SAVE THE DATE!

Due to the ongoing COVID pandemic, ASPRS is going to be conducting its 2021 Annual Conference virtually. The conference program will consist of:

- a multi-day series of technical sessions, including oral presentations, Ignite-Style talks, and invited panel discussions
- 2-hour and 4-hour workshops conducted as live, instructor-led webinars
- vendor spotlights and product demos*
- the ASPRS Annual Business Meeting, which includes the Installation of Officers and Directors, Presidential Address, and presentation of 2021 Awards and Scholarships.
- annual Division, Council, and Committee meetings
- The entire conference program will be recorded and made available on-demand for all registrants on the ASPRS online learning platform.

http://conferences.asprs.org/asprs-2021/
ANNOUNCEMENTS

AEC Next Technology Expo & Conference, International Lidar Mapping Forum, and SPAR 3D Expo & Conference are coming together to form Geo Week 2022 and will take place February 6-8, 2022 in Denver, Colorado. The joining of these events reflects the increased integration between the built environment, advanced airborne/terrestrial technologies, and commercial 3D technologies. Geo Week is at the forefront of this integration, providing education, technology, and resources for professionals in industries including AEC, Asset & Facility Management, Disaster & Emergency Response, Earth Observation & Satellite Applications, Energy & Utilities, Infrastructure & Transportation, Land & Natural Resource Management, Mining & Aggregates, Surveying & Mapping, and Urban Planning/Smart Cities.

“We’ve witnessed the growing convergence between geospatial and the built world, and we received positive feedback from customers about holding the events together, which had been the plan for 2020 and 2021 before the pandemic forced us to cancel due to the unavoidable consequence of the worsening magnitude of the public health and safety issues caused by the COVID-19,” said Lee Corkhill, Marketing Director at Diversified Communications. “We believe the market is ready and eager for this next step of leveraging the confluence of what are becoming ubiquitous technologies for improved collaboration, increased efficiency, and better outcomes. Much of the conference content and technology being showcased will reflect and support this increasing integration.” An Advisory Board of industry leaders will guide conference programming and event development.

In addition to Diversified Communications’ technology events coming together, powerful partnership events will also take place at Geo Week, including the ASPRS (American Society for Photogrammetry and Remote Sensing) Annual Conference and USIBD’s (U.S. Institute of Building Documentation) Annual Symposium. ASPRS, USIBD and other events have supported and taken place with ILMF, AEC Next and SPAR 3D when the latter events took place separately. Bringing all these brands together as a new powerhouse event under the Geo Week umbrella is a fitting evolution that recognizes the increasing convergence of the technologies.

Karen Schuckman, PLS, CP, CMS and Managing Director of ASPRS, said, “Bringing ASPRS and ILMF together beginning in 2018 reunited the photogrammetry, remote sensing, and lidar professionals and vendors who enthusiastically welcomed the opportunity to attend one consolidated event; an event where they could roam one large exhibit hall and attend educational workshops to broaden their expertise into related disciplines. Bringing the built world into this mix through AEC Next and SPAR 3D acknowledges not only the richness and complexity of the technologies we have available for spatial analysis and decision making, it also give us all the opportunity to explore and invent new analysis methods that leverage the fusion of imagery, elevation, and bathymetry with 3D models of the built world. The merging of these disciplines IS the future. Co-locating our annual conferences and expositions facilitates us traveling into the future on a multi-lane superhighway.”

“The coming together of professionals from the geospatial and built environment communities is long overdue,” said John Russo, AIA, President of USIBD. “Finally, one event, one place where we can all gather to network and gain insight into the convergence of our worlds. The USIBD is excited to participate in GeoWeek and share its expertise in reality capture, BIM, digital twin and more!”

Geo Week counts a broad range of industry organizations, publications, and portals as supporters during this unprecedented period of transformation and disruption driving the rapid expansion of the internet of things, the development of smart cities, and a data revolution altering how people live and work. At the center of this revolution are geospatial, 3D, and location-based technologies. Geo Week is the only platform-neutral event in North America that brings together industry leaders to harness these technologies and explore the myriad applications they empower.

According to Corkhill, there will also be content that addresses the built environment, advanced airborne/terrestrial technologies, and commercial 3D technologies independently of one another. “The event represents a continuum, with individuals and organizations from all corners of industry at differing levels of adoption. Geo Week will support a future vision, in which professionals and organizations that understand the full spectrum of data needs, work processes, software integration, and standards in both geospatial and BIM will be tomorrow’s technology leaders.”

The event will feature multiple tracks with content clearly identified as relevant to one or more of the audience groups feeding into Geo Week. The International Lidar Mapping Forum (ILMF) audience has historically been comprised of precision measurement professionals in surveying and mapping who use airborne and terrestrial lidar and related remote sensing technologies. The AEC Next audience has historically been comprised of professionals in architecture, engineering, and construction (AEC) that use technologies such as reality capture, automation, AI and XR to bid and manage projects and improve workflows. The SPAR 3D audience has historically been comprised of professionals who use 3D capture, scanning, visualization and modeling technologies across a variety of verticals. “We will use these familiar brands to designate content and make it easy and accessible for all stakeholders to find the solutions, connections, and education they need, no matter which vertical or industry segment they originated from,” says Corkhill. To this end, the organizers will also continue to publish Geo Week ENewsletter, SPAR3D ENewsletter, and AEC ENewsletter.
**URISA** is pleased to announce the Exemplary Systems in Government (ESIG) Awards process for 2021. This year marks the milestone 40th Anniversary of URISA ESIG Awards, which recognize extraordinary achievements in the use of geospatial information technology that have improved the delivery and quality of government services.

The award competition is open to all public agencies at the national/federal, state/provincial, regional, and local levels. Winners will be recognized during the Awards Luncheon on October 5 during GIS-Pro 2021 in Baltimore, Maryland. Submissions are invited in two categories Single Process Systems and Enterprise Systems.


**ACCOMPLISHMENTS**

Woolpert’s Mark Mockus has been promoted to market director. He will lead the firm’s private market, directing architecture and engineering projects for private sector clients. Mockus has more than 34 years of architecture and management experience, specializing in high-intensity, innovative and complex design.

Mockus has been with Woolpert since late 2019, serving as a program director out of the firm’s Chicago office. He has been integral to the firm’s pursuit of retail rollout projects, like Best Buy and 7-Eleven. Mockus said his goals in this new role are to continue to expand the firm’s design clientele, to draw bigger and more impactful architecture projects, and to increase and amplify Woolpert’s top talent.

“We have leading designers and architects accomplishing great things already, including Tim Reber, Jason Golub, Jon Grzywa, Tony Martin, Chris Perry—and so many more,” Mockus said. “We’re planning to make a strategic shift to major metro areas moving forward. Currently our Chicago office is in the suburbs, but it needs to move downtown. Emerging and established talent gravitates toward the bigger cities, even with the pandemic.”

Mockus also aims to extend and leverage the cross-service capabilities within Woolpert. He said having architecture, engineering, geospatial (AEG) and strategic consulting services in-house gives the firm an unparalleled advantage in the industry, and it is a differentiator the firm plans to wield more liberally.

“If a client has any questions regarding services or wants to get project consultants together, they make one call instead of five,” Mockus said. “It’s the true one-point of contact. I’ve been on the owner’s side of the equation and I would have greatly appreciated working with a firm that collaborates behind the scenes like Woolpert does.”

Woolpert Sector Leader Todd Duwel said he foresees heightened growth and creativity under Mockus.

“Mark hasn’t been with Woolpert long, but he has illustrated a focused ambition that will constructively elevate Woolpert’s private market,” Duwel said. “He already has made the firm better, and our current and future clients will have Mark to thank for making their companies better, as well. We’re excited to have him in this role.”

**EVENTS**

**ARSET-Use of Solar Induced Fluorescence and Lidar to Assess Vegetation Change and Vulnerability Online Training**

- 16 March, Part I—Lidar and its Applications
- 18 March, Part II—Accessing and Analyzing Lidar Data for Vegetation Studies
- 23 March, Part III—Solar Induced Fluorescence and its Applications
- 25 March, Part IV—Accessing and Analyzing SIF Data for Vegetation Studies


**CALENDAR**

- 16, 18, 23, 25 March, ARSET-Use of Solar Induced Fluorescence and Lidar to Assess Vegetation Change and Vulnerability Online Training
- 29 March - 2 April, ASPRS 2021 Annual Conference
- 23-25 April, GISTAM 2021, Prague, Czech Republic
- 17-19 May, 2021 Stratus Conference, Buffalo, New York
- 7-11 June, URISA GIS Leadership Academy, Minneapolis, Minnesota
- 16-20 August, URISA GIS Leadership Academy, Portland, Oregon
- 3-6 October, GIS-Pro 2021, Baltimore, Maryland
- 8-12 November, URISA GIS Leadership Academy, St. Petersburg, Florida
- 6-8 February 2022, Geo Week 2022, Denver, Colorado

161 Extraction of Impervious Surface Using Sentinel-1A Time-Series Coherence Images with the Aid of a Sentinel-2A Image
Wenfu Wu, Jiahua Teng, Qimin Cheng, and Songjing Guo
The continuous increasing of impervious surface (IS) hinders the sustainable development of cities. Using optical images alone to extract IS is usually limited by weather, which obliges us to develop new data sources. The obvious differences between natural and artificial targets in interferometric synthetic-aperture radar coherence images have attracted the attention of researchers. In this paper, we used time-series coherence images and introduced multi-resolution segmentation as a postprocessing step to extract IS.

171 Road Extraction from Cartosat-2F Multispectral Data with Object-Oriented Analysis
Chumbitha Leena, Manoj Raj Saxena, and Ravi Shankar Dwivedi
For detection of a road network, high-resolution satellite data have been used following the object-oriented classification approach. In this paper, we use object-based feature extraction algorithms for detection of road networks from a high resolution Cartosat-2F multispectral data in an Indian city with varying terrain conditions ranging from a compact built-up area to a predominantly vegetated area.

