PE&RS
November 2022 Volume 88, Number 11
PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING
The official journal for imaging and geospatial information science and technology

New-Generation Hyperspectral Sensors Improve Crop Characterization

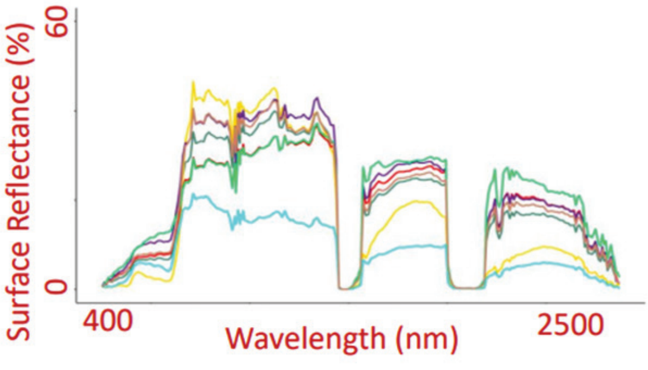


Figure 1. Crop Types for PRISMA

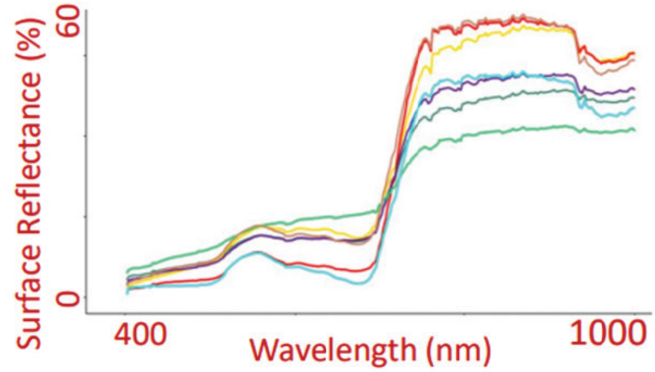


Figure 2. Crop Types for DESIS

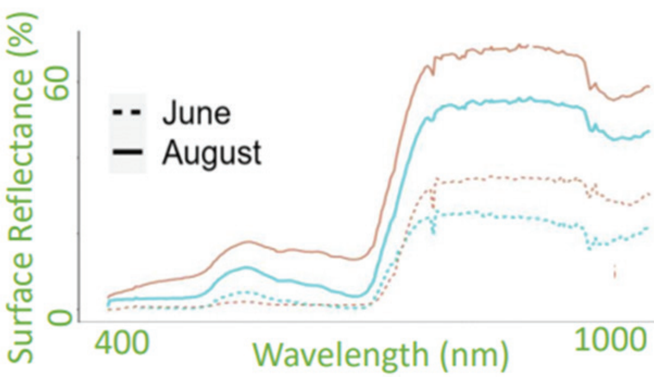


Figure 3. Crop Growth Stages for DESIS

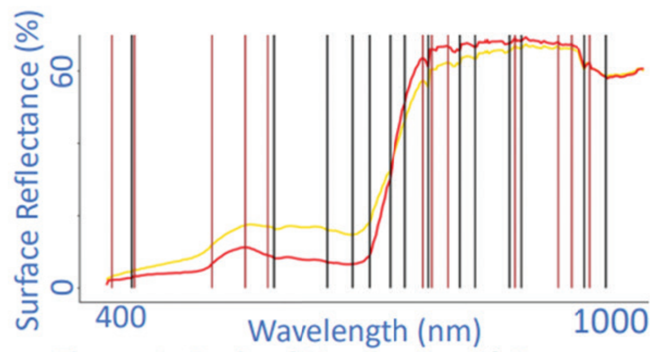


Figure 4. Optimal Hyperspectral Narrow Bands for DESIS

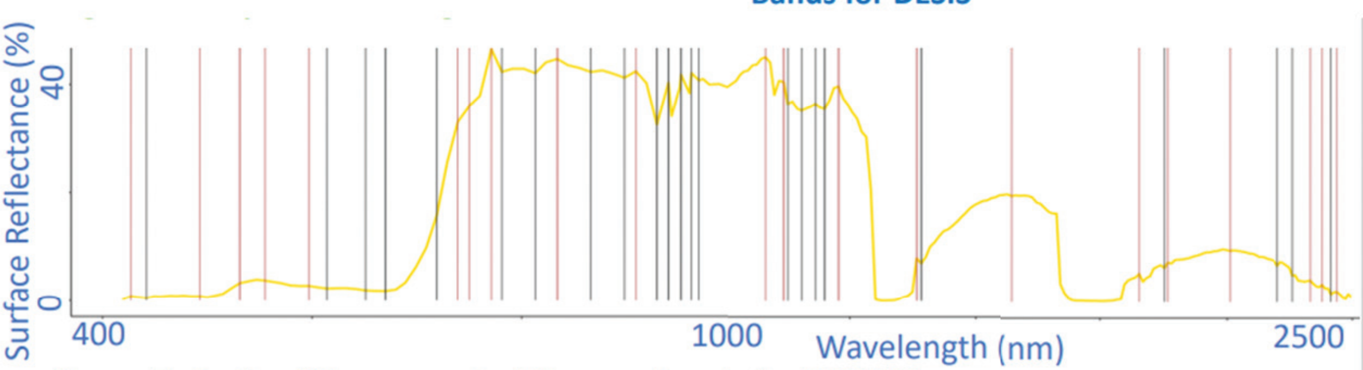
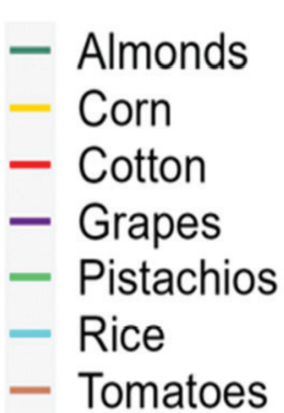


Figure 5. Optimal Hyperspectral Narrow Bands for PRISMA



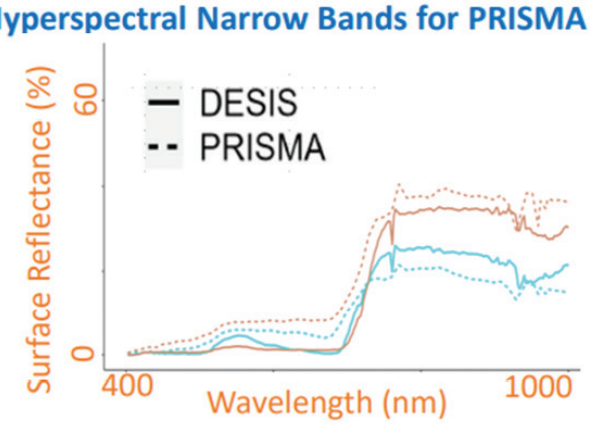


Figure 6. Spectral matching

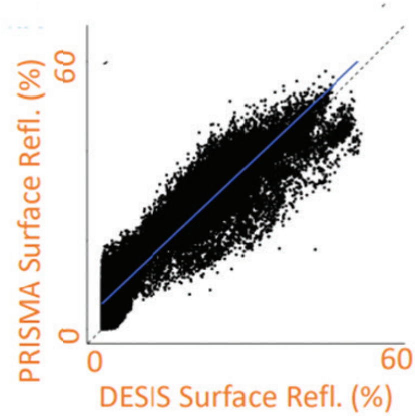


Figure 7. Correlation analysis

To have your press release published in *PE&RS*, contact Rae Kelley, rkelley@asprs.org.

ANNOUNCEMENTS

URISA is pleased to announce the newest members of its Vanguard Cabinet. The Vanguard Cabinet (VC) is a URISA initiative (which debuted in 2011) to engage young GIS practitioners, increase their numbers in the organization, and better understand the concerns facing these future leaders of the GIS community. The VC is an advisory board who represent the young membership of the organization. The Cabinet's mission is to collaborate with URISA's Board of Directors and Committees in creating and promoting programs and policies of benefit to young professionals.

Comprised entirely of passionate young members selected from different geospatial disciplines, the Cabinet aims to position URISA as the center of opportunities for ambitious young professionals who are committed to improving URISA and the geospatial profession via innovation, collaboration, networking, and professional development. Each will serve a three-year term. 2023-2025 URISA Vanguard Cabinet Members:

- Andrew Berens, GISP, Senior GIS Projects Coordinator, Peraton at CDC/ATSDR, Baton Rouge, Louisiana
- Kelsey Calvez, Environmental Scientist /GIS Analyst, Freese and Nichols, Inc., Austin, Texas
- Samantha "Sam" Dinning, GIS Analyst, Douglas County, Castle Rock, Colorado
- Brooke Hatcher, Senior Geospatial Consultant, New Light Technologies, Seattle, Washington
- Wanmei Liang, GIS Technician, Infrastructure Management Services, Los Angeles, California
- Ethan McGhee, GIS Specialist, City of San Luis Obispo, San Luis Obispo, California
- Matt Worthy, Program Manager, Optimal GEO, Huntsville, Alabama
- Sydney Young, GIS Technician, Chatham County Engineering Department, Savannah, Georgia

Cabinet members are selected through an application process, with interviews by the URISA Leadership Development Committee. The application process for the next class of Vanguard Cabinet members will open during the Summer of 2023. Learn more about VC activities here: https://www.urisa.org/vanguardcabinet.

Phase One, a leading developer of digital imaging technologies, has announced the successful launch and orbital deployment of an imaging sensor based on the Phase One iXM Series 150MP frame camera. Launched into low Earth orbit (LEO) earlier this year by a U.S. customer, the Phase One sensor system is performing as planned aboard a smallsat Earth observation mission.

"With our first sensor now in orbit, Phase One is pleased to announce the commercial release of a space-hardened camera system designed specifically for satellite-based Earth observation programs," said Dov Kalinski, Phase One Vice President of Security & Space. "The new imaging system will be available shortly."

The Phase One iXM Series is a commercial off-the-shelf (COTS) 150-megapixel camera commonly used for high-demand mapping in the globally deployed line of Phase One aerial imaging systems.

The client selected the Phase One camera for its groundbreaking technology. With a single large-format CMOS sensor composed of 3.76 micron pixels, the iXM camera provides high-resolution imagery over a large field of view. The Phase One camera system is available for a fraction of the cost of traditional satellite imaging sensors, allowing the client to obtain and integrate the iXM Series sensor within the aggressive schedule required by the mission.

For more information, visit www.phaseone.com.

ACCOMPLISHMENTS

Leica Geosystems, part of Hexagon, is pleased to announce that the Carl Pulfrich Award 2022 has been presented to Prof. Dr. Charles Toth for his outstanding contribution in the field of geospatial science and engineering. The Carl Pulfrich Award honours cutting-edge innovations and developments in geodesy, photogrammetry and Earth sciences.

"I am deeply grateful to receive the Carl Pulfrich Award among so many notable nominees and to join a distinguished group of prior recipients. This accomplishment is a significant milestone in my professional life, and I want to express my heartfelt gratitude to the team who selected me to receive this award," said Dr. Toth.

The seven-member jury selected Toth out of a number of qualified nominations. Toth works as a research professor at the Department of Civil, Environmental and Geodetic Engineering at the Ohio State University, United States.

Toth was born in Hungary, where he earned his Master of Science and PhD degrees in electrical engineering from the Technical University of Budapest in 1977 and 1980, respectively. In 1997, he completed his second PhD at the same university in geoinformation sciences. Toth has made several significant contributions to geospatial science and engineering. Most importantly, he is known worldwide for his visionary advancements to mobile mapping, and his seminal contributions to research in sensor georeferencing and digital imaging technologies. Publishing more than 400 journal and conference papers, and several book chapters, Toth has an outstanding scholarly record. He also received numerous awards, including the 2009 APSRS Photogrammetric Award, 2005 and 2015 United States Geospatial Intelligence Foundation Academic Achievement Award, the 2016 ISPRS Schwidefsky Medal, Ohio State College of Engineering Lumley Research Awards, and various best papers awards.

