to address large data sets, deep-learning algorithms, and hybrid workloads using both HPC and HTC. It is imperative to find out how applications with hybrid workloads can be run efficiently in existing HPC resources. Remote sensing (RS) big-data applications typically consist of hybrid workloads requiring efficient use of existing HPC systems. Lee et al. (2011) reviewed advances in HPC applied to remote sensing problems, and in particular HPC-based platforms, such as multi-processor systems and large-scale and heterogeneous networks of computers.

A seamless application of HPC resources for translating big satellite imagery into science-ready products can enable knowledge discovery at the nexus of the human and natural systems (Chi et al. 2016). In recent years, the use of HPC resources has become an inextricable component in big-imagery applications (Wang et al. 2018). A plethora of applications can be found in the literature involving big imagery and HPC. Amat et al. (2015) developed a workflow for light-sheet microscopy, which involves several tens of terabytes of data. Schmied et al. (2016) compared the performance of an automated workflow on a single workstation and an HPC cluster. Liu et al. (2016) analyzed a geosciences workflow on multi-core processors and graphical processing units (GPUs), achieving a 5× speedup on a multi-core processor and a 43× speedup for some parts of the workflow on GPU. In a recent study, Al-Saaidi et al. (2021) compared workflow application designs for high-resolution satellite-imagery analysis. They analyzed three workflow designs using the Extreme Science and Engineering Discovery Environment (XSEDE) HPC system for two use cases, for a total of 4672 high-resolution satellite and aerial images and 8.35 TB of data.

Modern HPC systems consist of many HPC computer nodes. Each node contains multi-core central processing units (CPUs) and multi-GPUs. RS big-data applications need to use both CPUs and GPUs in their workflow, because GPUs are efficient at processing RS images and CPUs are efficient at executing complex algorithms. Several traditional parallel paradigms are widely used in these systems, such as OpenMP and Message Passing Interface. Implementation of parallel RS algorithms using Message Passing Interface is difficult, and HPC systems are not optimized for data-intensive computing (Wang et al. 2016). RS workloads involve both HPC and HTC features, so they are considered hybrid HPC/HTC workloads. A single RS workload may not be large enough for use in many multiple nodes. It is therefore critical to examine how to optimize RS hybrid HPC/HTC workloads in a single node with

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Assessing the Impact of Land Use Changes on Net Primary Productivity in Wuhan, China

Yan Gu, Zhenfeng Shao, Xiao Huang, Yuanhao Fu, Jiyuan Gao, and Yewen Fan

Abstract
Since 2000, major changes have taken place in Wuhan city. Land use and land cover (LULC) has changed significantly, characterized by increased construction land, reducing farmland, grassland, and forest land due to the rapid urbanization process. Taking advantage of LULC data and Moderate Resolution Imaging Spectroradiometer Net Primary Production (MODIS NPP) data from 2000 to 2020, we analyze the impact of LULC type transformation on NPP, reveal the relationship between LULC type and NPP, and quantify the impact of urban expansion on NPP by taking Wuhan, China as a study case. The results showed that: 1) the transformation from farmland and grassland to construction land was a dominant LULC change type in Wuhan during the investigated period; 2) there exists a significant negative correlation between NPP and changes in farmland, woodland, and grassland area; 3) the distance from the city center has a significant positive correlation with NPP, and the dynamics of NPP vary in different regions; 4) there is a significant positive correlation between NPP and night light data. The results of this study provide scientific references for the formation of greening construction and sustainable development strategies in Wuhan.

Introduction
Net Primary Productivity (NPP) of vegetation refers to the amount of organic matter accumulated by green plants (per unit area and per unit time) through photosynthesis. NPP not only reflects the CO₂ fixation capacity of vegetation under natural environmental conditions, but also represents the quality status and production capacity of ecosystems (Yang et al. 2021). As human activities are constantly changing the Earth's ecosystem, NPP is a key ecosystem indicator that measures the influence of human interference with the environment (Zhang et al. 2021; Zhuang et al. 2022).