181 Digital Surface Model Refinement Based on Projected Images
Jiali Wang and Yannan Chen
Currently, the practical solution to remove the errors and artifacts in the digital surface models (DSM) through stereo images is still manual or semiautomatic editing those affected patches. Although some degrees of semiautomation can be gained, the DSM refinement remains a labor consuming and expensive process. This paper proposes a new method to correct errors in DSM or/and refine an existing coarse DSM.

189 Remote Sensing for Ecosystem Services and Urban Sustainability
John C. Trinder
The purpose of this paper is to demonstrate how geospatial technologies, especially remote sensing, can play a leading role in defining urban sustainability based on the evaluation of demand and supply of ecosystem services (ES).

197 Monitoring Work Resumption of Wuhan in the COVID-19 Epidemic Using Daily Nighttime Light
Zhenfeng Shao, Yun Tang, Xiao Huang, and Deren Li
This paper analyzes the characteristics of nighttime light (NTL) radiance variation, aiming to demonstrate the possibility of using NTL to monitor work resumption and evaluate the impact of COVID-19 on economic activities in Wuhan, China.

207 Progressive TIN Densification with Connection Analysis for Urban Lidar Data
Tao Wang, Lianbin Deng, Yuhong Li, and Hao Peng
Urban lidar data are advantageous for capturing the terrain surface of built-up areas, which can be directly used to provide digital surface models. Cloud points are classified into ground points to obtain digital terrain models. This paper proposes a method to improve the progressive triangulated irregular network (TIN) densification method using a TIN connection analysis algorithm, namely, connection analysis via slope analysis.

GIS Tips & Tricks—Tired of Looking at Tiny Icons in TerraScan? Here’s a Solution...

Top Geospatial Trends to Watch in 2021
By Qassim Abdullah, Ph.D., PLS, CP

Column of the Student Advisory Council
The Column of the Student Advisory Council

Book Review—Smarter Government—How to Govern for Results in the Information Age

Grids and Datums Update
This month we look at Federal Democratic Republic of Ethiopia

Headquarters News—ASPRS Announces Student Conference Presentation Grants!

New ASPRS Members
Join us in welcoming our newest members to ASPRS.

Call for Submissions—PE&RS Special Issue on Remote Sensing Monitoring for Urban Environment

Industry News

Calendar

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ASPRS Media Kit

See the Cover Description on Page 148
Four blackwater rivers—the Waccamaw, Pee Dee, Black, and Sampit—feed into Winyah Bay, an estuary in eastern South Carolina. All of them flow through swamps, wetlands, and forests that are rich with decaying vegetation and other organic matter. The dead leaves and debris stain the rivers and wetlands a transparent brown color as several natural chemical substances found in plants—tannin, phenol, and humic acid—seep into the water. The same process gives tea its yellow or brown color.

After heavy rains, stained floodwaters can get flushed out of swamps and wetlands into the estuary and ocean. That was happening on October 1, 2020, when the Operational Land Imager (OLI) on Landsat 8 acquired this natural-color image of Winyah Bay. Many waterways were swollen following heavy rains from Hurricane Sally.

When measuring the phenomenon with optical instruments, scientists describe heavily stained waters as being high in colored dissolved organic matter (CDOM). On October 1, a National Oceanic and Atmospheric Administration water quality monitoring system at North Inlet-Winyah Bay National Estuarine Research Reserve measured CDOM levels that were roughly 50 percent higher than the long-term average for that date, said Erik Smith, the head of the research reserve.

Blackwater flows can have important consequences for aquatic ecosystems because they change the color of the light available to phytoplankton for photosynthesis. “The compounds that make up CDOM absorb blue light wavelengths extremely well, so blue light does not penetrate very deep into the water. The red wavelengths are the ones left behind, hence the brownish-red appearance of the water,” explained Tammi Richardson, an oceanographer at the University of South Carolina. “If phytoplankton do not have pigments that can absorb red light, then they will not be able to photosynthesize.”

Since phytoplankton photosynthesis is a centerpiece of the ocean food web, CDOM levels can affect the productivity of the entire Winyah Bay estuary. In practice, cryptophytes and diatoms tend to do well in blackwater, while other types of phytoplankton tend to suffer.

Blackwater holds an interesting place in maritime history in this region. In the early years of European exploration and colonization of North America, mariners sought out blackwater streams to refill their casks because the water was thought to minimize the spread of disease. Sailors did not know why at the time, but the high acidity and presence of certain phenols have anti-bacterial properties.

Among those early sailors may have been the Spanish explorer Lucas Vázquez de Ayllón. He led an expedition of six ships that reached Winyah Bay in August 1526, and established San Miguel de Guadalupe, the first European settlement in the contiguous United States. It preceded Pensacola, Roanoke, and Jamestown by decades, but is often overlooked by historians because of how unsuccessful and short-lived it was.

Upon arrival in Winyah Bay, the Spaniards immediately lost their main supply ship—the Capitana—when it ran aground on a sandbar near the modern town of Georgetown. In the chaos that followed, the Native American guides and interpreters they had captured from the area during a previous expedition deserted and slipped into the forest. After about a month in Winyah Bay, Ayllón moved the colony of 500 Europeans and 100 enslaved Africans to a new location. Where exactly they went is unclear, but historians think they settled along Sapelo Sound in what is now Georgia.

However, unusually cold weather, disease, and lack of food quickly turned a difficult situation into a catastrophe for the colonists. Settlers died in large numbers by mid-October, including Ayllón himself. His death triggered a battle for leadership of the struggling colony. In the confusion, the African slaves revolted and escaped, meaning the first ever documented slave uprising in North America happened at San Miguel de Guadalupe. The 150 Europeans who were still alive after the uprising soon abandoned the colony and set sail for Hispaniola. The escaped slaves, meanwhile, were likely taken in by Native American communities in the area.

Top Geospatial Trends to Watch in 2021

By Qassim Abdullah, Ph.D., PLS, CP
Woolpert Vice President and Chief Scientist
It’s that time of the year, when we review geospatial methods and technology trends and I use my piercing crystal ball to see what’s on the horizon for the new year. While the pandemic changed the way we conduct business, geospatial sensor technologies continued their upward trend. As I have in the past, I’ll revisit the trends I forecasted at this time last year, note how those predictions panned out, and project how these and other trends are expected to evolve throughout 2021 and beyond.

Data Democratization: Big Data Needs Big Tools

Data democratization, or providing streamlined access to technical expertise, continued to evolve in 2020. Although still a work in progress, the geospatial community became more educated in many new and complex data topics like machine learning in application development. It also became more adept at sharing those tools and techniques so they can be easily understood by those without extensive experience, skills or training. An example of this increased awareness is the growing trend in the Geospatial Knowledge Infrastructure*, which is being tackled by the United Nations and its global strategic partners.

Crowd sourcing, big data and data science have been aggressively pursued by tech companies, whether they are for honest data gathering or for those who want to sell location-based data to the highest bidder. Location-based applications including smart buildings, self-driving cars and crowd sourcing will continue their upward growth and potential this year. These data, if used properly, can be a great service to diverse sectors that include planning, construction, utilities, transportation, government and energy.

However, although there is growing number of niche companies and services offering creative solutions, the mainstream geospatial industry witnessed sluggish growth in the creative methods and tools needed to mine, extract and convert these data into knowledge. These niche companies are mainly small business startups focused on innovative solutions that serve a segmented or specialized market. Often, they are snatched up upon arrival by giant tech companies before the industry has had a chance to work with them. The situation is different for the giant tech companies like Google and Amazon, which have continued their advancement of machine learning, artificial intelligence and deep learning. Their sophisticated methods and tools were developed for their use rather than for the geospatial community at large, but some of their developments are benefiting geospatial users on a limited scale.

Think Small—Miniaturized Sensors

Last year, I envisioned companies like Google, Apple and LG would invest more in advancing and integrating miniaturized imaging and lidar systems within their devices for mapping applications. The latest imaging capabilities of some smartphones exceeded my expectations, and I was pleased to see that Apple has a lidar sensor on its iPhone 12 Pro. Once I heard about it, of course I had to purchase one. I am still figuring out how it works. Based on the article posted on LinkedIn by Rami Tamimi, an Ohio State University student working toward his doctorate in geodetic engineering, the iPhone 12 Pro lidar looks awesome and is a great foray into sharing this technology with the masses. I expect other phone manufacturers will emulate Apple by incorporating this technology in 2021.

Living in the Cloud

Last year, I acknowledged that progress was made by agencies moving computing powers to the cloud. Many more companies are offering business models for cloud data hosting and processing. Amazon, Google and Microsoft continue to lead that market and offer users and developers sophisticated platforms like serverless cloud computing. These platforms enable developers to run apps and services without having to manage and operate costly and complicated server infrastructure.

Among members of the geospatial community who are utilizing the cloud for data storage and application development, the majority are interested in serverless cloud computing architecture. This supports our favorite geospatial applications, map libraries and GIS clients like ArcGIS Online, ArcGIS Desktop or QGIS. This trend will continue to evolve and grow strongly throughout 2021.

Lidar, Lidar, Everywhere

In 2020, lidar manufacturers continued to make huge technological advances, both in traditional linear-mode lidar and in newer lidar technologies, like single photon. These advancements will continue this year, offering more efficient data acquisition and more affordable lidar data to support national programs, such as the U.S. Geological Survey’s 3D Elevation Program†.