The chairman of the 2022 jury, Prof. Dr.-Ing. Uwe Sörgel says, “I am pleased about the recognition of the important work of Prof. Dr. Charles Toth in the fields of photogrammetry, laser scanning and mobile mapping. He has made major contributions to the geospatial industry and academia. In addition, he has served our scientific community for many years in leadership positions of the ASPRS and the ISPRS.” The tribute was given at the Carl Pulfrich Award Ceremony 2022 during the Photogrammetric Week at the University of Stuttgart.

The academic Earth imaging community was encouraged to submit nominations for the biennial award. Nominees were considered based on their experience in photogrammetry, remote sensing activities and contributions to advancing all aspects of the Earth imaging field. Applied work involving hardware systems, software solutions or innovative service activities was also considered.

The Carl Pulfrich Award is prestigious for recognizing cutting-edge innovations, hardware and software developments, and integrated systems design in geodesy, photogrammetry and the Earth sciences. Launched in 1968, it is announced biennially and attracts nominations and recommendations for candidates from all over the world. The biennial award honors the memory of Dr. Carl Pulfrich, a scientific staff member at Carl Zeiss from 1890 to 1927. During his tenure, Pulfrich directed the design of the first stereo photogrammetric and surveying instruments from Zeiss. Initially launched by Carl Zeiss, Oberkochen, then relaunched by Z/I Imaging and Intergraph, it was adopted by Leica Geosystems in 2011. For more than four decades, the Carl Pulfrich Award has recognised the many contributions of scientists worldwide.

CALENDAR

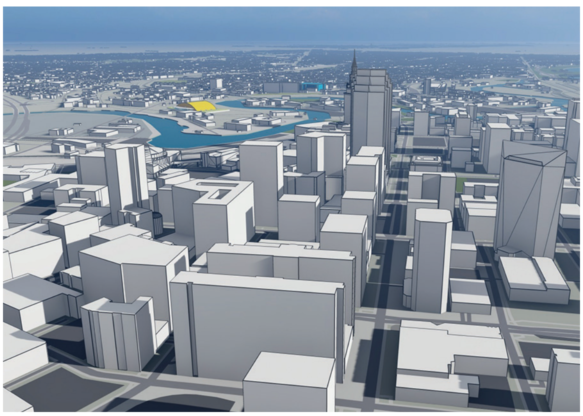
- 6-9 February 2023, Coastal GeoTools, Charleston, South Carolina. For more information, visit https://coastalgeotools.org.

PE&RS
PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING
The official journal for imaging and geospatial information science and technology
November 2022 Volume 88 Number 11

677 Digital Twins

Key to 21st-Century City Planning and Operations, Smart City Evolution

By Qassim Abdullah, Ph.D., CP, PLS, Woolpert Vice President and Chief Scientist



COLUMNS

ANNOUNCEMENTS

DEPARTMENTS

In the Army, the use of tracked or wheeled vehicles has increased considerably. For operation planning, every decision maker wants the current details of off-road trafficability. Therefore, vehicle-specific trafficability maps are needed. Soil variability in spatial and temporal dimensions affects the assessment of off-road trafficability. Genetically, it is assumed that similar soil types behave similarly at a regional scale to reduce the complexity due to its variability. Remolding Cone Index (RCI) of Soil is the indicator of its capability and for generic solution; its value can be related to gravimetric moisture of soil for getting a general idea. In this article, a logics-based, new concept has been introduced to rationalize the RCI values of these moist areas.

It was difficult to accurately obtain crop planting structure by using the spectral information of high spatial resolution and low spatial resolution multispectral images of panchromatic images at the same time. In this article, we propose a method of planting structure extraction based on indices and an improved U-Net semantic segmentation network.

Wireless networks using resource management with the enormous number of Internet of Things (IoT) users is a critical problem in developing networks for the fifth generation. The primary aim of this research is to optimize the use of IoT network resources. Earth surface features can be identified, and their geo-biophysical properties estimated using radiation as the medium of interaction in remote sensing techniques (RST). Deep reinforcement learning (DRL) has significantly improved traditional resource management, which is challenging to model. The Industrial Internet of Things (IIoT) network must be carried out in real time with excess network resources. Conventional techniques have a significant challenge because of the extensive range and complexity of wireless networks. This article discusses optical and microwave sensors in RST techniques and applications, examines the areas where there are gaps, and discusses Earth hazards. Furthermore, a comprehensive resource-based strengthening learning system is developed to ensure the best use of resources.

Using new remote sensing technology to study agricultural crops will support advances in food and water security. The recently launched, new generation spaceborne hyperspectral sensors, German DLR Earth Sensing Imaging Spectrometer (DESIS) and Italian PRecursore IperSpettrale della Missione Applicativa (PRISMA), provide unprecedented data in hundreds of narrow spectral bands for the study of the Earth. The goal of this article is to use these data to explore advances that can be made in agricultural research.

To extract buildings accurately, a foreground-aware refinement network for building extraction we propose. In order to reduce the false positive of buildings, we design the foreground-aware module using the attention gate block, which effectively suppresses the features of nonbuilding and enhances the sensitivity of the model to buildings. In addition, the reverse attention mechanism in the detail refinement module is introduced. Specifically, this module guides the network to learn to supplement the missing details of the buildings by erasing the currently predicted regions of buildings and achieves more accurate and complete building extraction.

See the Cover Description on Page 676

COVER DESCRIPTION

Using the California Central Valley as an example, the cover depicts how data from two new-generation spaceborne hyperspectral sensors, PRISMA and DESIS, were used to study agricultural crops. The figures illustrate hyperspectral agricultural crop characteristics of seven major world crops derived from: 1. the Italian ASI's PRISMA (400-2500 nm), launched in 2019, acquiring data in 238 hyperspectral narrowbands (HNBs), and 2. the German DLR's DESIS (400-1000 nm), launched in 2018 and onboard the International Space Station (ISS), acquiring data in 235 bands. Hyperspectral signatures of the same crops for the 2020 growing season are illustrated for PRISMA (Figure 1) and DESIS (Figure 2). Similarly, crop growth stages for crops in different growth stages, collected at different months within the growing season are shown in Figure 3. The optimal HNBs in the study of agricultural crops for DESIS (Figure 4) and PRISMA (Figure 5) were established in this study. Comparisons of spectral signatures derived from DESIS and PRISMA, in the 400-1000 nm range, are illustrated through spectral matching (Figure 6), and correlation analysis (Figure 7). Spectral data used in this study are available at: https://www.sciencebase.gov/catalog/item/62a91cc2d34ec53d2770f06d

For details read the article by Itiya Aneece and Prasad Thenkabail in this issue.

Cover page credits: Dr. Itiya Aneece and Dr. Prasad S. Thenkabail, U.S. Geological Survey (USGS).

Contact: ianeece@usgs.gov; pthenkabail@usgs.gov or thenkabail@gmail.com.

asprs

THE IMAGING & GEOSPATIAL INFORMATION SOCIETY

PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING

JOURNAL STAFF

Publisher ASPRS
Editor-In-Chief Alper Yilmaz
Director of Publications Rae Kelley
Electronic Publications Manager/Graphic Artist Matthew Austin

Photogrammetric Engineering & Remote Sensing is the official journal of the American Society for Photogrammetry and Remote Sensing. It is devoted to the exchange of ideas and information about the applications of photogrammetry, remote sensing, and geographic information systems. The technical activities of the Society are conducted through the following Technical Divisions: Geographic Information Systems, Photogrammetric Applications, Lidar, Primary Data Acquisition, Professional Practice, Remote Sensing Applications, and Unmanned Autonomous Systems Division. Additional information on the functioning of the Technical Divisions and the Society can be found in the Yearbook issue of *PE&RS*.

Correspondence relating to all business and editorial matters pertaining to this and other Society publications should be directed to the American Society for Photogrammetry and Remote Sensing, 8550 United Plaza Boulevard, Suite 1001, Baton Rouge, LA 70809, including inquiries, memberships, subscriptions, changes in address, manuscripts for publication, advertising, back issues, and publications. The telephone number of the Society Headquarters is 301-493-0290; the fax number is 225-408-4422; web address is www.asprs.org.

PE&RS. *PE&RS* (ISSN0099-1112) is published monthly by the American Society for Photogrammetry and Remote Sensing, 425 Barlow Place, Suite 210, Bethesda, Maryland 20814-2144. Periodicals postage paid at Bethesda, Maryland and at additional mailing offices.

SUBSCRIPTION. For the 2022 subscription year, ASPRS is offering two options to our *PE&RS* subscribers — an e-Subscription and the print edition. e-Subscribers can add printed copies to their subscriptions for a small additional charge. Print and Electronic subscriptions are on a calendar-year basis that runs from January through December. We recommend that customers who choose print and e-Subscription with print renew on a calendar-year basis.

The rate for a Print subscription for the USA is $1105.00 USD, for Canadian* is $1164.00 USD, and for Non-USA is $1235.00 USD.

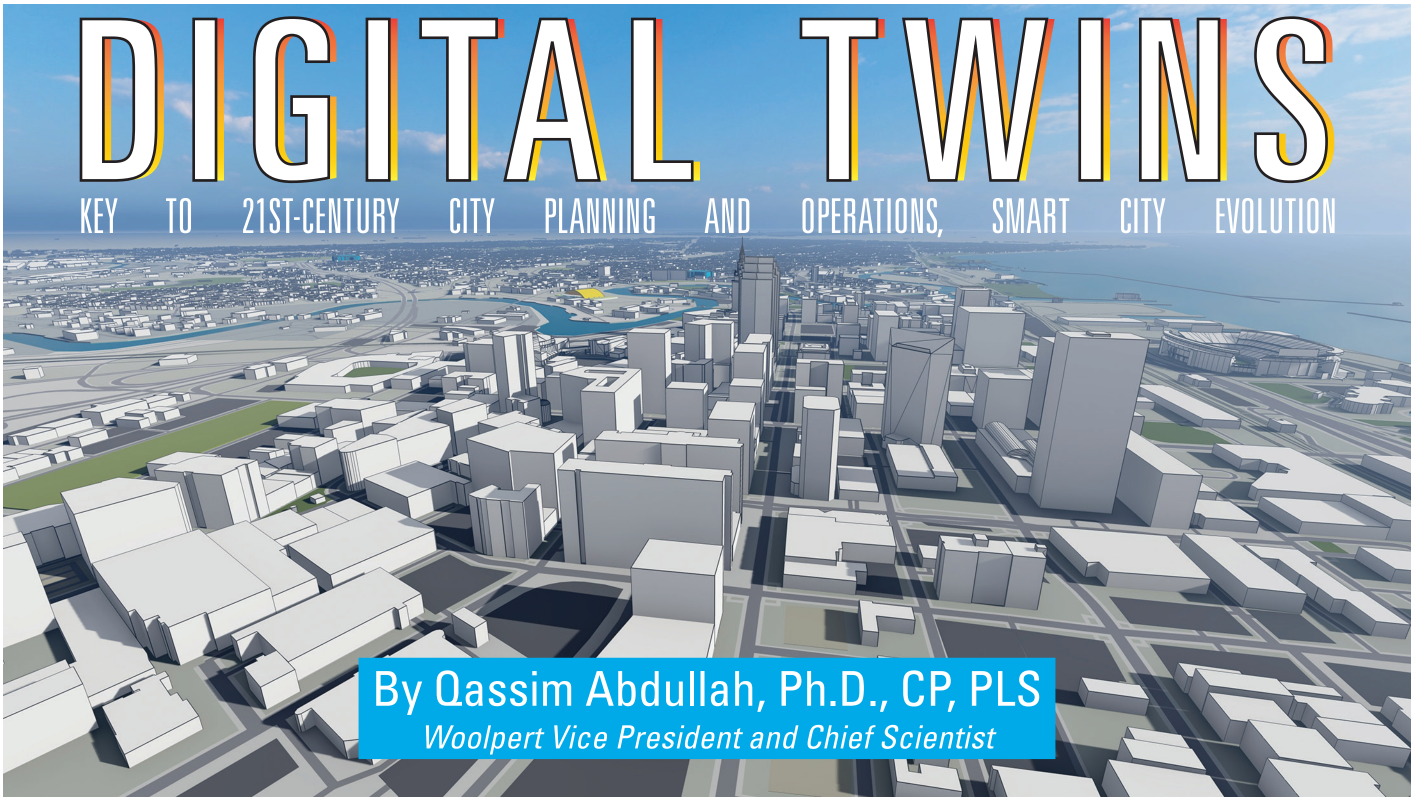
The rate for e-Subscription (digital) Site License for the USA and Non-USA is $1040.00 USD and for Canadian* is $1089.00 USD.