Numerous efforts have been made to study NPP based on varying driving factors and regional environments (Su et al. 2020; Xu et al. 2020; Zhuang et al. 2022). Many pieces of evidence have shown that NPP is more closely related to climate factors (Li and Qin 2019; Sun et al. 2019; Zahra et al. 2020). Based on the Carnegie-Ames-Stanford approach (CASA) model, Lin and Narangarav et al. (2015) analyzed the temporal and spatial patterns of NPP derived from Moderate-Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) in Mongolia using factor variance analysis and regression analysis. Zhang et al. (2020) studied the ecosystem of two high-yielding grasslands in the Great Plains of Central America in the 21st century, and the results showed that elevated atmospheric CO₂ has a fertilizing effect on the grassland ecosystem. NPP. Li et al. (2007) analyzed the spatiotemporal dynamic changes of landscape pattern in Jilin Province by using landscape index models such as landscape diversity, fragmentation degree, and average patch fractal dimension. Shao and Zhang (2016) proposed a new optical and microwave integrated vegetation index (VI) to estimate forest aboveground biomass using Landsat 8 Operational Land Imager (OLI) and RadarSAT-2 satellite data. Based on Landsat thematic mapper (TM) and field survey data, Zhou et al. (2011) discussed the applications of the K-nearest neighbor (KNN) technique in estimating terrestrial carbon. Mustafa et al. (2012) combined the output of the Physiological Growth Principle model with leaf area index (LAI) from advanced Spaceborne Heat and Reflection Radiometer satellite images to improve their estimated LAI. Qiu et al. (2014) studied the seasonal and interannual spatial and temporal dynamic patterns and complex relationships of vegetation and climate factors in China during 1982–1998 based on Global Inventory Modeling and Mapping Studies (GIMMS) data set and using wavelet transform method. Stohlf et al. (2010) used thermal infrared images to identify the effectiveness of plants affected by high CO₂ concentrations under soybean canopies in east-central Illinois. Bayarsaikhan et al. (2020) estimated the NPP of Mongolia during 1982–2015 using the third-generation GIMMS NDVI data and CASA model. Xiong et al. (2004) estimated NPP of the Mongolian Plateau by using a vegetation index based on pattern decomposition. Handcock and Csillag (2004) predict NPP at monthly temporal resolution for 16 years (1981–1996) at an 8-km spatial resolution for the approximately 106 km² area of Ontario, Canada.

Urbanization is one of the most important social and economic phenomena. The rapid expansion of urban fabrics has become an alarming issue (Hadeel et al. 2009; Shao et al. 2021; Xiao et al. 2019). Efforts have been made to investigate the effect of climate factors (He et al. 2021; Berauer et al. 2021), as well as the effect of land use and land cover (LULC) dynamics on NPP (Zhang et al. 2020; Xing et al. 2021). Ma (2020) studied the impact of the spatiotemporal distribution of LULC on total primary production and net primary production in Schleswig-Holstein, northern Germany. Ge et al. (2021) analyzed the relative contribution of human activities and climate change on China’s NPP using residual trend analysis. Pan et al. (2021) assessed the impact of individual farmland displacement on NPP in a data-driven manner using the mean difference method, the newly introduced ridge regression method, and the method based on actual change excluding climate impacts. Zhang et al. (2020) took Zhengzhou, China, as the study area and explored the urban expansion pattern and its relationship with NPP and climate change. Yan et al. (2008) used National Oceanic and Atmospheric Administration/Advanced Very High Resolution Radiometer (NOAA/AVHRR) remote sensing data and NPP model, combined with China’s LULC data from 1990 to 2000, to evaluate the impact of farmland conversion on agricultural productivity. Yang et al. (2021) used MODIS and meteorological data to estimate the regional NPP in the Yangtze River Basin from 2001 to 2018 and...
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Photogrammetric Engineering and Remote Sensing (PE&RS) is seeking submissions for a special issue on AI-Based Environmental Monitoring with UAV Systems.

Global warming and climate change have become the most important factor threatening the world. Climate change results in dramatical environmental hazards and threatens the planet and human life. A wide variety of policies have been proposed to decrease the effects of global warming and climate change. The most important one is the Paris Agreement which aims to limit global warming to well below two degrees Celsius. Many countries have formulated long term low greenhouse gas emission development strategies related to the Paris Agreement which aimed to meet the essential strategies addressing issues with climate change, environmental protection and low carbon.

The astonishing developments on unmanned aerial vehicle (UAV) systems and artificial intelligence (AI) technologies enables a great opportunity to monitor the environment and propose reliable solutions to restore and preserve the planet and human health.

Data acquisition and processing paradigm has been changed as a result of technological developments. It is obvious that new solutions, innovative approaches will make significant contributions to solve the problems which our planet is facing. UAV data can be collected by various platforms (planes or helicopters, fixed wing systems, drones) and sensors for earth observation and sustainable environmental monitoring which are also utilized by the United Nations to support the delivery of its mandates, resolutions, and activities.

UAV based earth observation data and AI techniques have a wide range of applications such as risk management, disaster monitoring and assessment, environmental impact evaluation and restoration, monitoring agriculture and food cycles, urban analysis, digital twin and smart city applications and providing increased situation awareness. This growth of widely available UAV data associated with the exponential increase in digital computing power, machine learning and artificial intelligence plays a key role in the environmental monitoring and solution generation of geospatial information for the benefit of humans and the planet.

The proposed special issue aims to contributes ASPRS’s key mission on ‘Simplify and promote the use of image-based geospatial technologies for the end-user’, ‘Promote collaboration between end users and geospatial experts to match data and technology to applications and solutions’ and ‘promote the transfer of geospatial data and information technology to developing nations’ by serving as an innovative knowledge exchange platform for authors from the globe to deliberate on the latest advancements, state-of-the-art developments and solutions that can help the community to solve many real-world challenges on the topic of “AI-Based Environmental Monitoring with UAV Systems.”