For a glimpse of the industry’s current capabilities in aerial lidar mapping, here are some figures I presented during the Geo Week webinar “Airborne Lidar and Actionable Data,” that was held earlier this month. In my presentation, I noted that Woolpert has collected dense lidar data over 700,000 square kilometers worldwide in the last three years. As part of those collections, 100,000 km² was topo-bathy lidar. Before lidar and its immense capabilities, we used to generate topographic maps using traditional stereophotogrammetry. This manual, labor-intensive method, in many cases, could not match the quality or the accuracy of a lidar-derived digital terrain model. It also would take us decades to compile a 700,000 km² DTM using stereo imagery.

Lately, we’ve seen lidar manufacturers start to invest a great deal of energy into the development of AI-based applications that will help users weed through the massive number of point clouds to extract the information they need. Improvements in lidar data density, quality and accuracy continued to attract new users and new applications in 2020, and this trend will continue for years to come. Unmanned aircraft system, or drone-based, lidar data acquisition also witnessed massive growth in 2020 as new lidar systems emerged. The most impressive development was the recent introduction of a flash lidar sensor with 200-meter range by...
ers. Imagine if a leasing manager or builder gave you access with the ability to edit floor plans in real time and to share to manage their workspaces and provide property managers with the ability to be mass produced for the automobile industry will also make it an attractive lidar option for UAS.

The great thing about flash lidar is that it is lightweight and has no moving parts. All UAS-based lidar systems other than flash lidar are based on a scanning mechanism that can introduce unstable geometry and therefore compromise the positional accuracy of the resulting product. Another UAS lidar development worth mentioning is DJI lidar. Like other DJI products, DJI lidar is considered to be the least expensive lidar acquisition method for drones. Affordable and efficient lidar systems such as this will force manufacturers and integrators to lower the cost of UAS-based lidar, which is win-win for the geospatial industry.

Topo-Bathy Lidar

This year, the importance of the bathymetric survey has earned its own section in this forecast. The reason for this is two-fold. First, manufacturers have excelled in providing the industry with an awesome new breed of lidar systems that can be used for the dual data acquisition for topographic and bathymetric survey. These new systems made it much more practical to survey coastlines without the need for two types of lidar systems—topographic and bathymetric. The second reason is that on Jan. 5, 2021, the White House Council on Environmental Quality and the Office of Science and Technology Policy released an implementation plan for the “National Strategy for Ocean Mapping, Exploring and Characterizing of the United States Exclusive Economic Zone.” The implementation plan was drafted by the National Oceanic and Atmospheric Administration. This presidential memorandum applies to an oceanic area larger than the terrestrial landmass of the United States. This is good news for the geospatial industry, since we will help implement the plan.

Marrying BIM to GIS and Digital Twin

Building information modeling, virtual reality and augmented reality will continue their growth within the geospatial and engineering communities. The mapping and geospatial industry must refine its tools and methods by building efficient GIS databases and applications to take advantage of upcoming opportunities. This year, we will hear more about the concept of the digital twin and its importance to planning and decision-making. If you are not familiar with the concept, I would define digital twin as “the digital surrogate of the physical environment, which you can use and abuse without harming or disturbing the physical environment representing your project site.”

The digital twin opens huge opportunities for the geospatial community, since lidar is becoming the most efficient tool from which to generate data and build a model. The geospatial community needs to familiarize itself with the digital twin concept and what it entails to enhance geospatial modeling technologies moving forward.

Another interesting development in the BIM arena in 2020 was combining the power of indoor mapping and digital facility management services. This integration enables companies to manage their workspaces and provide property managers with the ability to edit floor plans in real time and to share those changes immediately with employees and facility users. Imagine if a leasing manager or builder gave you access to the dynamic digital floor plan of a new project or of your new apartment before you moved in. Having a 3D digital twin of that space before you sign a lease or purchase contract can provide the kind of empowerment that leads to a better quality of life. This capability was recently introduced to the market by Mappedin of Waterloo, Canada.

A “Smart” Revolution

The concepts of smart cities and intelligent transportation systems will continue their healthy growth in 2021. This growth will be accelerated by geospatial trends cited here, most notably digital twin methods, big data, machine learning and deep learning. Helping this growth are the continued advancements in utilizing the Internet of Things for cloud data storage and processing in near-real time. Autonomous driving will continue to make strides as more car manufacturers go down this road. Self-driving cars require artificial intelligence and geospatial data to understand infrastructure details and conditions. As predicted last year, our geospatial community is poised to earn a substantial market share of the services and technologies needed to support and navigate the smart revolution.

Mapping-as-a-Service

Gradually, the term mapping-as-a-service is expanding to encompass all cloud-based geospatial data solutions, including data-as-a-service, software-as-a-service, and online analytical solutions based on AI and machine learning. There is not expected to be any substantial development in speculated data acquisition, on-demand geospatial data and data subscription services in 2021, largely due to the pandemic. I expected this sector to grow in 2020 but unfortunately our geospatial business, like everything else, was impacted by COVID-19. However, MaaS capabilities are expected to see measurable growth in 2022.

I ended my article from last year with: “These geospatial trends will continue to blossom throughout 2020, as the need for advanced technologies continues to rise. I look forward to seeing what the year will bring.” Well, we all know what 2020 brought to us. However, our geospatial community is resilient, and we will survive the wrath of 2020. Our success will require the collaboration of multiple tiers of government, the private sector, public utilities, community activists, building owners, average citizens, etc. It will also require hard work on several levels as we advance application developments like dashboards and databases to achieve real-time situational awareness, and scientific datasets and analysis to create technology solutions for use around the world.

Happy New Year!

Woolpert Vice President and Chief Scientist Qassim Abdullah, Ph.D., PLS, CP, has more than 40 years of combined industrial, R&D and academic experience in analytical photogrammetry, digital remote sensing, and civil and surveying engineering. When he’s not presenting at geospatial conferences around the world, Qassim teaches photogrammetry and remote sensing courses at the University of Maryland and Penn State, authors a monthly column for the ASPRS journal PE&RS, and mentors R&D activities within Woolpert.

Previously published on https://woolpert.com/media/blogs/

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.
GREETINGS FROM THE ASPRS STUDENT ADVISORY COUNCIL (SAC)!

As we continuously network with our ASPRS Chapter community, we are highlighting the San Diego State University Student Chapter of the ASPRS for their continued commitment to emerging technology, education, engagement, and fellowship.

GO AZTECS! The San Diego State University Student Chapter of the ASPRS is made up of both graduate and undergraduate students interested in remote sensing; GIS; and geospatial education, research, and outreach. Advised by Distinguished Professor Emeritus Dr. Douglas Stow, the current chapter includes students affiliated with both the Department of Geography and the Department of Biology (Ecology Program Area).

The SDSU chapter aims to connect students interested in geospatial technologies, provide opportunities to meet with professionals in GIS and remote sensing fields, discuss research ideas and planned methodology, and lead or participate in technical workshops. Over the years, the student chapter has hosted a variety of workshops, to include sessions focused on: object-based image classification approaches, structure-for-motion (SfM) processing, and spectral unmixing techniques. With the Department of Geography being home to a few drones and a handheld spectrometer, student chapter advisors and members have organized and led demos using these tools.

The chapter’s main focus is on the annual Spring Technical Meeting it hosts for the ASPRS Pacific Southwest (PSW) Region, usually held on the SDSU campus and open to the public. This meeting features three-to-four short presentations and concludes with a longer keynote presentation (often given by the acting ASPRS President). Followed by a student chapter-hosted social hour, students and members of the community have the opportunity to meet the speakers and dive deeper into what was shared during the day’s presentations.

Due to 2020’s COVID-19-related restrictions, the SDSU student chapter postponed its originally planned wildland fire-themed Spring Technical Meeting and worked with the PSW Region to create the 1st Annual ASPRS PSW Remote Sensing & Wildland Fire Symposium (RS Fire 2020). Each session featured speakers who are respected and well known in the remote sensing and GIS, landscape ecology, and wildland firefighting communities; the primary goal was to help open lines of communication between imaging scientists and firefighters. Held over four Monday afternoons in November and chaired by the SDSU Student Chapter President, Krista West, this new symposium series was a success.
Sometimes small improvements and useful tips pay off big in terms of time and convenience, especially when using geospatial software in a production mode. Small icons, crowded onto toolbars, can confuse new users and infuriate long-time users. Then, some software products require the user to hold down multiple keyboard keys and/or a combination of mouse buttons to navigate the interface. This is the case with the Terrascan MDL (MicroStation Development Library) application that runs within MicroStation. While Terrascan MDL with MicroStation is the “industry standard” for lidar editing, here is a tip to update Terrascan MDL user interface.

When loading the Terrascan MDL Application into Microstation you have a small docked Window with 16 icons to choose tools from. The standard method requires a combination of (1) continuous firm pressure (push down/click) with the left mouse button each icon, to (2) activate all the sub tools that can be opened. Then, (3) you have to move your cursor down the row of tools, making sure not to let up with the left mouse hold to select the tool you want to use, as in the “standard” sequence, Figures 1-4. Throughout this process, a user may need to search through several options to find the desired toolbar.

This Terrasolid “active workflow ribbon” library allows the Terrasolid toolbar to be viewed in the typical MicroStation/CAD ribbon format rather than the “standard” Terrascan mode. The new active workflow ribbon has condensed the tools into fewer tabs (9 for Terrascan), and with each tab you now can see the tools across the ribbon, as in the ribbon sequence, Figures 5-8. Each tool is clearly described and the
icon symbol ready for you to click and open the tool. This streamlining results in fewer click and drags, and eliminates searching through multiple levels of interface. The active workflow ribbon library does not replace the “standard” interface, so if you still prefer the standard interface, both options are available on-screen.

For additional installation instructions, Geocue has a support document at: https://support.geocue.com/terrasolid-design-library/.

And it is that easy to update the Terrascan interface!