The rate for e-Subscription (digital) plus Print for the USA is $1405.00 USD, for Canadian* is $1464.00 USD, and for Non-USA is $1435.00 USD.

*Note: e-Subscription, Print subscription, and e-Subscription plus Print for Canada includes 5% of the total amount for Canada's Goods and Services Tax (GST #135123065). **PLEASE NOTE: All Subscription Agencies receive a 20.00 USD discount.**

POSTMASTER. Send address changes to *PE&RS*, ASPRS Headquarters, 8550 United Plaza Boulevard, Suite 1001, Baton Rouge, LA 70809. CDN CPM #(40020812).

MEMBERSHIP. Membership is open to any person actively engaged in the practice of photogrammetry, photointerpretation, remote sensing and geographic information systems; or who by means of education or profession is interested in the application or development of these arts and sciences. Membership is for one year, with renewal based on the anniversary date of the month joined. Membership Dues include a 12-month electronic subscription to *PE&RS*. To receive a print copy of *PE&RS* there is an additional postage fee of $60.00 USD for U.S. shipping; $65.00 USD for Canadian shipping; or $75.00 USD for international shipping per year. Annual Individual Member dues for members residing in the U.S. and Other Foreign Members are $150.00 USD and $158.00 USD for Canadians. Annual Student Member dues for members residing in the U.S. are $50.00 USD; $53.00 USD for Canadian; and $60.00 USD for Other Foreign Members. A tax of 5% for Canada's Goods and Service Tax (GST #135123065) is applied to all members residing in Canada.

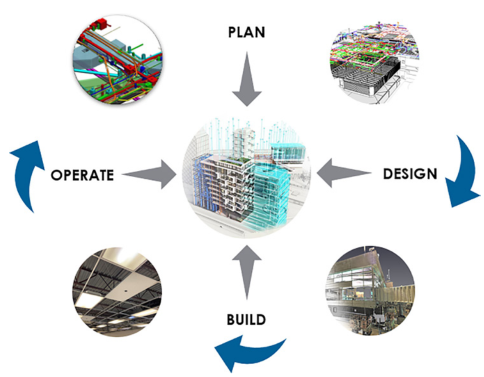


DIGITAL TWINS

KEY TO 21ST-CENTURY CITY PLANNING AND OPERATIONS, SMART CITY EVOLUTION

By Qassim Abdullah, Ph.D., CP, PLS
Woolpert Vice President and Chief Scientist

The concept of the digital twin originated in the manufacturing industry around 2002, and it has been gaining momentum in the geospatial industry since around 2016. Digital twin and 3D models are often confused because they are both virtual representations of the physical environment. The digital twin however, distinguishes itself from the static 3D model by its ability to incorporate data and information from other systems and to evolve over time to support all facets of an asset or ecosystem, from planning through operations.



Because of this dynamic capability, digital twin applications have reproduced quickly over the last handful of years, with industries from manufacturing to supply chain to health care capitalizing on the value of this geospatial tool. But one of the most promising applications is as multifaceted as the concept itself: city planning and management.

According to a recent report by Guidehouse Insights, a global technology consultancy, due to relatively low costs and high utilities, the incorporation and benefits from municipal digital twins are expected to grow immensely over the next decade. The group estimates that revenue generated from digital twins will rise from more than $331 million in 2022 to $2.5 billion by 2031, representing an annual growth rate of more than 25%. The primary limiting factor to this growth is expected to be lack of knowledge about the technology and its applications.

That's where we come in.

Digital Twins, 3D Modeling and Smart Cities

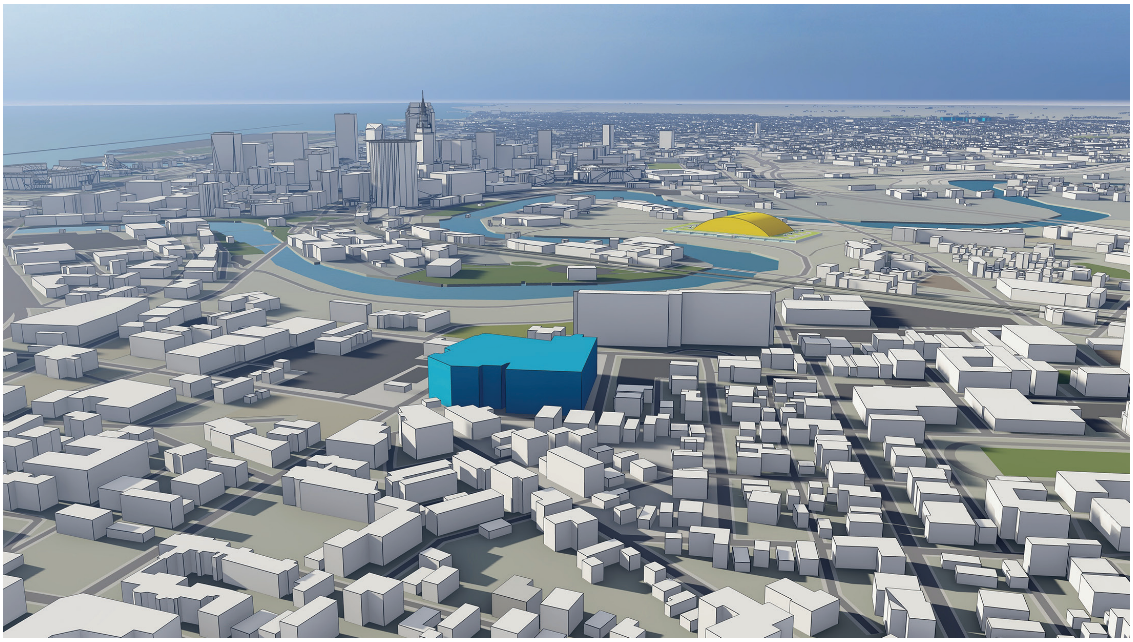
Digital twins and 3D models have contrasting applications in a city setting. It is the difference between a highway overpass model and a digital and dynamic replication of a highway. A 3D model is the best platform for presenting a realistic environment for the interpretation of integrated data. That model then provides the base that can be fed architecture and engineering designs, real-time environmental measurements, and daily operation data to make it a living, breathing digital twin.

Immense amounts of data are collected daily by local, state and federal agencies to support the planning and operations of cities. These data support infrastructure, water and sewer services; energy and utilities; transportation; property management; health care; social services; education; parks and recreation; police and rescue; etc.—pretty much everything that contributes to city facilities and functions.

In most cities, each of these databases are siloed. If those databases are integrated into a digital twin, city officials gain access across city departments to make individual and

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 677–679.
0099-1112/22/677–679

doi: 10.14358/PERS.88.11.677



collaborative decisions. This not only helps realize synergies to advance each department and service, but it provides the framework to identify opportunities to improve that city's overall operations, research, planning, resilience and emergency response.

Although a digital twin can be created without it, building information modeling (BIM) plays an integral role in creating an accurate digital twin for industrial facilities and the urban environment. BIM is a collaborative work method for structuring and managing assets by utilizing data accrued throughout each asset's life cycle. BIM employs augmented and virtual reality to envision a project so changes can be discussed, and next steps can be determined. The integration of data sources from multiple BIM sources, alongside other data and information accrued, creates a digital twin that increases access to that information, forging connections for improved and defensible decision-making.

Specific to a municipal digital twin, BIM is essential. Every city structure represented in that BIM should include a complete development history, from planning to construction to operations, before it is added to the digital twin to accurately reflect those assets within the virtual environment.

The implementation of a digital twin is highlighted in the goal of a smart city, which is to use digitally managed infrastructure to achieve a more sustainable and livable municipality. This is accomplished by improving the quality of life of citizens by ensuring that available resources are functioning correctly and are utilized efficiently. The real-time, integrated data of the digital twin enables that city to optimally manage and operate its assets. The combination of these concepts can effectively serve current city development projects, informing data-rich multidisciplinary models to manage valuable resources through visualization and analytical modeling.

City Applications, ROI

Due to the readily available municipal data and the adoption of evolving technologies around the world, city GIS and IT managers have been taking the lead on the integration and management of these data. Many cities are building 3D models with increased dimension and detail, including the integration of building interiors. These models are supported by the current capabilities of the geospatial industry, including high-accuracy and high-resolution lidar data and imagery that are acquired, from satellite to drone. These city models represent a cornerstone for the municipal digital twin, enhancing shared information among all levels of governments to address traditional and emerging municipal issues.

According to experts in the field, roughly 70% of the return on the digital twin investment comes from facility operation and management after construction is completed because it supports the life cycle of the project. This digital access to the physical structure is then extended and shared with city and departmental managers. While an economic development officer will want to know how many people live in a building, the fire marshal will want to know immediately where his crew can find access to those people, the utility company will want to know how those people are utilizing various energy resources to support grid reliability, etc. A digital twin combined with artificial intelligence can provide a city's engineering and maintenance team with an early warning about a routine maintenance schedule and can warn the team of a defect in any segment of the utilities network.

Correct digital twin implementation requires a massive investment in digital twin infrastructure, data governance, stakeholders' coordination and collaboration, through agreed upon frameworks and processes. It also changes workflows and requires the work force to gain new skills. The continuing drop in the cost of IT infrastructure coupled with affordable cloud data storage and processing will contribute to the affordability of the digital twin, as will the fact that costs associated with the technology can be shared across departments. Additional savings can be realized by reducing physical security and maintenance personnel.

A mature digital twin platform can be extended to connect the wider community of citizens with their government using smart city concepts. Citizens can login to the platform to learn about health and environmental issues and regulations, review their energy use and how it compares to the neighborhood usage, check in on city development plans and how they affect their neighborhoods, etc. You may have noticed here, much of this citizen interaction happens through a smart hub, representing elements of a smart city that are encompassed within the digital twin ecosystem.