This special issue aims to bring researchers to share knowledge and their expertise about state-of-art developments and contribute to the goal of a livable world by integrating human creativity with UAV and AI technologies for environmental monitoring to combat global threats on ecosystems. We wish to discuss the latest developments, opportunities and challenges that can solve many real-world challenges in environmental monitoring including but not limited to:

- AI-Based UAV and GIS Applications
- AI-Based Object Detection and Recognition from UAV Imagery
- AI-Based Digital Twin Applications
- AI-Based Smart City Applications

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**Guest Editor**

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Abstract
In object-oriented information extraction from high-resolution remote sensing images, the segmentation and classification of images involves considerable manual participation, which limits the development of automation and intelligence for these purposes. Based on the multi-scale segmentation strategy and case-based reasoning, a new method for extracting high-resolution remote sensing image information by fully using the image and nonimage features of the case object is proposed. Feature selection and weight learning are used to construct a multi-level and multi-layer case library model of surface cover classification reasoning. Combined with image mask technology, this method is applied to extract surface cover classification information from remote sensing images using different sensors, time, and regions. Finally, through evaluation of the extraction and recognition rates, the accuracy and effectiveness of this method was verified.

Introduction
With the rapid advancement of remote sensing technology and the popularization of high-resolution remote sensing images, in order to accurately extract information from high-resolution remote sensing images, experts focus on remote sensing information to extract the ecological environment (Shao et al. 2014; Cao et al. 2015), sustainable development (Shao et al. 2020; Shao et al. 2020), protection of cultivated land (Shao et al. 2020), and other issues that have been under in-depth and extensive research.

The accuracy of large-scale information extraction from high-resolution remote sensing images, the degree of complexity, and universality of the method are still big challenges (Wang et al. 2013). The existing methods of extraction of surface cover classification information fail to meet practical application requirements (Zhang et al. 2013). The reasons for this are:

1. The decision tree has poor antinoise abilities (Shao et al. 2016); obtaining clustering results using the fuzzy clustering method when the sample size is too large is difficult (Shao et al. 2018); geographic information systems (GIS)-aided classification methods are limited by the present status and accuracy of GIS data; the support vector machine (SVM) algorithm has difficulties solving the problem of multi-classification (Zhang et al. 2018).

2. Artificial neural networks are prone to local minimization problems, the relationship between knowledge rules is not transparent, and expert systems do not have sufficient learning ability (Du et al. 2002); convolutional neural networks have a huge demand for samples (Shao et al. 2020).

The idea of case-based reasoning was first described by Schank of Yale University in the United States. Its principle is to use the original case to explain or solve a new problem. It is mainly to solve the problem through the method of analogy, to integrate problem solving and learning, and to use case to express knowledge, emphasizing the use of past experience accumulation and appropriate modifications to solve new problems; many scholars have also tried to apply this method to the fields of geography and remote sensing. The case-based approach has played an important role in the classification of and information extraction from radar images (Li et al. 2004; Li et al. 2009), synthetic-aperture radar (SAR) images (Chen et al. 2008), SPOT-5 images (Liu et al. 2014), and hyperspectral images (Tang 2010). But it does not form a unified model.

As of yet, there has been no in-depth study of the case-based and case-based management methodologies of information extraction from high-resolution remote sensing images. Currently, the following three problems commonly exist in object-oriented image classification methods for information extraction (Miao et al. 2010):

1. First, the optimal segmentation scale problem: The spectral characteristics of high-resolution remote sensing images are less stable, and the texture features are more variable, resulting in different optimal segmentation scales for each type of surface cover (Wang et al. 2009). Common methods for determining the optimal image segmentation scale include the trial and error method, maximum area method, object function method, local variance method, and area ratio method. However, the calculations involved are cumbersome and the result obtained cannot be used as a fixed value (Li, 2013).

2. Second, the optimal combination of features: The feature information from high-resolution remote sensing images is rich, and in order to get the best combination of features for each type of surface cover the redundant features need to be removed (Shao et al. 2020). Due to the characteristics of object-oriented classification with small samples and high-dimensional features, the quality of feature selection may be affected due to a limitation in the number of samples.

3. Finally, the applicability of classifiers: There are various classifiers, such as artificial neural networks (Pacifici et al. 2009), expert systems (Sun et al. 2007), fuzzy clustering (Li et al. 2011), support vector machine (Chang et al. 2012), and decision tree (Yan 2011; Chen et al. 2013). However, each classifier has its own limitations, creating a need to further amend and improve the classification strategy and enhance the applicability of the classifier for high-resolution images of the different types of surface cover.

This paper proposes a new method of high-resolution remote sensing information extraction. This method constructs multi-scale cases of different land cover classification types and uses case-based reasoning to predict the land cover type of the target case.
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