**Michael Baranowski, CLT, GISP** and **Al Karlin, Ph.D., CMS-L, GISP** are with Dewberry’s Geospatial and Technology Services group in Tampa, FL. Mike is a Senior Geospatial Analyst at Dewberry who manages many aspects of lidar production along with resource allocation. As a senior geospatial scientist, Al works with all aspects of Lidar, remote sensing, photogrammetry, and GIS-related projects.

Please e-mail questions or comments to GISTT@ASPRS.org.

**ASPRS WORKSHOP SERIES**

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https://conferences.asprs.org/geoweek-2020/workshops/
The book authored by Martin O’Malley, the former Maryland Governor, clearly sends the message that technology is a key to better government and improved results in the information age. He makes the case for using improved technologies, specifically GIS (Geographic Information System) technology, to gather, manage, and analyze data to enhance government performance and service delivery. The governor states that “First as mayor of Baltimore and then as governor of Maryland, I experienced firsthand the power of GIS …Whether the goal is improving public education, reducing violent crime, or restoring the health of our natural environment, GIS provides a powerful platform for progress. GIS is making government smarter.” The governor’s intent is to share how the data, the map, and the method for achieving dramatic public-sector progress during his service helped him to work with his administration to achieve measurable results using GIS technology.

The author provides his reasons for running for Baltimore Mayor and the challenges his administration faced with lagging information from various unrelated and outdated systems that made governing difficult. He brought CompStat, a combination of management, philosophy, and organizational management tools, to his police department. Moving forward, the mayor brought on CityStat, a new system for governing the whole of city government. The author detailed the implementation and achievements of StateStat that is based on the CityStat Techniques across the entire state after he became the governor of Maryland.

He tells the story of his meeting with ESRI co-founder Jack Dangermond, who introduced him to the concepts of GIS, from which the governor saw the power of the GIS map as “The Power of Information Shared by All,” a new platform and new tools that can be integrated into the government system so the results can be seen through GIS maps and internet. In his own words,” The capacity that a common operating platform provides for managing dynamic and sometimes fast-moving problems with real-time data is a big innovation in government. In fact, these new technologies – GIS and the Internet of Things (IoT) – and the ability these technologies give us to model belief space – that is to say, to model the changing dynamics of our built and natural environments – are ushering in a whole new way of governing in the Information Age.”

There are 14 chapters in the book. Each chapter includes a “Learn & Explore” section that provides a link to the book’s website (www.smartergovernment.com). On this website, the user can watch videos, explore the story maps, dashboards, books, blogs, data resources, and examples that support the concepts and ideas presented in the book and other information related to the book. Study and Discussion questions based on the chapters are listed in Appendix A of the book. The user can also find those questions on the aforementioned website.

GIS exercises for each chapter can be found in Appendix B of the book, from there, a user can get hands-on experience with the GIS software and learn the technology by working with real data. Esri provides free trial software and student licenses so users can learn the technology at their convenience with little financial burden.

The book is by no means a highly technical tome; however,
users can find a good deal of helpful technological information through the sidebars. There are interesting stories about how the technologies were used by the governor's administration.

The author lays out “A New Way of Governing,” about a method that emphasizes the relationship between the governed and the trust required for governing. This new way of governing is based on data collection, management, and analysis, showing and measurement of results through GIS technology. Maps, pictures, charts, and illustrations are provided to help the reader understand the concepts the author attempts to convey in the book. Additional sections include “Acknowledgments,” a list of “Contributors” and a long list of “Credits”.

The book totals 332 pages; is well written and easy to read. Each chapter begins with a meaningful, relatable, artistic, and beautiful picture. Maps, charts, and other illustrations in the book are thoughtfully chosen and well placed. The book has relevant stories, pictures, leadership practices, and nuggets of wisdom.

This book could serve as a textbook for undergraduate or graduate students with majors in Geospatial Science as well as Political Science, History, or other related disciplines. The book’s website is well designed and easy to navigate. The study and discussion questions are carefully written and closely related to the context of the book. The GIS exercises and data are appropriate and challenging enough to benefit the student. It can also serve as a reference resource for government leaders to consider applications to improve governance. A few small improvements could be made, for example, the map elements such as a north arrow, scale bar, or legend could be added to the map on page 255 to display clearer and more meaningful information.

The governor showcases the power of GIS technology and ways it can be used to govern and lead in the Information Age. GIS is not just a sterile geospatial technology but an evolutional tool for human societies to live smarter and better. For that, GIS should be written as a chapter in a modern history book.
THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Ethiopia, occasionally called Abyssinia, is an ancient country in Northeast Africa. It is bounded on the north by Eritrea (912 km), on the east by Djibouti (337 km) and Somalia (1,626 km), on the south by Somalia and Kenya (830 km), and on the west by Sudan (1,606 km). Ethiopia has an area slightly less than twice the size of Texas, it is landlocked, and is mainly high plateau with a central mountain range divided by the Great Rift Valley. The lowest point is Denakil (−125 m), and the highest point is Ras Dashen Terara (4,620 m). Modern Ethiopia began with the reign of Tewodros II and the conquest of other chiefs in 1855. Later coming under Italian rule in 1882 and claimed as an Italian Protectorate by the Treaty of Ucciali in 1889, the coastal region was made a separate Italian Colony in 1890 and named Eritrea. Territorial integrity of Ethiopia was recognized by Great Britain, France, and Italy in 1906. Invaded by the Italians in 1935, and organized with Eritrea and Italian Somaliland as the Empire of Italian East Africa, the region was liberated by the British in 1941. The new constitution was adopted in 1987. Ethiopia’s entire coastline along the Red Sea was lost with the de jure independence of Eritrea on 27 April 1993.

Very little mapping was done of Ethiopia in the 19th century. One of the earliest investigations of the region resulted in a “Report of the German Expedition to East Africa, 1861 and 1862, published in 1864 by Munzinger. The British explorer, Sir Samuel Baker, wrote of the region in 1867 in “The Nile Tributaries of Abyssinia.” The Italians made some ground surveys in the region of Eritrea from 1888 to 1891, and these surveys formed the basis of the old Carta della Colonia Eritrea (Map of the Colony of Eritrea) at a scale of 1:50,000 which was published from 1909 through 1938. Another series was also published during the same time by the Italians at a scale of 1:100,000. New surveys of 1935 through 1938 resulted in one sheet being compiled on a Santoni stereoplotter with 50-meter contours. Smaller scale series were derivative compilations at the time.

The Ethiopian Datum of 1936 was established by the Italians at the West End of Metahara Base (10,083.560 m) where \( \phi = 8\textdegree 53\text{'} 22.53\text{”} \pm 0.18\text{”} \), \( \lambda = 39\textdegree 54\text{’} 24.99\text{”} \) East of Greenwich, the reference azimuth to Monte Fantalli was \( \alpha = 13\textdegree 05\text{’} 21.97\text{”} + 0.43\text{”} \), and the presumed ellipsoid of reference was the International 1924 where \( a = 6,378,188 \) m and \( \frac{1}{f} = 297 \). The check base for the chain commencing at Metahara was Giggiga base, which was 12,962.620 m in length. Halfway north from Metahara base to the now Eritrean port city of Massawa was the North End of Alomalà base (18,211.982 m) where \( \phi = 12\textdegree 24\text{’} 56.56\text{”} \pm 0.13\text{”} \), \( \lambda = 39\textdegree 33\text{’} 30.42\text{”} + 0.30\text{”} \) East of Greenwich, and the reference azimuth to the South End of Alomalà base was \( \alpha = 130\textdegree 00\text{’} 03.88\text{”} \pm 0.18\text{”} \). The old Italian 1:50,000-scale series mentioned above is based on the old datum origin located in the (now) Eritrean capitol city of Asmara. The coordinates of that origin elude me, and I suspect that the observations...
may have been made by the Italian navy rather than by the Istituto Geografico Militare di Firenze (Florence). In any case, there was no grid printed on any of the above series, even though the cartographic and geodetic work was done by the Italian military!

The Blue Nile River Basin Investigation Project was funded by the United States, and the geodetic work was performed by the U.S. Coast & Geodetic Survey. The origin of the geodetic work was in southern Egypt near Abu Simbel, south of Lake Nasser, at station Adindan where \( \Phi_0 = 22^\circ \text{10}' \ 07.1098'' \text{N} \), \( \Lambda_0 = 31^\circ \text{29}' \ 21.6079'' \text{East of Greenwich} \), the deflection of the vertical \( \xi = +2.38'' \) and \( \eta = -2.51'' \), and the ellipsoid of reference was the Clarke 1880 (modified) where \( a = 6,378,249.145 \text{ m} \) and \( \frac{1}{f} = 293.465 \). The Blue Nile Datum of 1958 appears to be the established classical datum of Ethiopia and much of North Africa. Adindan is the name of the origin, it is not the name of the datum; a most common mistake found in many “reference works.” The Ethiopian Transverse Mercator grid is based on a central meridian where \( \lambda_0 = 37^\circ \text{30}' \text{E} \), scale factor at origin where \( m_0 = 0.9995 \), False Easting = 450 km, and False Northing = 5,000 km.

Ethiopia and Kenya signed a boundary treaty on 09 June 1970, and the field surveys for the demarcation of the border were performed by British surveyors. The datum used for that survey was the Arc 1960 Datum, referenced to the Clarke 1880 (modified) ellipsoid. The grid system used at the time was the East Africa Transverse Mercator Belts H, J, and K where the central meridians are \( \lambda_0 = 37^\circ \text{30}' \text{(H)}, \ 42^\circ \text{30}' \text{(J)}, \) and \( 47^\circ \text{30}' \text{(K)} \); the scale factors at origin are all where \( m_0 = 0.9995 \), all False Eastings = 400 km, and False Northings = 4,500 km.