As its benefits are more widely understood, the application of digital twins will continue to expand and improve the management of assets in multiple environments. The geospatial industry expects increasing demand for these technologies and the corresponding opportunities they present. The geospatial industry needs to pay close attention to forthcoming opportunities in the digital twin market for multiple reasons:

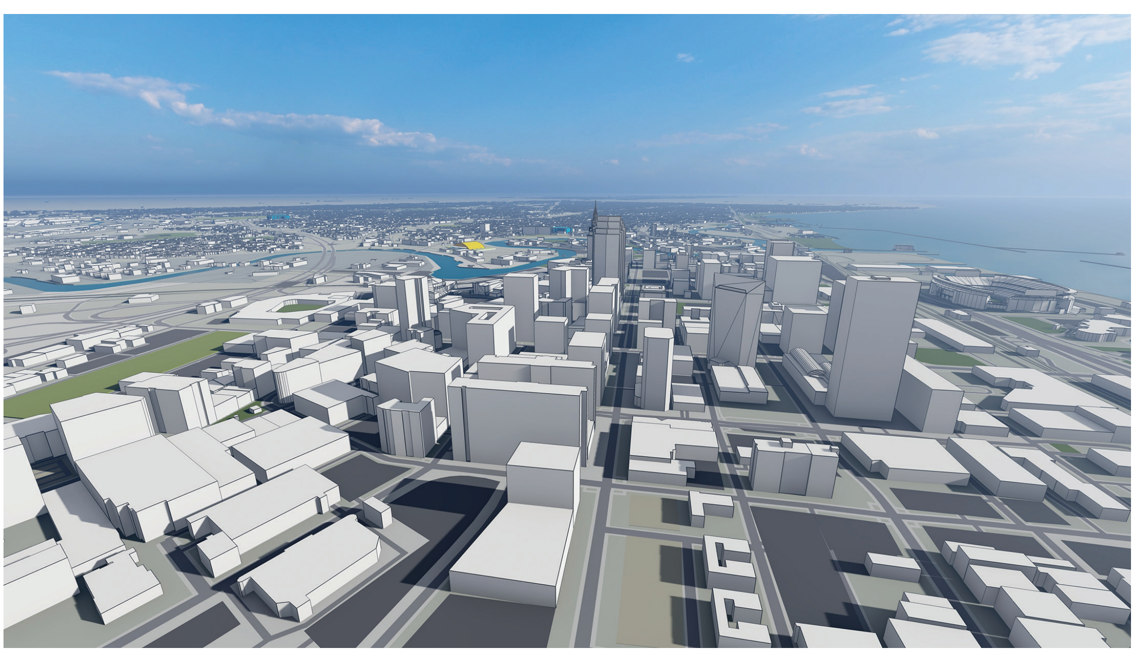
- Geospatial data and information are critical enablers for smart cities and therefore digital twins.
- Geospatial data and information form the framework for the digital infrastructure needed for digital twin implementation.
- Digital twins do not exist in isolation; they exist in an ecosystem of systems that are interconnected and interwoven. Many of these interconnected systems are based on geospatial data components.

In addition to AI and deep learning, data analytics and modeling fields will prosper from the tremendous amount of data generated from operating an asset within a digital twin that needs to be converted to knowledge.

We need to continue to expand these technologies and advance their applications, while educating those who can most benefit. As the Guidehouse Insights study noted, the learning curve is the biggest impediment to municipal digital twin technology and applications. It is our job to fix that.

###

This article is also being published in Lidar Magazine.



GIS Tips & Tricks

Al Karlin, Ph.D. CMS-L, GISP

Need a special GIS Tool? Here are some options.

Introduction

No matter whether you are a GIS-newbie or a seasoned professional, there will come a time when you search through the hundreds of GIS tools in whatever GIS software you are using, whether it is one of the Esri packages, QGIS, GlobalMapper, etc., and just not find the right tool to do what you need done. Of course, if you are a newbie it might just be that you don't know the name of the tool to enter into your search engine, but sometimes, the tool is simply not available. So… what to do? Believe it or not, you have options.

Three options come to mind;

Option 1 – Buy the tools from a commercial off the shelf (COTS) ready-made GIS package, or

Option 2 – Find the tool in an open-source (or shareware) toolkit; don't forget… GOOGLE knows everything, and

Option 3 – Make it yourself.

So, your finances and/or programming skillset are the limiting factors to getting the GIS tool.

This month's tip provides some details on these options. (*The tools identified below are not to be taken as endorsements, personal recommendations, or even a complete listing of those available.*)

So… here are a few starting places when you need a GIS tool:

Option 1 – Buy the Tool

If you are an Esri ArcGIS Desktop or ArcGIS Pro user, you have already purchase over 25 Toolboxes; the Spatial Analyst toolbox alone contains over 200 tools. So, it may be a daunting task just to know what tool is located where, even with the Geoprocessing "Search" in Desktop and the Find Tools in ArcGIS Pro that I discussed in the April 2022 column. If you still want more help finding the tools that you already own, there are "Cheat Sheets" available for free (http://s3.amazonaws.com/arena-attachments/1483540/1e582e391e6e24ae34754e36210b03a4.pdf?1512435403) that may provide some clues. Also, there are additional toolsets that are available for purchase from the Esri MarketPlace (https://www.esri.com/arcgis-blog/products/arcgis-pro-net/announcements/arcgis-pro-add-ins-on-the-arcgis-marketplace/.)

Probably the most popular COTS toolkit, XTools (https://xtools.pro/), is available for both ArcGIS Desktop and ArcGIS Pro. Licensing is available in both "you own it" and "annual subscription" modes. This package is advertised as a "Productivity Package" with over 100 additional tools for ArcGIS users. A listing of the tools and their functions is available on the website.

Then, of course, there are multiple COTS GIS software packages. Here is a raking of the top 30 GIS software packages (https://gisgeography.com/best-gis-software/) with links to their websites. Most of the COTS options include a "try before you buy" option, so you can "try" the tool, albeit with limited functionality, to see if it is the right one for you.

Option 2 – Find the Tool

If you are looking for a "Free" or "ShareWare" option, a good start would be to search through the Wikipedia listing of GIS packages (https://en.wikipedia.org/wiki/List_of_spatial_analysis_software). While this listing is not all-inclusive, it does contain the major options, availability, and their dependencies. Many tools are "free" but require ArcGIS (not free), so this is a case of user-beware.

While discussing ShareWare and OpenSource, do not forget that the entire GRASS and SAGA toolsets are included with the QGIS distributions along with options for over 1100 additional tools. You may need to activate/manage the tools/plugins using the Plugins Manager (Figure 1) in QGIS. Warnings: (1) With over 1100 plugins available, you can install one, select multiples, or there is an option to install all of them, so be careful, (2) some plugins are identified as "experimental" as in Figure 1, so you may get unexpected results, and (3) I have found that some combinations of tools

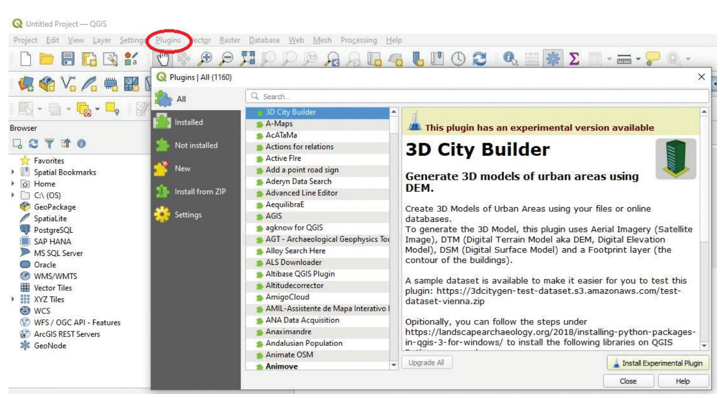


Figure 1. QGIS Plugin Manager. Note that some plugins are identified as "experimental".

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 681–682.
0099-1112/22/681–682

doi: 10.14358/PERS.88.10.681

result in interference, cause the software to crash and will require a complete re-installation without the plugins.

A complete list of all QGIS plugins can be viewed and downloaded at the QGIS Pythons Plugins Respository (https://plugins.qgis.org/plugins). This repository contains all previous and new plugins, as in this example in Figure 2 below which was uploaded just recently as of this writing.

There are several toolkits that come as pre-packaged Esri Toolboxes and stand-alone tools. The WhiteBox Geospatial Analysis tools (https://www.whiteboxgeo.com/) from the University of Guelph's Geomorphonmetry and Hydrogeomatics Research Group are an open-source platform containing over 500 tools. The tools can be downloaded (user contribution encouraged but not required) as a basic or extended (donation required) toolset. The ready-packaged ArcGIS toolbox is found at Github (https://github.com/giswqs/WhiteboxTools-ArcGIS) and a similar toolbox for QGIS versions 3 and above is found at the Plugins Repository (https://plugins.qgis.org/plugins/wbt_for_qgis/) sited above .

Figure 2. A new QGIS plugin available on the QGIS Plugin Respository website.

Option 3 - Make the Tool

Depending on your programming skills, constructing the tool yourself may be an option. For Esri users, if your need is a workflow-tool, you may be able to use ModelBuilder in either Desktop or Pro to construct a custom workflow using Toolbox components. Jupyter Notebooks, (https://www.dataquest.io/blog/jupyter-notebook-tutorial/) used for developing and presenting data science projects, have also proven valuable for GIS workflows and data development. Jupyter Notebooks can make use of exposed Esri, GRASS and SAGA tools and there are several Guides, Tutorials and YouTubes available. Just use GOOGLE!

When all else fails, there are multiple programming languages available to build your own tool, but Python and R are probably the most popular, especially as they work well in combination with Jupyter Notebooks.

***Python*:** There are several spatially compatible programming tools available for those proficient in programming. Perhaps the most readily available library for Python. Python GIS Libraries can be found at: https://gisgeography.com/python-libraries-gis-mapping/ and of course, a wealth of information for Esri ArcPy at: https://www.esri.com/en-us/arcgis/products/arcgis-python-libraries/overview. Hint: Included with the "Help" for each Esri tool, you can find the Python code that you can copy/paste for your use. There are lots of Python tutorials on the web, just GOOGLE "Python GIS Tutorial" to find them.

***R*:** Another spatially aware programing packages are the "R" and "RStudio" libraries. As with Python, these libraries are opensource, robust and come with lots of web support (https://gisgeography.com/r-programming-gis/) and tutorials. R contains an expansive list of over 45 packages for spatial analysis (https://www.gislounge.com/r-packages-for-spatial-analysis/) and, like Python, works well in Jupyter Notebooks and has robust support, tutorials and YouTube videos.

These tips are just starters and are not meant to be inclusive. But when you need a tool and don't know where to start, these are all good places.

A special thanks to James Parker, GISP, PMP (Senior Project Manager, Dewberry) and Colin Flynn (GIS Developer, Dewberry) for their input on Option 3 – Make the Tool.

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

Al Karlin, Ph.D., CMS-L, GISP is with Dewberry's Geospatial and Technology Services group in Tampa, FL. As a senior geospatial scientist, Al works with all aspects of Lidar, remote sensing, photogrammetry, and GIS-related projects. He also teaches beginning map making at the University of Tampa.

Grids & Datums

BY Clifford J. Mugnier, CP, CMS, FASPRS

Independent State of Papua New Guinea

The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on Independent State of Papua New Guinea was originally printed in 2005 but contains updates to their coordinate system since then.

During the 16th century, Portuguese and Spanish navigators visited the island. Annexed by Queensland in 1883, the region became a British Protectorate in 1884 and was annexed by Great Britain in 1888 as British New Guinea. Administration was passed to Australia in 1905, and the name was changed to the Territory of Papua. In 1949, it was united with the Territory of New Guinea to form Papua New Guinea.

The Independent State of Papua New Guinea became independent in 1975. The country is comprised of the Eastern part of New Guinea, the island of Bougainville, and the Bismarck Archipelago: a total area of 462,840 km^2 which is slightly larger than the State of California. The land area totals 820 km^2 and is mostly mountains with coastal lowlands and rolling foothills. The lowest point is the Pacific Ocean, and the highest point is Mount Wilhelm (4,509 m). According to the *CIA Factbook*, the "natural hazards include active volcanism; situated along the Pacific 'Ring of Fire'; the country is subject to frequent and sometimes severe earthquakes; mud slides; tsunamis. On 18 July 1998, a tsunami took the lives of 2,200 north shore residents of Papua New Guinea.

The first Australian Engineer Officer for mapping was posted to Rabaul on New Britain in 1914. Topographic mapping of the area began during World War II, and consisted mainly of one inch to the mile compilations with classical triangulation control. The Australian military mapping installations consisted of drafting and computation sections quartered in tents. Map printing services in Queensland were transferred to the U.S. Army 69th Engineer Topographic Battalion's lithographic detachment in Port Moresby. Supplemented by reconnaissance aerial photo mosaics, additional mapping control continued through the 1950s with assistance from the Royal Australian Survey Corps and the U.S. Army (Australia's Military Map-Makers, 2000).

The oldest "Astro station" serving as a local datum is Paga Hill 1939 near Port Moresby where: Φ_o = 9º 29' 00.31" S, Λo = 147º 08' 21.66" E of Greenwich, and the ellipsoid of reference is the Bessel 1841 where: a = 6,378,397.155 m., and $1/f$ = 299.1528. The grid system commonly associated with the Paga Hill Datum of 1939 is the 1943 Southern New Guinea Lambert Zone where the Latitude of Origin, φ_o = 8° S, Central Meridian, λ_o = 150° E, Scale Factor at Origin, m_o = 0.9997, False Northing = 1,000 km, False Easting = 3,000 km. The original limits of the Zone were for the North: Parallel of 7° S, east to 153º 30' E, thence north along this meridian to 5° S, thence east along this parallel to 165° E. East: Meridian of 165° E. South: Parallel of 12° S, west to 145° E, thence west along this parallel to 141° E, thence south along this meridian to 11° S, thence west along this parallel to 137° E. West: Meridian of 137° E. Recent source data for Paga Hill Datum of 1939 now state the ellipsoid of reference as: International 1924 where: a = 6,378,388 m and $1/f$ = 297. When this supposed change occurred is unknown.

Thanks to John W. Hager for the following: other astro positions in Papua New Guinea include: Brown Island, East New Britain Province Φ_o = 5° 01' 40" S, Λo = 151° 58' 54" E; Cay, Panaeati & Deboyne Island, Milne Bay Province Φ_o = 14° 41' S, Λ_o = 152° 22' E; Dedele Point, Central Province Φ_o = 10° 14' S, Λ_o = 148° 45' E; Dobodura Astro Fix, Northern Province, Φ_o = 8° 45' 50.13" S, Λo = 148° 22' 38.8" E; Dumpu. Madang Province, Φ_o = 5° 50' 34.4" S, Λ_o = 145° 44' 29.55" E; Guadagasal Astro Fix, Gulf Province, Φ_o = 7° 15' 33.6" S, Λ_o = 146° 58' 42.0 E; Guasopo B. Woodlark Island, Milne Bay Province, Φ_o = 9° 13' 39" S, Λ_o = 152° 57' 03" E; Hetau Island Naval Astro, Buka Island, North Solomons Province, Φ_o = 5° 09' 57" S, Λo = 154° 31' 12" E;

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 683-684.
0099-1112/22/683-684

doi: 10.14358/PERS.88.10.627

Hong Astro (1947), Manus Island, Manus Province, West Base, Φ_o = 1° 58' 03.930" S, Λo = 147° 22' 03.320" E, azimuth αo = 111° 55' 58.00" to Azimuth Mark from north, Clarke 1866 ellipsoid, elevation = 6.0 ft.; Jammer Bay, Milne Bay Province, Φ_o = 9° 58' 28" S, Λ_o = 152° 11' 15" E; Kavieng, New Ireland Province, Φ_o = 2° 36' S, Λ_o = 150° 50' E; Keila Island Astro, East New Britain Province, Φ_o = 4° 48' 28" S, Λo = 152° 11' 15" E; Kieta, North Solomons Province, Ashton, Φ_o = 6° 12' 42.68" N, Λ_o = 155° 37' 43.69" E; Koiaris, North Solomons Province, Koiaris Astro 1947, Φ_o = 6° 18' 06.11" S, Λ_o = 155° 11' 47.32" E, azimuth α_o = 322° 19' 42.4" to Azimuth Mark #1 from south, International ellipsoid, established by 657th Engineering Astronomic Determination, March 1947; Losuia, Milne Bay Province, Losuia, Φ_o = 8° 32' 33.825" S, Λ_o = 151° 03' 59.466" E; Matupi, East New Britain Province, Matupi Astronomic Station 1957, Φ_o = 4° 14' 12.210" S, Λ_o = 152° 11' 26.54" E, International ellipsoid, Elevation = 2.4 meters; Popondetta, Astro fix, Φ_o = 8° 46' 07.76" S, Λ_o = 148° 12' 51.55" E; St. Matthais, New Ireland Province, South Base, Φo = 1° 40' 30" S, Λ_o = 149° 54' 54" E; Salankaua, Morobe Province, Φ_o = 6° 33' 28.4" S, Λ_o = 147° 51' 07.2" E; Torokina, North Solomons Province, Naval Astronomic Station, Φ_o = 6° 12' 18" S, Λo = 155° 02' 02.5" E; Wabutina, Milne Bay Province, Wabutin (spelling may be Wabutima), Φ_o = 8° 30' 54.628" S, Λo = 151° 03' 24.947" E; Wau, Morobe Province, Φo = 7° 20' 28.12" S, Λo = 146° 42' 55.6" E; Wewak. Φ_o = 3° 32' 52" S, Λo = 143° 37' 37" E.

The various local astro datums listed above represent the fixes used for navigational charts. In regard to how these various datums are related to the WGS 84 Datum, the Australian Maritime Safety Authority comments: "For some charts, particularly in Papua New Guinea, the correction to be applied to GPS cannot be calculated and these charts display a specific warning to this effect. Use of GPS alone on these charts is hazardous."

For the most part, cartographic products of Papua New Guinea have been on the Australian Geodetic Datum of 1966 with its origin at Johnston Cairn where: Φ_o = 25° 56' 54.5515" S, Λ_o = 133° 12' 30.0771" E, h_o = 571.2 m., and the ellipsoid of reference is the Australian National Spheroid: a = 6,378,160 m, and $1/f$ = 298.25. A new system is the Papua New Guinea Geodetic Datum 1994 (PNG94), which is a geocentric datum defined by a widespread network of geodetic stations around PNG. There are three permanent GPS base stations operating in PNG. The Papua New Guinea Map Grid 1994 (PNGMG) is the UTM grid on the GRS80 ellipsoid. According to the Department of Surveying and Land Studies of the Papua New Guinea University of Technology, "A very approximate relationship between AGD66 and PNG94 coordinates is as follows: PNG94 Latitudes are approximately 5" north of AGD66 latitudes, PNG94 Longitudes are approximately 4" east of AGD66 longitudes, PNGMG Eastings are approximately 120 m greater than AMG66 Eastings, and PNGMG Northings are approximately 160 m greater than AMG66 Northings."

There is a caveat to this approximate relation between AGD66 and PNG94. Again, according to the Department of Surveying and Land Studies, "Tectonic motion is unaccounted for in the realization of the datum. Relative motion between different tectonic regions in PNG is often in excess of 8 cm per year. There are inconsistencies of up to 12 m between tabulated PNG94 coordinates and those derived from high precision GPS survey network adjustments…."

Thanks to John W. Hager for his patience with my requests and his generous help.

Update

"Existing PNG94 already 21+ years old now (i.e. Possibly past its coming of age) PNG2020? (ITRF2014 at epoch 2020.0) would remove any uncertainty arising from 26 years of earthquakes (coseismic and postseismic deformation). Coordinates closer to current ITRF, but up to 2 m different to PNG94. Requires gridded distortion model for PNG94 to PNG2020 transformations (e.g. legacy data such as DCDB, project datums, GIS data).. 50 Years (and +) of Geodesy in PNG, Richard Stanaway, 2016.

The Association of Surveyors of Papua New Guinea, Inc. has numerous technical papers and notes available for download in pdf format at: http://www.aspng.org/techinfo.htm

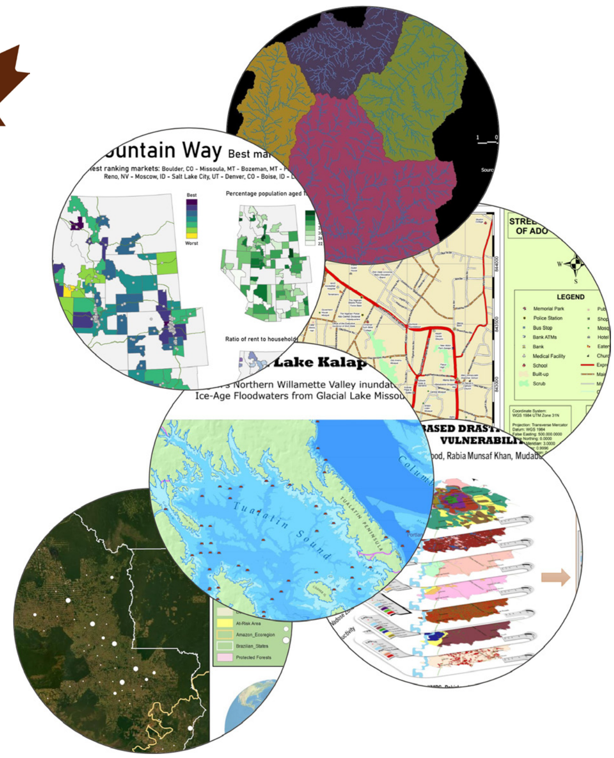
Geodetic and Vertical Datums Used in Papua New Guinea – An Overview
https://www.searchanddiscovery.com/pdfz/documents/2020/70410stanaway/ndx_stanaway.pdf.html

A Semi-Dynamic Geodetic Datum For Papua New Guinea
https://www.semanticscholar.org/paper/A-SEMI-DYNAMIC-GEODETIC-DATUM-FOR-PAPUA-NEW-GUINEA-Stanaway/49f1c8a765a39ddf672da0c89a4109a0b6df9f79

This column was previously published in the March 2005 issue of *PE&RS*.

ASPRS SAC IS FALLING INTO A NEW SCHOOL YEAR!

As we move into the new school year, your Student Advisory Council would like to inform you of some exciting new happenings within the Council: fun events, new members, and more. Make sure you don't miss out on these exciting opportunities!



Exciting Events in November!

- **GIS Day Map Contest**

  Every year the geospatial community celebrates all things GIS and Remote Sensing on GIS Day (November 16th). Your SAC celebrates this special time with a fun, student map contest!

  Submit your best map to the SAC to be voted on! The five maps with the most votes will win fun prizes and bragging rights! Must be a student member of ASPRS to enter. Watch the weekly newsletter or email us at Sac@asprs.org for contest information.

  Need inspiration? Check out the maps and winners from the 2021 contest: https://tinyurl.com/ASPRSSAC2021MAPCONTEST

- **SAC Elections and a New SAC Chair**

  The SAC is currently looking for new Councilors to join our team! Positions include Deputy Chair, Educational & Professional Development Councilor, Deputy Educational & Professional Development Councilor, Communications Councilor, Deputy Communications Councilor, and SAC & ECPC Liaison.

  All ASPRS student members are eligible to be nominated and to vote in the election on November 30. The SAC Elections will take place in a virtual meeting on November 30, 2022. Student members of ASPRS must be present at this virtual meeting to vote! SAC Councilor terms are one year, beginning and ending at the ASPRS Annual Meeting at Geo Week.