An International Boundary Commission has been formed by the United Nations to establish and demarcate a boundary between Ethiopia and Eritrea. The boundary has been researched and established, but the demarcation remains to be performed at the present time. The 125-page document published by the United Nations in April 2002 makes for some fascinating reading. The datum of record of the Commission is the WGS84, and will be used for the demarcation survey someday.

There are two sets of parameters published by NIMA for transforming from the Blue Nile Datum of 1958 to the WGS84 Datum: the mean solution for Sudan and Ethiopia is based on a 22-station solution where \( \Delta X = -166 \text{m} \pm 5 \text{m}, \Delta Y = -15 \text{m} \pm 5 \text{m}, \) and \( \Delta Z = 204 \text{m} \pm 5 \text{m} \). The solution for Ethiopia is based on an eight-station solution where \( \Delta X = -165 \text{m} \pm 3 \text{m}, \Delta Y = -11 \text{m} \pm 3 \text{m}, \) and \( \Delta Z = +206 \text{m} \pm 3 \text{m} \).

**Ethiopia Update**

A 2019 thesis covers a detailed analysis of datum transformations in the northwest area of Ethiopia, but has no new data points, just more elaborate math models:

- Determination of Parameters for Datum Transformation between WGS 84 and ADINDAN-Ethiopia, Hassen, A. M.
- http://etd.aau.edu.et/bitstream/handle/123456789/23487/Abubeker%20Mohammed.pdf?sequence=1&isAllowed=y

As referenced in the original column, the United Nations has now published some boundary monuments in a report:


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 (C4G). This column was previously published in *PE&RS*.

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Too young to drive the car? Perhaps!

**But not too young to be curious about geospatial sciences.**

The ASPRS Foundation was established to advance the understanding and use of spatial data for the betterment of humankind. The Foundation provides grants, scholarships, loans and other forms of aid to individuals or organizations pursuing knowledge of imaging and geospatial information science and technology, and their applications across the scientific, governmental, and commercial sectors.

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ASPRS ANNOUNCES STUDENT CONFERENCE PRESENTATION GRANTS!

ASPRS, with support of the ASPRS Foundation, has identified funding to sponsor Student Presentations in the upcoming ASPRS 2021 Annual Conference, which will be held virtually from March 29 – April 2, 2021. Individuals who are awarded Student Presentation Grants will have their conference registration fees waived, and will receive a complementary one-year student membership in ASPRS. Click the link above for full details.

How do I know if I qualify for a Student Conference Presentation Grant?

- The student must be the conference Presenter; other non-students may be listed as co-authors.
- The student will be asked to provide proof of current enrollment before receiving final approval for a conference grant. Proof of current enrollment could be a copy of a student ID, an unofficial transcript, registration record for the current semester, or a letter from a supporting faculty member on institution letterhead.
- Abstracts that are accepted by the Technical Program Committee but not chosen to receive grants will still be eligible to participate in the conference. The presenters will be required to register and pay appropriate fees.

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ASPRS would like to welcome the following new members!

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Your Path To Success In The Geospatial Community
Remote Sensing Monitoring for Urban Environment


Urban remote sensing provides images with multiple spatio-temporal-spectral attributes, which can provide qualitative, quantitative, dynamic and comprehensive information and support for urban environmental monitoring and evaluation, and serve urban planning and management, ecological environment protection. In recent decades, global urban areas have been rapidly expanding, especially in developing countries. Rapid urbanization, along with manufacturing industries and large number of vehicles has resulted in serious environmental problems, called “urban diseases”, including increased vulnerability to natural hazards, natural vegetation cover decline and arable land loss, urban heat islands, air pollution, hydrological circle alteration and biotic homogenization. Urban ecosystems are strongly influenced by anthropogenic activities. Considering this, this special issue of PE&RS is aimed at reporting novel studies on exploiting remote sensing big data to monitor and improve urban environment, and showing the potential of remote sensing in developing sustainable cities, including but not limited to:

- Urban thermal-environment remote sensing
- Remote sensing image acquisition and processing for urban environment
- Remote sensing dynamic monitoring of urban expansion
- Remote sensing change detection of urbanization
- Remote sensing retrieval of urban ecological environment
- Remote sensing evaluation of urban human settlements
- Urban sustainability indicators and assessment
- Urban environmental monitoring

Papers must be original contributions, not previously published or submitted to other journals. Submissions based on previous published or submitted conference papers may be considered provided they are considerably improved and extended. Papers must follow the instructions for authors at http://asprs-pers.edmgr.com/.

Important Dates (Tentative)
- March 1, 2021—Submission system opening
- September 31, 2021—Submission system closing
- Planned publication date is December 2021

Guest Editors

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Sentinel-1A Time-Series Coherence Images with the Aid of a Sentinel-2A Image

Wenfu Wu, Jiahua Teng, Qimin Cheng, and Songjing Guo

Abstract
The continuous increasing of impervious surface (IS) hinders the sustainable development of cities. Using optical images alone to extract IS is usually limited by weather, which obliges us to develop new data sources. The obvious differences between natural and artificial targets in interferometric synthetic-aperture radar coherence images have attracted the attention of researchers. A few studies have attempted to use coherence images to extract IS—mostly single-temporal coherence images, which are affected by de-coherence factors. And due to speckle, the results are rather fragmented. In this study, we used time-series coherence images and introduced multi-resolution segmentation as a postprocessing step to extract IS. From our experiments, the results from the proposed method were more complete and achieved considerable accuracy, confirming the potential of time-series coherence images for extracting IS.

Introduction
Impervious surface (IS) as an indicator for the urban environment can reflect the status of urban development to some extent (Liu et al. 2019; Gong et al. 2020). An increase in IS usually brings a series of problems, including urban heat islands (Xu 2010) and a decrease in cultivated land (Shao et al. 2020). Therefore, monitoring the distribution of IS makes a lot of sense and can advance the implementation of the United Nations 2030 Sustainable Development Agenda. Satellite remote sensing has become the most effective tool to monitor IS due to its advantages of low cost, large imaging range, and short revisit cycle (Shao et al. 2020).

Numerous urban IS extraction methods based on remote sensing have been proposed, mainly including visual interpretation (Zhou and Wang 2006; X. Zhang et al. 2013), spectral mixing analysis (C. Wu and Murray 2003; Z. Zhang et al. 2015), urban-index methods (Deng and Wu 2012; Liu et al. 2013; Shao, Tian and Shen 2014; Wang et al. 2015), image-classification methods (Shao and Liu 2014; Li and Gong 2016; L. Zhang, Weng and Shao 2017), and multi-source image-fusion methods (H. Zhang et al. 2019; Lin et al. 2020). Nevertheless, these methods have some limitations. For example, although visual interpretation is very accurate, it is time-consuming and laborious, especially to extract IS at city, region, or larger scales. Spectral mixing analysis methods are mainly used in low- and medium-resolution images, and are proposed to solve the problem of mixed pixels and obtain results at sub-pixel scale. But the selection of end members remains challenging in heterogeneous urban areas. It is suitable to use high-resolution images in urban areas (Shao et al. 2020). Image-classification methods are the most used, but they face some problems, such as spectrum confusion. Multi-source data fusion is considered a promising method for mapping IS (Weng 2012). There are three levels (pixel, feature, and decision) for image fusion. For pixel-level fusion, fusion rules must be carefully designed to improve the extraction of IS (W. Wu, Guo and Cheng 2020). Unfortunately, the design of fusion rules is very difficult, without clear rules that can be obeyed.

Due to the all-weather and day-night imaging ability of interferometric synthetic-aperture radar (SAR), it has become an important data source for IS extraction (Y. Zhang, Zhang and Lin 2014). Interferometric SAR (InSAR), an important branch of SAR, is widely used in surface deformation (Zhao et al. 2018) and earthquake deformation (Cheloni et al. 2017). As an intermediate product of InSAR processing, coherence images have attracted the attention of researchers and been used in many fields, such as land cover classification (Jiang et al. 2017; Yun et al. 2019), change detection (Del Frate, Pacifici and Solimini 2008), and human-settlement detection (Corbame et al. 2018). In coherence images, human-made targets generally are stable with high coherence, while natural targets have low coherence with great fluctuation. This property is useful for distinguishing IS and pervious surface (NIS). Therefore, a few studies have attempted to introduce coherence images into IS extraction, with most using a single image which is sensitive to temporal de-coherence factors (L. Yang et al. 2009). In addition, the results are fragmented due to inherent speckle. In view of this, a time-series analysis technique may be an effective solution. But the potential of time-series coherence images for IS extraction has still not been fully explored.

In this study, based on the assumption that urban land covers do not change significantly in a few months, we used Sentinel-1A time-series coherence images to extract IS with a random-forest (RF) algorithm. To further relieve the effect of speckle, we introduced multi-resolution segmentation as a postprocessing step. First we generated the time-series coherence images and introduced multi-resolution segmentation as a postprocessing step. First we generated the time-series coherence images and introduced multi-resolution segmentation as a postprocessing step. First we generated the time-series coherence images and introduced multi-resolution segmentation as a postprocessing step.
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Road Extraction from Cartosat-2F Multispectral Data with Object-Oriented Analysis

Chumbitha Leena, Manoj Raj Saxena, and Ravi Shankar Dwivedi

Abstract
For detection of a road network, high-resolution satellite data have been used following the object-oriented classification approach. We used object-based feature extraction algorithms for detection of road networks from a high resolution Cartosat-2F multispectral data in an Indian city with varying terrain conditions ranging from a compact built-up area to a predominantly vegetated area. The approach involves multi-resolution segmentation (MRS) and spectral difference segmentation (SDS) followed by road extraction using fuzzy rule-based algorithm based on various object features, viz. gray-level co-occurrence matrix homogeneity, density, rectangular fit, etc. With overall accuracies ranging from 77.46% to 92% SDS approach performed better than MRS which could afford 60.46% to 75.0% only. However, both of these approaches score over the classical Gaussian maximum likelihood classifier which could register only 50.0% to 68.0% overall accuracy. Furthermore, the maximum overall accuracy was obtained in compact built-up site (85% to 92%) followed by sparsely built-up site (75.0% to 88%) and predominantly vegetated site (60.46% to 77.14%).