  To submit a nomination, please fill out the form here https://tinyurl.com/ASPRSSACVOTE.

  Nominations are due by 11:59 PM Eastern time on November 28, 2022.

  Also, the SAC welcomes the new Chair, Oscar Duran and sincerely thanks outgoing Chair Lauren McKinney-Wise for her service to the SAC and to the ASPRS student community!

- **Student Scholarships**

  ASPRS scholarships are available for students and the application deadline is November 11, 2022! Scholarships will be awarded at the 2023 ASPRS Annual Meeting at Geo Week. The total award pool for the current year is over $40,000. Don't miss out on this amazing opportunity and APPLY. Check out this link for more details: https://www.asprs.org/education/asprs-awards-and-scholarships

---

If you are interested in participating in SAC activities:

Join us via Zoom every other Wednesday from 12–1 pm Pacific Time! To get the Zoom link, email us at sac@asprs.org.

ASPRS STUDENT ADVISORY COUNCIL

OSCAR DURAN COUNCIL CHAIR	TBD EDUCATION & PROFESSIONAL NETWORKING CHAIR	RABIA MUNSAF KHAN COMMUNICATIONS COUNCIL CHAIR
TBD DEPUTY COUNCIL CHAIR	ALI ALRUZUQ EDUCATION & PROFESSIONAL NETWORKING COUNCILOR	KENNETH EKPETERE CHAPTERS COMMITTEE CHAIR
CHUKWUMA JOHN OKOLIE COMMUNICATIONS COUNCIL MEMBER	TESINI PRECIOUS DOMBO COMMUNICATIONS COUNCIL MEMBER	FREDA ELIKEM DORBU COMMUNICATIONS COUNCIL MEMBER

ASPRS ANNUAL ELECTION ANNOUNCMENT

Amendments to the ASPRS Bylaws (www.asprs.org/governance/current_bylaws), adopted by the Board of Directors on July 19, 2022, resulted in changes to annual election procedures. Election balloting will now take place annually between November 1 – 30. Individuals who are elected will be installed at the next Annual Meeting of the Society, which for 2023 will take place in February at Geo Week.

In accordance with the Bylaws, all ballots shall be cast electronically. The upcoming election will be conducted using SurveyMonkey. All Individual Members of the Society in good standing as of November 1 are eligible to vote. Ballots will be sent to the primary email address in each Member's MyASPRS profile. Please take a moment to login and update your profile. If you have any questions or need assistance to login, please contact office@asprs.org.

The Bylaws provide for additional nominations to be presented by petition. The deadline for petitions was October 10, after this edition of *PE&RS* had already gone to the printer. Please review the electronic ballot carefully for possible additional candidates. Full candidate biographies and vision statements will be also included in the electronic ballot. For further description of the duties of the officers and details of the election process, please refer to the ASPRS Bylaws.

See next page for candidates►

NEW ASPRS MEMBERS

ASPRS would like to welcome the following new members!

At Large
Hadi Karimi

Cascadia
Friedrich Knuth
Jack Rosenblit

Eastern Great Lakes
Aaron Michael Gonick
Jian Wang

Florida
Shane Williams

Gulf South
Mathew Abraham Chennikara
Jose Galvan, III
Karla M. Negron Loubriel
Shaun Piepkorn

Northeastern
Christine Bunyon

Pacific Southwest
Glenn Ingram

Potomac
Rachel Hixson
Larry Eldred Kirkpatrick
Steven Painter

Rocky Mountain
Adeoti Basheerah Akinbode-Olalere
Jonathan Stanford Keller
Dennis McCarville
Jared Robertson

Western Great Lakes
Quentin Ikuta
Jae Sung Kim

FOR MORE INFORMATION ON ASPRS MEMBERSHIP, VISIT
HTTP://WWW.ASPRS.ORG/JOIN-NOW

ASPRS ANNUAL ELECTION ANNOUNCMENT *continued*

The candidates for ASPRS Vice President for 2023 are:

Dr. Amr Abd-Elrahman
Associate Professor of Geomatics,
University of Florida

Dr. Caixia Wang
Associate Professor of Geomatics,
University of Alaska, Anchorage

The candidates for Assistant Director of the Primary Data Acquisition Division for 2023–2024 are:

Mike Baranowski
Senior Geospatial Analyst,
Dewberry

Ravi Soneja
Geospatial Services Technician,
Ayres Associates

The candidates for Assistant Director of the Professional Practice Division for 2023–2024 are:

Matthew Elious
Senior Project Manager,
KCI Technologies

Christian Stallings
Director of Operations,
Alynix

The candidates for Assistant Director of the Remote Sensing Applications Division for 2023–2024 are:

Dr. Indumathi Jeyachandran
Assistant Professor of Civil and
Environmental Engineering,
San Jose State University

Dr. Michael Starek
Assistant Professor of GISc
and Geospatial Survey Engineering,
Texas A&M University

Call for *PE&RS* Special Issue Submissions

Innovative Methods for Geospatial Data using Remote Sensing and GIS

Internationally comparable data is a global need for managing resources, monitoring current trends and taking actions for sustainable living. Even though there has been a significant progress on geospatial data availability, extensive data gaps are still a major problem for general assessment and supervise the progress through the years. According to United Nations 2022 The Sustainable Development Goals Report, while health and energy sectors have the highest data available, limited data available for climate action.

The COVID-19 crisis has also shown that there are innovative data collection methods utilizing information and computer technologies. However, only 5% of the countries have benefit from remote sensing technologies to measure the impact of COVID-19. Additionally, novel approaches such as artificial intelligence should be used in conjunction with assessments to make sure they are put to use for critical situations.

The recent developments in remote sensing, geographic information systems and ICT have provided a wide accessibility to create geospatial data for various purposes. The proposed special issue focuses on *"Innovative Methods for Geospatial Data using Remote Sensing and GIS" for wide range of applications. This special issue aims to bring researchers to share knowledge and their expertise about innovative methods to contribute to fill data gaps around the world for a better future.*

The proposed special issue aims to contributes ASPRS's key mission on 'Simplify and promote the use of image-based geospatial technologies for the end-user', 'Promote collaboration between end users and geospatial experts to match data and technology to applications and solutions' and 'promote the transfer of geospatial data and information technology to developing nations' by providing innovative methods to create geospatial data using remote sensing and geographic information systems utilizing state-of-the-art developments and solutions.

Deadline for Manuscript Submission—July 1, 2023

Submit your Manuscript to http://asprs-pers.edmgr.com

Guest Editors

Dr. Tolga Bakirman, bakirman@yildiz.edu.tr , *Yildiz Technical University, Department of Geomatic Engineering*, Davutpasa Campus, 34220 Esenler-Istanbul/Turkey

Dr. George Arampatzis, garampatzis@pem.tuc.gr, *Technical University Crete, School of Production Engineering & Management*, 73100 Chania – Crete/Greece

Development of Technique for Vehicle Specific Off-Road Trafficability Assessment Using Soil Cone Index, Water Index, and Geospatial Data

Sunil Kumar Pundir and Rahul Dev Garg

Abstract
Nowadays, the type of vehicles, either tracked or wheeled in the Army has increased considerably and every decision maker wants the current details of off-road trafficability for operation planning. Therefore, vehicle-specific trafficability maps are the need of the hour. Emphasis should be given on soils capable of bearing the moving load of a vehicle and it is an important factor to be considered. Soil variability in spatial and temporal dimensions affects the assessment of off-road trafficability. Genetically, it is assumed that similar soil types behave similarly at a regional scale to reduce the complexity due to its variability. Remolding Cone Index (RCI) of Soil is the indicator of its capability and for generic solution; its value can be related to gravimetric moisture of soil for getting a general idea. In this paper, a logics-based, new concept has been introduced to rationalize the RCI values of these moist areas. Most significantly, moisture- and water-bound areas play an important role in the assessment of off-road trafficability. Therefore, to cover larger areas, a grid-based approach was taken as a base and, to get a preliminary idea of prevailing moisture, Normalized Difference Water Index was also mapped. Every vehicle has fixed vehicle cone index based on its vehicular characteristics and can be related with RCI for trafficability purpose. This new technique will save time and field work and is immensely useful for the trafficability assessment of any specific vehicle.

Introduction
Off-road trafficability mapping is a very important tool for strategic planning for battlefield operations; therefore, advanced techniques and tools should be developed for its assessment. A technique was developed by using not only soil properties but also other geo-parameters like landform, land use, slope, and moisture. New ways were found out in the form of logics using domain knowledge and complemented by extensive use of advance remote sensing tools. Therefore, trafficability analysis of any particular vehicle was done for a larger area within a limited time and it was the main objective of the present study. Numerous geographic factors are responsible for off-road trafficability (Rybansky 2014). Whereas, to avoid complexity and biasness, a rule-based approach was also used for trafficability assessment by considering only four factors like slope in six ranges (0–7; 8–14; 15–21; 22–28; 29–35, >35°), land use, soil moisture, and soil type (Pundir and Garg 2020b). However, out of four, variability of slope, land use, and soil type are less in spatial and temporal domain and can be extracted precisely with established methods, while soil moisture is highly variable in both domains (Owe *et al.* 1989). It is directly related with weather, water bodies, and its peripheral topography of study area. Soil texture is inversely affected by moisture in the current scenario as the larger the grain size, the lesser is the effect of moisture for off-road trafficability. Trafficability can be assessed with soil remolding cone index (RCI) based on soil characteristics and vehicle cone index (VCI) based on vehicular characteristics (Hubacek *et al.* 2014). A vehicle based experimental study of terrain accessibility was also carried out to assess the obstacles in maneuvering (Jagirdar and Trikande 2019). In an earlier attempt, map overlay was used to prepare desert terrain analog for quantification of desert areas using remote sensing data and methods (Van Lopik and Kolb 1959). Remote sensing-based thematic integration for terrain characterization was also tried for different purposes. In this direction, a way ahead, qualitative trafficability data was converted into various quantitative zones based on assessment of obstacles produced by contributing factors (Pundir and Garg 2020a).

Recent advancement of geographic information systems (GIS) and image processing tools have facilitated the extraction of direct or indirect information in the form of thematic maps or measurement from digital topographic and satellite data. Extracted information depends on the skill and experience of the interpreter to convert the information as per the requirements (Collins 1975). To make the information more specific as per requirement, information from various sources can be integrated with remote sensing techniques (Anderson 1977).

Nowadays, plenty of satellite data in a wide range of spectrum are available and several GIS (Baijal *et al.* 2002; Taloor *et al.* 2020) and image processing software are also available to process the data in desired shape. Initially, efforts were made to improvise the method in terms of speed, precision, and ease (Wright and Burns 1968). A study on unmanned ground vehicles was also done to predict the suitability of terrain for off-road movement (Pokonieczny and Rybanský 2018).

Pioneer work on prediction of seasonal forecasts of mobility using water budget models was also a landmark in this direction (Kennedy *et al.* 1988). A model was also developed between soil strength and soil moisture using generalized relationships (Sullivan *et al.* 1997). Further, estimation of RCI for different soils and its linkage with California Bearing Ratio was established for trafficability (Mason and Baylot 2016).

The Normalized Difference Water Index (NDWI) measures liquid water molecules in vegetation canopies produced with interaction of solar radiation. It is sensitive to changes in the water content and spongy mesophyll in vegetation canopies (Gao 1996). This is conceptualized for the estimation of soil moisture and canopy water content (Jackson *et al.* 2004). Water presence in the area depends upon local climate and soil properties, which in turn can be related with NDWI. This index uses short-wave infrared (SWIR)-1 bands M10, which is sensitive to changes in liquid water. The spectra region having green vegetation is affected by water absorption and can capture information on temporal change of water (Sanchez-Ruiz *et al.* 2014). An empirical relation was also developed to assess the spatial variability of off-road trafficability based on experiments on analogous sites (Pundir and Garg 2021). Meanwhile, an approach was also presented by developing of

Sunil Kumar Pundir is with the Defence Geoinformatics Research Establishment, Defence Research and Development Organization (DRDO), Chandigarh, India (sunilremotesensing@gmail.com).

Rahul Dev Garg is with the Department of Civil Engineering, Indian Institute of Technology, Roorkee, Uttarakhand, India.

Contributed by Petra Helmholz, July 9, 2021 (sent for review April 14, 2022; reviewed by Alper Yilmaz, Atul Kant Piyoosh, Salahuddin M. Jaber).

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 689–697.
0099-1112/22/689–697

doi: 10.14358/PERS.21-00041R3

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

**PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS**

**FOR MORE INFORMATION VISIT
MY.ASPRS.ORG**

PEER-REVIEWED CONTENT IS ONLY AVAILABLE TO ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT MY.ASPRS.ORG

IN-PRESS ARTICLES

Yanzhe Shi, Yumin Tan, Yunxin Li, Bo Xu. Automatic registration method of multi-source point clouds based on building facades matching in urban scenes.

Muhammad Nasar Ahmad, Shao Zhengfeng, Andaleeb Yaseen, Muhammad Nabeel Khalid, Akib Javed. The simulation and prediction of Land Surface Temperature based on SCP and CA-ANN models using Remote sensing data: A case study of Lahore.

Yan Lv, Hongwei Guo, Shuanggen Jin, Lu Wang, Haiyi Bian, and Haijian Liu. Permanganate index variations and factors in Hongze Lake from Landsat-8 images based on machine learning.

Songjing Guo, Xueling Wu, Ruiqing Niu, and Wenfu Wu. Exploring spatiotemporal variations and driving factors of urban comprehensive carrying capacity in the Yangtze River Delta urban agglomeration.

Clement Akumu, Sam Dennis. Exploring the Addition of Airborne Lidar-DEM and Derived TPI for Urban Land Cover and Land Use Classification and Mapping.

Zhigang Deng, Xiwei Fan, Jian Chen. A machine learning method for building height estimation based on Sentinel-2 bi-temporal images.

Ji Won Suh, William B Ouimet. Generation of High-Resolution Orthomosaics from Historical Aerial Photographs using Structure-from-Motion (SfM) and Lidar data.

Muhammad Nasar Ahmad, Zhenfeng Shao, Akib Javed, Fakhrul Islam, Hafiz Haroon Ahmad, Rana Waqar Aslam. The Cellular Automata approach in dynamic modelling of land use change detection and future simulations based on Remote Sensing Data in Lahore Pakistan.

Firat Erdem, Nuri Erkin Ocer, Dilek Kucuk Matci, Gordana Kaplan, Ugur Avdan. Apricot Tree Detection from UAV-Images Using Mask R-CNN and U-Net.

Batuhan Sariturk, Damla Kumbasar, Dursun Zafer Seker. Comparative Analysis of Different CNN Models for Building Segmentation from Satellite and UAV Images.

The Use of Indices and Modified U-Net Network in Improving the Classification of Planting Structures

Weidong Li, Fanqian Meng, Linyan Bai, Yongbo Yu, Inam Ullah, Jinlong Duan, and Xuehai Zhang

Abstract

It was difficult to accurately obtain crop planting structure by using the spectral information of high spatial resolution and low spatial resolution multispectral images of panchromatic images at the same time. In this paper, we propose a method of planting structure extraction based on indices and an improved U-Net semantic segmentation network. Based on the original band of Landsat-8, we used an image fusion algorithm to highlight the characteristics of vegetation, water, and soil respectively by three indices added, and the improved U-Net network was used to classify the type of planting structure. The results showed that the overall accuracy of classification was more than 91.6%, and the accuracy of crops was up to 93.8%. Automated water extraction index in image fusion effectively improved the classification accuracy. This method could extract a variety of information about planting structures automatically and accurately. It provided theoretical support for adjusting and optimizing regional planting structures.

Introduction

The classification of crop planting structures based on remote sensing has the capabilities of large-area detections and rapid imaging. This type of classification is a high-tech method used to quickly determine the crop planting structure. In recent years, high-spatial resolution remote sensing satellites have developed rapidly (Wardlow and Egbert 2008; Xiong and Huang 2009; Xu *et al.* 2014; Zhang *et al.* 2014). High-spatial resolution remote sensing images can be used as data sources to more accurately detect crop planting structures (Bai *et al.* 2019; Baojia *et al.* 2019; Shuang 2018; Xiong and Zhang 2019). Traditional methods such as decision tree classifications and normalized difference vegetation index (NDVI) curves can extract only shallow features and cannot integrate multiple source images, making it impossible to effectively improve the accuracy when obtaining planting structure information (Lin *et al.* 2018; Shu-Kui *et al.* 2016; Yang *et al.* 2018). The traditional technique of remote sensing image classification firstly requires feature extraction such as texture and geometry of the ground object target (Wang 1990), and then carries out classification calculation. However, this classification method relies on feature representation, expert knowledge, and weak generalization ability, so it cannot be applied to complex large samples of high-resolution remote sensing images (Atkinson *et al.* 2000; Li *et al.* 2014).

With the development of machine learning, neural networks (NNs) (Pacifici *et al.* 2009), support vector machines (Huang and Zhang 2013), and other algorithms have been applied to classify high-resolution remote sensing images. Nevertheless, these are all shallow learning algorithms and cannot express complex functions well (Ball *et al.* 2017; Yang *et al.* 2017; Yuan *et al.* 2017). Therefore, these models cannot adapt to the semantic segmentation problems with large sample sizes and high complexities (Zhang *et al.* 2016). Convolutional neural networks (CNNs) have the advantages of automatic feature extraction and automatic classification, and they show significant benefits when analyzing remote sensing data (Mou *et al.* 2018a Zhao *et al.* 2017; Zhu *et al.* 2018). As critical network models in semantic segmentation research, fully convolutional neural networks (FCNs) are widely used for high-resolution remote sensing images (Fu *et al.* 2017; Long *et al.* 2015; Mou *et al.* 2018b; Shrestha *et al.* 2018). Many scholars have transformed and developed FCNs, creating a series of convolution-based segmentation models, including SegNet (Badrinarayanan *et al.* 2017), U-Net (Ronneberger *et al.* 2015), DeepLab (Chen *et al.* 2018), multi-scale FCN (Lin *et al.* 2017), among which U-Net can achieve the highest number of samples with predicted results (Flood *et al.* 2019; Haiou *et al.* 2019; Nakai *et al.* 2020; Xu *et al.* 2020; Yue *et al.* 2019). In recent years, researchers have also proposed integrating long short-term memory networks into the U-Net structure to enhance temporal information between diachronic images (Shi *et al.* 2021). In addition, a mapping network (CASNet) is constructed through a deep context-aware sub-pixel to better preserve the geometric structures in the data (He *et al.* 2022).

The subtle features of some planting structures are only visible on high-resolution panchromatic images (PANs) of the corresponding spectral images. These features are challenging to recognize using low-spatial-resolution multispectral images (MSIs). When using traditional methods to classify spectral images, it is challenging to make full use of the high spatial resolutions of PANs and the rich spectral information of MSIs to accurately obtain crop planting structures. At present, the commonly used image fusion methods are hue, luminance, and saturation transformation, Gram-Schmidt transformation (GS), principal component analysis, the nearest-neighbor diffusion fusion algorithm (NND), the UNB fusion algorithm (UNB), wavelet transform (WT), etc. The image spectral fidelity after GS fusion is high (Chen *et al.* 2019; Jiwei *et al.* 2017; Sun *et al.* 2014; Yalan *et al.* 2018; Yang *et al.* 2018), so this paper uses the GS fusion method for the image fusions.

The above research mainly used a single-spatial-resolution data source to select training images. In order to classify single crops and other ground objects, the methods of crop classification based on deep learning mostly adopt binary classification algorithms (Gilcher *et al.* 2019). Based on the above-mentioned research, indices are seldom used to increase spectral complexity (Bouguettaya *et al.* 2022), resulting in serious misclassification in marginal areas. In this paper, we propose a combined index and image fusion approach to optimize the classification of hybrid regions and improve the image spectral

Weidong Li, Yongbo Yu, Inam Ullah, Jinlong Duan, and Xuehai Zhang are with College of Information Science and Engineering, Henan University of Technology, Zhengzhou 450001, China (wdli@haut.edu.cn).

Fanqian Meng is with College of Marine Technology, Faculty of Information Science and Engineering, Ocean University of China, Qingdao 266100, China.

Linyan Bai is Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094.

Contributed by Hongyan Zhang, January 21, 2022 (sent for review July 11, 2022; reviewed by Man Liu, Qian Shi).

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 699–706.
0099-1112/22/699–706

doi: 10.14358/PERS.22-00032R2

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT IS ONLY AVAILABLE TO ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

**PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS**

**FOR MORE INFORMATION VISIT
MY.ASPRS.ORG**

Managing Earth Hazards Using the Deep Reinforcement Learning Algorithm for the Industrial Internet of Things Network

Weiwei Liu

Abstract

Wireless networks using resource management with the enormous number of Internet of Things (IoT) users is a critical problem in developing networks for the fifth generation. The primary aim of this research is to optimize the use of IoT network resources. Earth surface features can be identified and their geo-biophysical properties estimated using radiation as the medium of interaction in remote sensing techniques (RST). Deep reinforcement learning (DRL) has significantly improved traditional resource management, which is challenging to model. The Industrial Internet of Things (IIoT) network has to be carried out in real time with excess network resources. Conventional techniques have a significant challenge because of the extensive range and complexity of wireless networks. The DRL method has been used in several areas, including management and allocation of resources, dynamic channel access, mobile downloading, unified edge computing, caching and communication, and fog radio access networks. DRL-IIoT is more successful than the Q-learning technique for a single agent. The design and analysis of the DRL-based approach in stationary base stations to solve the typical assignment of resources issues have been mostly restricted. The DRL is used as a clustering technique to construct the primary model of the system with k-means. This article discusses optical and microwave sensors in RST techniques and applications, examines the areas where there are gaps, and discusses Earth hazards. Furthermore, a comprehensive resource-based strengthening learning system is developed to ensure the best use of resources. Simulation results show that the suggested method efficiently (97.24%) allocates available spectrum, cache, and computer resources to deep deterministic policy gradient benchmarks.

Overview of Resource Management Using Deep Reinforcement Learning

In resource management, deep learning approaches in Internet of Things (IoT) networks are applied in resource management (Amudha 2021). Machine learning– and deep learning–based resource management in wireless IoT environments is currently available between communications and networks (Shakeel *et al.* 2020). The directions in the use of the deployment and management of these resources plays an important role in IoT networks (Pham *et al.* 2020). The blending of the physiological, virtual, and natural realms is referred to as the fourth industrial revolution. Three-dimensional printing, genetic modification, and quantum entanglement are a few of the cutting-edge technologies that have come together to form this powerful new tool for monitoring Earth hazards with remote sensing techniques (RST).