Introduction
Timely and reliable information on the current status of road networks and changes therein due to incessant developmental activities is a prerequisite for planning and implementation of road network. High spatial resolution (HSR) satellite images offer immense potential in deriving such information in a timely and cost-effective manner. Different road features in an image have different image characteristics. For instance, geometric features have the direct relationship with the road shapes. Photometric features relate to the gray levels or colors of roads, and topological features and functional features are relatively simple but very difficult to apply in real applications (Wang et al. 2016). Various methods of road extraction from HSR satellite images have been developed (Mena 2003; Wang et al. 2016; Kahraman et al. 2018). These methods can be grouped into three categories: (1) pixel-based methods, (2) knowledge-based methods, and (3) object-based -oriented methods (Shi et al. 2014).

Pixel-Based Methods
The per-pixel classifiers typically develop a spectral signature by combining the spectra of all training-set pixels for a given feature. The resulting signature contains the contributions of all materials present in the training pixels. Per-pixel classification algorithms can be parametric or nonparametric. The parametric classifiers assume that a normally distributed data set exists, and that the statistical parameters (e.g., mean vector and covariance matrix) generated from the training samples are representative of the ground features. With nonparametric classifiers, the assumption of a normal distribution of the data set is not required. No statistical parameters are needed to separate image classes. These classifiers are, thus, especially suitable for the incorporation of nonspectral data into a classification procedure. Included in the per-pixel classifiers category are Gaussian maximum likelihood classifier (GMLC), neural networks, space vector machine (SVM), and expert systems.

Knowledge-Based Methods
Owing to difficulties in extracting the roads from remote sensing images based solely on the local spectrum and texture information, and due to the stripe structure of the road, remote sensing data could not be input to the classifier directly. Parameter models such as the energy function can be used to operate on the maximum value of the energy function. The knowledge-based methods which use higher level information, e.g., a vision-based system (Poullis and You 2010), Gabor filtering and tensor voting for geospatial-feature classification have, therefore, been developed for feature detection. These models usually extract some structural elements according to the relationship among them and detect the specific structure. Wang and Zheng (1998) proposed a method for detection of roads and bridges from synthetic aperture radar (SAR) images by using geometric features to extract general objects and subsequently adopted the mathematical morphology and Hough transform to extract the small regions and to connect the discontinuous segments. Similarly, Grote et al. (2012) integrated radiometric and geometric features derived from remote sensing images to extract road networks. Initially, the normalized cut algorithm was used to segment the images; the segments were subsequently grouped.

Object-Oriented Methods
In contrast to per-pixel classification, which relies solely on the spectral information in each pixel, object-oriented methods are based on information from a set of similar pixels called segments or image objects. Image objects or segments are groups of pixels that are similar to one another based on the spectral properties, i.e., color, size, shape, and texture, as well as context from a neighborhood surrounding the pixels. These methods entail segmentation of the images into regions/"objects"/"segments" first, followed by detection of roads using contextual image characteristics like image spectrum, texture, and structure, and other features (Sun et al. 2006; Zhong et al. 2014).

Image Segmentation
Image segmentation is a computer-based process of dividing digital image and other raster data into spectrally and/or texturally homogeneous groups of pixels, referred to as segments or image objects (Hamilton et al. 2007). The segments or image objects, thus formed, meet the homogeneity criteria based on...
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Abstract
Currently, the practical solution to remove the errors and artifacts in the digital surface models (DSM) through stereo images is still manual or semiautomatic editing those affected patches. Although some degrees of semiautomation can be gained, the DSM refinement remains a labor consuming and expensive process. This paper proposes a new method to correct errors in DSM or/and refine an existing coarse DSM. The method employs the concept of projected images together with some image matching techniques to correct/refine the affected regions in DSM. Since projected images are used, the proposed method can greatly simplify the complicated coordinate transformations and pixel resampling; therefore, the errors/artifacts in DSM can be amended more efficiently and accurately. Several experiments demonstrate the practical usefulness of the proposed method under some scenarios, and some potential improvements are also pointed out to accommodate the various needs during refining DSM.

Introduction
The digital surface model (DSM) is probably one of the most popular products widely used in photogrammetric and remote sensing applications. DSM also has its role in many other application areas. For example, the prerequisite for the recently popular digital twins for cities (Ruohomaki et al. 2018) is the replicas of physical cities’ appearances that is basically the detailed virtual photorealistic DSM. High-resolution three-dimensional (3D) urban DSM can be used for urban planning, environment monitoring, infrastructure asset management, and so on. With the advance of digital imaging technology, very high-resolution imagery can be captured from airborne camera systems. DSM can be derived from those multiple overlapped images in unprecedented detail using some of the latest 3D surface reconstruction commercial photogrammetric systems, such as ContextCapture (Bentley Systems), Correlator 3D (Simactive Inc.), Inpho Match-T (Trimble Navigation Ltd.), Metashape (Agisoft), Pix4Dmapper (Pix4D), Pixel Factory (Airbus Defence and Space), SocetSet (BAE System), SURE (nFrames), UltraMap (Vexcel Imaging), and so on.

Automatic matching algorithms are essential to DSM generation in 3D surface reconstruction systems. There are several classic matching techniques such as the normalized correlation coefficients (NCC) (Bourke 1996), least squares multi-point matching (Rosenholch 1987), dynamic programming matching techniques (Cormen et al. 1990), relaxation method matching techniques (Christmas et al. 1995; Geman and Geman 1984), semiglobal matching technology (Hirschmüller 2008), etc. Although the latest matching techniques in 3D surface reconstruction systems can achieve great matching accuracy and efficiency, it is true that, more or less, various errors and artifacts exist in almost every DSM that is automatically reconstructed using image matching techniques, especially in image areas where less information is available (Gruen 2012). These DSM artifacts may be caused by a variety of imaging phenomena, such as occlusions, moving objects, illumination oversaturation, surface reflections, lack of surface texture, etc., and/or due to the limitations of image matching algorithms (Zhang 2005).

In recent years, many researchers have put forth efforts to improve matching techniques from various aspects to reduce matching errors: for example, using redundant information of multiple images to improve the DSM accuracy (Zhang and Gruen 2006; Zhang et al. 2017; Zhao et al. 2018; Zhu et al. 2010); using geometric feature information to obtain highly accurate DSM (Alobeid et al. 2010; Gao et al., 2018; Jiang and Jiang 2019); and adopting the multi-view stereo matching method to reconstruct the surfaces (Furukawa and Ponce 2010; Zhu et al. 2020). With all the efforts, the DSM refinement still remains a labor consuming and expensive process, since processing all images may remove previous errors but introduce new errors and artifacts somewhere else. Because no perfect matching algorithms exist yet, some commercial photogrammetric systems provide DSM editing tools that allow manually correcting errors and artifacts in DSM.

This paper proposes a new method to refine an existing DSM based on projected images, the new method is inspired by the Vertical Line Locus (VLL) method (Chen et al. 2012; Cogan et al. 1988; Li 1988).Unlike VLL, which is based on the geometric relationships between the original images and the ground surface, this proposed method first projects the original images onto a common reference plane (horizontal) to form so called “projected images”, then applies image matching algorithms on the projected images in the hope that errors in DSM can be corrected. The main contribution of this paper is utilization of the concept of projected images during image matching and 3D coordinate calculations to greatly simplify (1) expensive coordinate transformations between the image space and the object space and (2) correlation window resampling.

In the following sections, the proposed methods are presented in detail (section “Methods”); the principle of the proposed method is illustrated through a single-point correction experiment (Experiment A, section “Single-Point Correction”), followed by an experiments that shows a coarse DSM patch can be refined effectively (Experiment B, section “Coarse DSM Patch Refinement”), and a wrong DSM patch can be corrected through rematching (Experiment C, section “Wrong DSM Patch Correction”); in the last experiment (Experiment D, section “DSM Patch Refinement and Editing Comparisons”), the results from the proposed method are compared with common manual editing tools, and some
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Remote Sensing for Ecosystem Services and Urban Sustainability

John C. Trinder

Abstract

The purpose of this paper is to demonstrate how geospatial technologies, especially remote sensing, can play a leading role in defining urban sustainability based on the evaluation of demand and supply of ecosystem services (ES). A brief review of sustainable development and urban sustainability will be given followed by demonstrations of the need for green spaces in cities, and the consequences of fragmentation of green spaces on biodiversity. Although there are no substantive figures for desirable levels of green spaces in urban areas for the benefit of inhabitants, the paper proposes minimum desirable areal percentages. The paper defines natural capital and ES and the procedures adopted by researchers in balancing the supply and demand for ES for urban areas. The genuine progress indicator is presented as a measure of assessing human welfare, but it is not pursued as an indicator of sustainability. Examples of the applications of remote sensing technologies for determining supply and demand of ES are reviewed as are the potential of the supply and demand of ES to support decision-making in urban areas, to ensure that development decisions are sustainable and are in the best interests of the urban residents who depend on ES for their life support.

Introduction

The growth of cities is causing increasing stress on many aspects of urban environments. The United Nations (UN) Economic and Social Council reported in 2017 that 54% of world’s population lived in cities, and some estimates indicate global urban populations may reach 65% of the world’s population by 2050. Challenges and opportunities for the development of Megacities is discussed in Li et al. (2019). Sustainable development has been proposed for many years as a means of ensuring that human impacts are within the capacity of the Earth’s environment to cope with changes. While there have been many definitions presented, sustainability in this paper refers to the adoption of practices in relation to environmental use and management which provide a satisfactory standard of living for today’s population, and which do not impair the capacity of the environment to provide for and support the needs of future generations. Alternatively, sustainable development is that which meets the needs of society today without foreclosing the needs or options of the future (Blanco et al. 2001). Sustainability “focuses on interactions between resources, its users, and the governance required to sustain ecosystems while also delivering what people need and value” (Newlands 2017, p. 16). This last description suggests that the provision by the environment of benefits and services to users’ needs to be controlled by governance from local administrations or higher-level governments. While there are numerous examples of controls over human behavior within various national administrations, such controls should be managed by the assessment of appropriate measures, often prescribed as sustainability indicators (SI). Many examples of SI have been provided in literature including Trinder (2016), for a range of aspects of urban environments and cities.

Urban Environments

Sustainability of Urban Environments

A sustainable city, or eco-city, which can be described as a complex adaptive system (Newlands 2017), is a city designed considering the three pillars of sustainability, namely social, economic, and environmental impact. Such a city will be a resilient habitat for existing populations with the capacity to respond to disruptions or disturbances and recover quickly. That city will also not compromise the ability of future generations to experience similar habitat conditions. The environments in which cities have been located have clearly been changed significantly from their original states. However, their new states require assessment using appropriate measures, which, according to a definition above, also need to be assessed as to whether they can provide a satisfactory standard of living for its current inhabitants and future generations. While Costanza and Patten (1995) state somewhat negatively that sustainability can only be assessed after the fact and not in advance, it is essential that the sustainability of existing urban environmental practices are assessed in consideration of future generations.

Berger (2014) states that cities are unsustainable, while Gardner (2016) in providing a significant review of the sustainability of cities, provides a negative projection for the future of the world’s environment. This environment will be dominated by cities and, if the majority of the world’s population achieves a similar standard of living as the affluent populations today, global material use will grow by 3 to 5 times current levels. Even technology gains will not reduce the use of materials, since in the past 500 years technology developments are estimated to have increased environmental impacts by 1.5 times. “Creating sustainable cities for all will require great creativity as well as decidedly lower levels of consumption. It will only be possible if a new relationship between humans, energy, and materials is achieved” (Gardner 2016). Experiences with global forums are discussed in Holden et al. (2008) and, although written before the development of Agenda 2030 and the Sustainable Development Goals (United Nations 2016), it contrasts actions that are presented to achieve sustainability of urban areas, which include a paradigm shift that must occur before a major global crisis occurs. Mori and Christodoulou (2012) argue that no satisfactory sustainability indicators have been developed for cities because such indicators should do the following: (a) take into account the three components of sustainability—social, economic, environmental impacts; (b) include consideration of
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Monitoring Work Resumption of Wuhan in the COVID-19 Epidemic Using Daily Nighttime Light

Zhenfeng Shao, Yun Tang, Xiao Huang, and Deren Li

Abstract
This study analyzes the characteristics of nighttime light (NTL) radiance variation, aiming to demonstrate the possibility of using NTL to monitor work resumption and evaluate the impact of COVID-19 on economic activities in Wuhan, China. The results show that NTL radiance generally decreased during the epidemic. Despite the fact that increased NTL radiance was observed after lifting the lockdown, it was still lower than normal, indicating that socioeconomic activities have been largely resumed but the production scale has not been fully restored, and the decrease in nitrogen dioxide concentration verified this phenomenon. We find that central urban areas and distant suburban areas present different modes of NTL radiance variation. We further observed a decrease in NTL radiance from different urban functional areas, including industrial parks, airports, business districts, loop lines, and residential area, that corresponds to the impact of the COVID-19 epidemic on both industrial production and the service sector.

Introduction
The COVID-19 epidemic broke out in Wuhan, China, at the end of December 2020. This virus has greater transmissibility than severe acute respiratory syndrome and Middle East respiratory syndrome (Tomar and Gupta 2020). Within a few months, it had spread at a drastic rate and covered almost the whole world as of March 2020. The World Health Organization (WHO) estimated that the virus has an incubation period of 2 to 10 days, which makes the control measures of the epidemic more intractable. Additionally, asymptomatic and pre-symptomatic infections have become significant factors in preventing the epidemic from spreading and rebounding. These infected cases can transmit the virus without displaying any symptoms. According to WHO, the cumulative number of confirmed COVID-19 cases worldwide exceeded 20 million on 12 August, the cumulative number of deaths exceeded 730,000, and these numbers are still growing rapidly. Thus, the global epidemic prevention and control situation remains grim. With the strong contagions of the COVID-19 epidemic, many countries have enforced a series of emergency measures, including city lockdowns, ceasing industrial production, and restricting population movement (Pervaiz et al. 2020). Wuhan adopted lockdown measures to reduce the spread of COVID-19 from 23 January to 8 April. Soon afterward, a majority of provinces in mainland China carried out rigorous measures to restrict social activities, production, and transportation. Thus, analyzing the impact of the lockdown on people’s daily lives and enterprise production becomes a significant scientific research not only to China but to other countries and regions as well.

At present, many studies that conduct analysis for the epidemic spread and impact of COVID-19 have been published. Research has investigated the future patterns and temporal dynamics of COVID-19 using time series models (Feroze 2020; Griffith et al. 2020; Li et al. 2020; Zhou et al. 2020), estimated and predicted the impact of different factors on the outbreak and spread of COVID-19 (Buckee et al. 2020; Luo et al. 2020; Oliveiros et al. 2020; Sajadi et al. 2020), illustrated the impact of containment measures on people’s daily lives (Liu et al. 2020), analyzed the improvement of air quality (Adams 2020; Griffith et al. 2020; Liu et al. 2020; Pervaiz et al. 2020; Tao et al. 2020), and presented the spatiotemporal characteristics of the epidemic spread (Liu 2020; Liu et al. 2020; Wang et al. 2020). However, few studies have focused on analyzing the impact of epidemic prevention and control measures on the progress of work resumption. During the COVID-19 epidemic, especially during the city lockdown, most enterprises were unable to execute production and business activities, and the governments made unified arrangements for work resumption in accordance with the improvement in prevention and control measures for the epidemic. This study aims to monitor the work resumption of Wuhan in the COVID-19 epidemic and understand the impact of the epidemic at the city level, providing evidence that can help governments adjust lift-lockdown strategies and better evaluate economic losses. Nighttime light (NTL) remote sensing data have been widely used to estimate socioeconomic parameters and serve as an indication of economic activity (Bennie et al. 2014; Shi et al. 2014; Li et al. 2016, 2018; Hu and Huang 2019) given their capability of demonstrating enterprise production, energy consumption, transportation, and other socioeconomic activities. Scholars have applied NTL data to understand the progress and impacts of critical threats as well as to monitor economic recovery in near real time at low cost (Hudecheck et al. 2020). NTL data provide an opportunity to understand people’s movements and activity changes during the lockdown. The Earth Observation Group utilizes cloud-free average radiance composites to calculate brightness changes between the pre-epidemic period and the lockdown period. The results show that light intensity was decreased in many parts of China in February 2020, the peak of the epidemic (Elvidge et al. 2020). NASA has presented the NTL results of Wuhan, showing the comparisons before and during the lockdown. Their results demonstrated significant dimming, especially in certain districts and highways. Furthermore, NTL changes reflect the shutdown of business and transportation around Hubei province (NASA Earth Observatory 2020). The Gauteng City-Region Observatory has released comparisons of light intensity before the beginning of lockdown (March 2020) and...
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Abstract
Urban lidar data are advantageous for capturing the terrain surface of built-up areas, which can be directly used to provide digital surface models. Cloud points are classified into ground points to obtain digital terrain models. This study proposes a method to improve the progressive triangulated irregular network (TIN) densification method using a TIN connection analysis algorithm, namely, connection analysis via slope analysis. The proposed method comprises five steps: selection of seed points, connection and slope analysis, increasing the seed points, construction of the TIN model of the seed points, and an iterative construction of the final TIN. Seven data sets from the International Society for Photogrammetry and Remote Sensing Working Group are used to test whether the proposed method can preserve discontinuities of landscapes and reduce omission and total errors by an average of 9% and 5%, respectively; achieving such results can reduce the amount of workload required for result modification during posttreatment, thus decreasing costs.

Introduction
With ongoing urbanization, the urban–rural fringe has gradually become built-up areas, thus affecting the quality of urban life and sustainable development (Ding et al. 2016). In developing countries, the problems are severe (Shao et al. 2020) and may lead to new challenges to urban development. For example, if the proportion of urban buildings and roads is too large, it may lead to the decrease in permeable surfaces, such as vegetation. Moreover, the unreasonable distribution of impervious surfaces increases urban surface run-off, leading to waterlogging (Shao et al. 2020); the reduction of vegetation also results in the decrease in urban aboveground biomass (Zhang and Shao 2020).

Airborne light detection and ranging (lidar) has become increasingly popular for creating digital terrain models. With lidar data, cultivated land is easily distinguished from buildings (Shao et al. 2020). Lidar can measure the distance between the sensor and a target. Airborne and satellite remote sensing are precise and useful (Shao et al. 2020), but substantial work is required for automatic extraction from airborne lidar data.

Sithole and Vosselman (2004) compared different filter methods, concluding that filters that incorporate a surface concept perform better than others; however, no good segmentation-based filters are available at present. Four algorithms, i.e., weighted linear least squares, multi-scale curvature classification, progressive morphological filter, and progressive triangulated irregular network (TIN) were compared for filtering in a forest environment (Silva et al. 2018), Chen et al. (2017) classified existing methods into six categories: surface-based adjustment, morphology-based filtering, TIN-based refinement, segmentation and classification, statistical analysis, and multi-scale comparison.

Digital elevation model (DEM) extraction algorithms use several methods to judge if a point is a ground point (Vosselman and Klein 2010). Lidar data are three-dimensional points. In remote sensing, images are usually processed in two dimensions. Thus, if lidar data are converted to an image format, many image processing methods can be used to process point cloud data. However, the precision is changed after conversion. (Shan and Charles 2009; Markus and Hanspeter 2007).

Filtering algorithms can be divided into four categories: morphological filtering, progressive densification, interpolation, and segmentation algorithms.

Morphological filtering algorithms use a morphological method to process the images converted from lidar data (Broeelli et al. 2009). These algorithms mostly detect height differences, whereas surface-based filters also consider surface trends (Chen et al. 2007). Therefore, surface-based filters can obtain more reliable outcomes than morphological ones. On the one hand, morphological algorithms remove the object points through slope analysis. On the other hand, features on flat areas must be maintained. The simple morphological filter algorithm uses increasing window sizes to remove the object points with a slope threshold and fills the empty cell (Thomas et al. 2013). Hui et al. (2016) improved the morphological method by using multi-level Kriging interpolation. Liu and Lim (2018) used a voxel-based multi-scale morphological filtering method to extract DEMs under forest areas. Li et al. (2017) made a geodesic transformation of mathematical morphology. Bigdeli et al. (2018) included two main sections, i.e., iterative geodesic morphology and scan labeling. Ozcan and Unsalan (2016) proposed a novel filter based on two-dimensional empirical mode decomposition. Wang et al. (2018) created a terrain relief index to tune the slope-related parameters of ground filtering methods.

Progressive densification constructs terrain TIN models by detecting ground points increasingly. Axelsson (2000) divided data into grid cells. The point with the lowest height in each cell is selected as the seed point. Then, these points are triangulated to construct the initial TIN model. If a point is located in a triangle of the TIN model, then it is added to the TIN model. Zhang and Lin (2013) improved the above model using the segmentation method, and Zhao et al. (2016) improved this method using a morphological algorithm. He et al. (2018) proposed a method that progressively detects terrain points through energy minimization using a graph cut.

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<td>Barry N Haack</td>
<td>Guoyuan Li</td>
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Special Advertising Opportunities

FRONT COVER SPONSORSHIP
A PE&RS cover sponsorship is a unique opportunity to capture the undivided attention of your target market through three premium points of contact.

1 – PE&RS FRONT COVER
(Only twelve available, first-come, first-served)
PE&RS is world-renowned for the outstanding imagery displayed monthly on its front cover—and readers have told us they eagerly anticipate every issue. This is a premium opportunity for any company, government agency, university or non-profit organization to provide a strong image that demonstrates their expertise in the geospatial information industry.

2 – FREE ACCOMPANYING “HIGHLIGHT” ARTICLE
A detailed article to enhance your cover image is welcome but not a condition of placing an image. Many readers have asked for more information about the covers and your article is a highly visible way to tell your story in more depth for an audience keenly interested in your products and services. No article is guaranteed publication, as it must pass ASPRS editorial review. For more information, contact Rae Kelley at rkelley@asprs.org.

3 – FREE TABLE OF CONTENTS COVER DESCRIPTION
Use this highly visible position to showcase your organization by featuring highlights of the technology used in capturing the front cover imagery. Limit 200-word description.

Terms: Fifty percent nonrefundable deposit with space reservation and payment of balance on or before materials closing deadline.

Cover Specifications:
Bleed size: 8 5/8” x 11 1/4” Trim: 8 3/8” x 10 7/8”

Offprints of the cover, Table of Contents page, and highlight article are available at the time of publication. These must be ordered and paid for in advance.

For front cover offprints or other quantities, contact Rae Kelley, ASPRS Assistant Director – Publications 505-819-3599 e-mail rkelley@asprs.org.

PRICING

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<th>Corporate Member</th>
<th>Exhibitor</th>
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<td>$2,000</td>
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Belly Bands, Inserts, Outserts & More!
Make your material the first impression readers have when they get their copy of PE&RS. Contact Bill Spilman at bill@innovativemediasolutions.com

VENDOR SEMINARS
ASPRS Sustaining Members now have the opportunity to hold a 1-hour informational session as a Virtual Vendor Seminar that will be free to all ASPRS Members wishing to attend. There will be one opportunity per month to reach out to all ASPRS Members with a demonstration of a new product, service, or other information. ASPRS will promote the Seminar through a blast email to all members, a notice on the ASPRS web site home page, and ads in the print and digital editions of PE&RS.

The Virtual Seminar will be hosted by ASPRS through its Zoom capability and has the capacity to accommodate 500 attendees.

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EMPLOYMENT PROMOTION
When you need to fill a position right away, use this direct, right-to-the-desktop approach to announce your employment opportunity. The employment opportunity will be sent once to all ASPRS members in our regular Wednesday email newsletter to members, and will be posted on the ASPRS Web site for one month. This type of advertising gets results when you provide a web link with your text.

<table>
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<th>Employment Opportunity</th>
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<td>30-Day Web + 1 email</td>
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<tr>
<td>Web-only (no email)</td>
<td>$300/opportunity</td>
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Do you have multiple vacancies that need to be filled? Contact us for pricing details for multiple listings.

NEWSLETTER DISPLAY ADVERTISING
Your vertical ad will show up in the right hand column of our weekly newsletter, which is sent to more than 3,000 people, including our membership and interested parties. Open Rate: 32.9%

<table>
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<th>Newsletter vertical banner ad</th>
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<tr>
<td>180 pixels x 240 pixels max</td>
<td>$500/opportunity</td>
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PE&RS Digital Edition
Digital Edition E-mail Blast: 5,800+ PE&RS is available online in both a public version that is available to anyone but does not include the peer-reviewed articles, and a full version that is available to ASPRS members only upon login.

The enhanced version of PE&RS contains hot links for all ASPRS Sustaining Member Companies, as well as hot links on advertisements, ASPRS Who’s Who, and internet references.

Become a sponsor today!
The e-mail blast sponsorship opportunity includes a 180 x 240 pixel ad in the email announcement that goes out to our membership announcing the availability of the electronic issue.

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<th>Digital Edition Opportunities</th>
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For more information, contact Bill Spilman at bill@innovativemediasolutions.com │ (877) 878-3260 toll-free │ (309) 483-6467 direct │ (309) 483-2371 fax
**PE&RS Media Kit 2021**

**PE&RS 2021 Advertising Rates & Specs**

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Other Advertising Opportunities

| Wednesday Member Newsletter Email Blast | 1 Complimentary Per Year | 1 Complimentary Per Year | $600 | $600 |

A 15% commission is allowed to recognized advertising agencies

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Source: PE&RS Readership Survey, Summer 2017

For more information, contact Bill Spilman at bill@innovativemediasolutions.com │ (877) 878-3260 toll-free │ (309) 483-6467 direct │ (309) 483-2371 fax
The 3rd edition of the DEM Users Manual includes 15 chapters and three appendices. References in the eBook version are hyperlinked. Chapter and appendix titles include:

1. Introduction to DEMs
   David F. Maune, Hans Karl Heidemann, Stephen M. Kopp, and Clayton A. Crawford
2. Vertical Datums
   Dru Smith
3. Standards, Guidelines & Specifications
   David F. Maune
4. The National Elevation Dataset (NED)
   Dean B. Gesch, Gayla A. Evans, Michael J. Oimoen, and Samantha T. Arundel
5. The 3D Elevation Program (3DEP)
   Jason M. Stoker, Vicki Lukas, Allyson L. Jason, Diane F. Eldridge, and Larry J. Sugarbaker
6. Photogrammetry
   J. Chris McGlone and Scott Arko
7. IfSAR
   Scott Hensley and Lorraine Tighe
8. Airborne Topographic Lidar
   Amar Nayegandhi and Joshua Nimetz
9. Lidar Data Processing
   Joshua M. Novac
10. Airborne Lidar Bathymetry
    Jennifer Wozencraft and Amar Nayegandhi
11. Sonar
    Guy T. Noll and Douglas Lockhart
12. Enabling Technologies
    Bruno M. Scherzinger, Joseph J. Hutton, and Mohamed M.R. Mostafa
13. DEM User Applications
    David F. Maune
14. DEM User Requirements & Benefits
    David F. Maune
15. Quality Assessment of Elevation Data
    Jennifer Novac

   Appendix A. Acronyms
   Appendix B. Definitions
   Appendix C. Sample Datasets

This book is your guide to 3D elevation technologies, products and applications. It will guide you through the inception and implementation of the U.S. Geological Survey’s (USGS) 3D Elevation Program (3DEP) to provide not just bare earth DEMs, but a full suite of 3D elevation products using Quality Levels (QLs) that are standardized and consistent across the U.S. and territories. The 3DEP is based on the National Enhanced Elevation Assessment (NEEA) which evaluated 602 different mission-critical requirements for and benefits from enhanced elevation data of various QLs for 34 Federal agencies, all 50 states (with local and Tribal input), and 13 non-governmental organizations.

The NEEA documented the highest Return on Investment from QL2 lidar for the conterminous states, Hawaii and U.S. territories, and QL5 IfSAR for Alaska.

Chapters 3, 5, 8, 9, 13, 14, and 15 are “must-read” chapters for users and providers of topographic lidar data. Chapter 8 addresses linear mode, single photon and Geiger mode lidar technologies, and Chapter 10 addresses the latest in topobathymetric lidar. The remaining chapters are either relevant to all DEM technologies or address alternative technologies including photogrammetry, IfSAR, and sonar.

As demonstrated by the figures selected for the front cover of this manual, readers will recognize the editors’ vision for the future – a 3D Nation that seamlessly merges topographic and bathymetric data from the tops of the mountains, beneath rivers and lakes, to the depths of the sea.

Co-Editors
David F. Maune, PhD, CP and Amar Nayegandhi, CP, CMS

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