When many devices use a communication path at the same time, a channel can become overloaded (Gao *et al.* 2020a). As IoT devices proliferate, they pose new issues in terms of congestion control, smart device networking and storage architecture, and effective data exchange protocol design (Manogaran *et al.* 2018). IoT device access channel bottlenecks can be alleviated using various access probability and targeting distinct connected devices (Elgendy *et al.* 2021). Resources for cellular distributed systems require resource sharing and access control methods to support larger bandwidths or connections with various network resources (Jan *et al.* 2020). The existing problems resulting from deep reinforcement learning (DRL) significantly improved traditional resource management, which is challenging to model (Gunasekaran and Narayanasamy 2018). It is becoming increasingly difficult for information technology professionals to keep up with the increasing number of devices in use, which necessitates a lot of time-consuming day-to-day tasks to monitor hazards by RST methods. The Industrial Internet of Things (IIoT) network has to be carried out in real time with excess network resources. Using low-cost IoT devices for reliable unsupervised localization is difficult (Shakeel *et al.* 2018). As a result, this study provides an unsupervised wireless-location approach based on DRL (Ranjan *et al.* 2020). DRL-based distributed control planning performed effectively in an observable IIoT scenario (Gao *et al.* 2020b). The major goal of this article is to highlight the methods for enhancing the IIoT using machine learning (Abdel-Basset *et al.* 2019). Deep learning manages resource approaches in IoT networks, which use deep learning. It is currently possible to use machine learning– and deep learning–based resource management in wireless RST environments. In monitoring Earth hazards, these resources can be deployed and managed in various ways.

Mobile networks with wide coverage are becoming increasingly important for the IIoT to achieve the goal of the fourth industrial revolution (Abd EL-Latif *et al.* 2020). In general, the 5G wireless mesh network will serve as a unifying network, connecting billions of IIoT devices to support sophisticated IIoT operations (Awuson-David *et al.* 2021). This research describes a distributed Q-learning supported channel assignment technique for two distinct IIoT networks (Chi *et al.* 2015). The quality of service of femtocell and conventional cellular blockchain-based IoT gear or impartiality is considered when building incentive functions (Bachmann *et al.* 2018). Fixed and dynamic learning rates and various types of multivalent cooperation modes are examined (Ren and Bao 2020). DRL is used as a clustering technique to construct the primary model of the system with k-means (Ding *et al.* 2020). In the sphere of wireless sensor networks, minimizing network delay and increasing network longevity are always major concerns (Yassine *et al.* 2020). Data, information, and physical hardware that can be easily reached from a remote computer via a local area network or corporate intranet are known as shared resources to monitor hazards by RST methods.

In this research, the cell outage situation in ultradense networks (UDN) aims to improve customers' throughput even while maintaining service quality criteria for each mobile user (Zhang *et al.* 2020). The k-means clustering approach assigns compensated users to neighbors and then uses a deep neural network to estimate the implementation

Weiwei Liu is with the School of Computer Science, Wuhan University, Wuhan 430072, People's Republic of China (wwliu2022@126.com).

Contributed by Priyan M K, January 18, 2022 (sent for review February 23, 2022; reviewed by Sarala V, Rinesh Sahadevan, Mohamed A S Doheir, Sundar Raj A).

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 707–714.
0099-1112/22/707–714

doi: 10.14358/PERS.22-00011R3

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

New Generation Hyperspectral Sensors DESIS and PRISMA Provide Improved Agricultural Crop Classifications

Itiya Aneece and Prasad S. Thenkabail

Abstract

Using new remote sensing technology to study agricultural crops will support advances in food and water security. The recently launched, new generation spaceborne hyperspectral sensors, German DLR Earth Sensing Imaging Spectrometer (DESIS) and Italian PRecursore IperSpettrale della Missione Applicativa (PRISMA), provide unprecedented data in hundreds of narrow spectral bands for the study of the Earth. Therefore, our overarching goal in this study was to use these data to explore advances that can be made in agricultural research. We selected PRISMA and DESIS images during the 2020 growing season in California's Central Valley to study seven major crops. PRISMA and DESIS images were highly correlated (R^2 of 0.9–0.95). Out of the 235 DESIS bands (400–1000 nm) and 238 PRISMA bands (400–2500 nm), 26 (11%) and 45 (19%) bands, respectively, were optimal to study agricultural crops. These optimal bands provided crop type classification accuracies of 83–90%. Hyperspectral vegetation indices to estimate plant pigment content, stress, biomass, moisture, and cellulose/lignin content were also identified.

Introduction

Twenty-first century remote sensing calls for increased use of data from hyperspectral sensors to advance the study of agricultural crop characteristics. In the past, this advance has been hindered by the lack of availability of spaceborne hyperspectral data covering the planet. The Hyperion Earth Observing-1 (EO-1) sensor was the first spaceborne hyperspectral sensor with publicly available data that provided significant insights into the possibilities of great scientific advances in the study of agricultural crops and vegetation (Bannari *et al.* 2015; Bhojaraja *et al.* 2015; Breunig *et al.* 2011; Houborg *et al.* 2016; Lamparelli *et al.* 2012; Moharana and Dutta 2016; Pan *et al.* 2013; Sonmez and Slater 2016; Thenkabail *et al.* 2013). EO-1 acquired over 70 000 images of the Earth from the year 2001 through 2015 in 242 narrow spectral bands in the 400–2500 nm spectral range (Aneece and Thenkabail 2018). This acquisition was a quantum leap in spectral data relative to multispectral broadband data acquired in a few broad bands such as from Landsat, Moderate Resolution Imaging Spectroradiometer (MODIS), *Satellite pour l'Observation de la Terre* (*SPOT*), and the *Indian Remote Sensing* (*IRS*) series of satellites (Mariotto *et al.* 2013; Marshall and Thenkabail 2015). However, the recent launch of advanced spaceborne hyperspectral sensors such as the Italian PRecursore IperSpettrale della Missione Applicativa (PRISMA) and the German Deutsches Zentrum für Luft- und Raumfahrt (DLR) Earth Sensing Imaging Spectrometer (DESIS) onboard the International Space Station (ISS) has opened up a new dimension in remote sensing by offering hundreds of hyperspectral narrowbands (HNB) along the electromagnetic spectrum (Heiden *et al.* 2019; Loizzo *et al.* 2016; Lu *et al.* 2020). PRISMA acquires data from 400 to 2500 nm and DESIS from 400 to 1000 nm (Table 1) and both acquire data as near-continuous HNB, generating a "spectral signature" rather than a few "data points" as acquired by broadband sensors (Heiden *et al.* 2019; Loizzo *et al.* 2016). In addition, a number of spaceborne hyperspectral sensors were recently launched, such as Germany's Environmental Mapping and Analysis Program (EnMAP) (EnMAP 2022), or planned for launch in the coming years, such as the United States' National Aeronautics and Space Administration (NASA) Surface Biology and Geology (SBG) mission (SBG 2022).

Table 1. Characteristics of hyperspectral data used in this study: Deutsches Zentrum für Luft- und Raumfahrt (DLR) Earth Sensing Imaging Spectrometer (DESIS) and PRecursore IperSpettrale della Missione Applicativa (PRISMA) (Heiden *et al.* 2019; Loizzo *et al.* 2016).

	DESIS	PRISMA
Sensor Type	Spaceborne, on ISS	Spaceborne, polar-orbiting
Spectral Range	400 to 1000 nm	400 to 2500 nm
Number of Bands	235	238
Spectral Resolution	2.55 nm	≤12 nm
Spatial Resolution	30 m	30 m; 5 m for panchromatic band
Signal to Noise Ratio (@ 550 nm)	205	200
Radiometric Resolution	13-bit	12-bit
Swath Width	30 km	30 km

ISS = International Space Station.

DESIS Hyperspectral Data

The German Aerospace Center (formerly DLR) partnered with Teledyne Brown Engineering to design the DLR Earth Sensing Imaging Spectrometer (DESIS) (Heiden *et al.* 2019; Krutz *et al.* 2019; Peschel *et al.* 2018). It is mounted on the Multi-User System for Earth Sensing (MUSES) platform on the International Space Station (ISS) (Heiden *et al.* 2019). Since the sensor is mounted on the ISS, its coverage depends on the overpasses of the ISS which has a non–sun-synchronous and varied orbit, with no repeat cycle (Heiden *et al.* 2019). Despite the challenges of the variable orbit and collection environments, the cost-savings of mounting DESIS on the ISS are substantial (Krutz *et al.* 2019). Since it is unable to point at the sun, moon, or deep space for calibration, DESIS has in-orbit spectral calibration and in-orbit radiometric calibration (Krutz *et al.* 2019). Because of the push broom mechanism, DESIS data are affected by a low smile effect of 1.7 pixels and an even lower keystone effect of 0.3 pixel across the entire field of view and spectral range (Krutz *et al.* 2019). For details on smile, keystone, striping, and rolling shutter corrections, refer to Alonso *et al.* (2019).

DESIS has 235 bands along a spectral range from 400 nm to 1000 nm (Heiden *et al.* 2019; Krutz *et al.* 2019). It has a spectral resolution of

US Geological Survey, Western Geographic Science Center, 2255 N. Gemini Rd., Flagstaff, AZ 86001 (ianeece@usgs.gov).

Contributed by Ahmed Abd El-Latif, February 5, 2022 (sent for review May 23, 2022; reviewed by Michael J. Campbell, Xun Geng).

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 715–729.
0099-1112/22/715–729

doi: 10.14358/PERS.22-00039R2

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

**PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS**

**FOR MORE INFORMATION VISIT
MY.ASPRS.ORG**

PEER-REVIEWED CONTENT IS ONLY AVAILABLE TO ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT IS ONLY AVAILABLE TO ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

SUSTAININGMEMBERS

ACI USA Inc.
Weston, Florida
https://acicorporation.com/
Member Since: 2/2018

Aerial Services, Inc.
Cedar Falls, Iowa
www.AerialServicesInc.com
Member Since: 5/2001

Airworks Solutions Inc.
Boston, Massachusetts
Member Since: 3/2022

Applanix
Richmond Hill, Ontario, Canada
http://www.applanix.com
Member Since: 7/1997

Ayres Associates
Madison, Wisconsin
www.AyresAssociates.com
Member Since: 1/1953

CT Consultants
Mentor, Ohio
Member Since: 3/2022

Dewberry
Fairfax, Virginia
www.dewberry.com
Member Since: 1/1985

Esri
Redlands, California
www.esri.com
Member Since: 1/1987

GeoCue Group
Madison, Alabama
http://www.geocue.com
Member Since: 10/2003

Geographic Imperatives LLC
Centennial, Colorado
Member Since: 12/2020

GeoWing Mapping, Inc.
Richmond, California
www.geowingmapping.com
Member Since: 12/2016

Halff Associates, Inc.
Richardson, Texas
www.halff.com
Member Since: 8/2021

Keystone Aerial Surveys, Inc.
Philadelphia, Pennsylvania
www.kasurveys.com
Member Since: 1/1985

Kucera International
Willoughby, Ohio
www.kucerainternational.com
Member Since: 1/1992

L3Harris Technologies
Broomfield, Colorado
www.l3harris.com
Member Since: 6/2008

Merrick & Company
Greenwood Village, Colorado
www.merrick.com/gis
Member Since: 4/1995

Nearmap
South Jordan, Utah
www.nearmap.com
Member Since: 6/2023

NV5 Geospatial
Sheboygan Falls, Wisconsin
www.quantumspatial.com
Member Since: 1/1974

Pickett and Associates, Inc.
Bartow, Florida
www.pickettusa.com
Member Since: 4/2007

Riegl USA, Inc.
Orlando, Florida
www.rieglusa.com
Member Since: 11/2004

Robinson Aerial Surveys, Inc.(RAS)
Hackettstown, New Jersey
www.robinsonaerial.com
Member Since: 1/1954

Sanborn Map Company
Colorado Springs, Colorado
www.sanborn.com
Member Since: 10/1984

Surdex Corporation
Chesterfield, Missouri
www.surdex.com
Member Since: 12/2011

Surveying And Mapping, LLC (SAM)
Austin, Texas
www.sam.biz
Member Since: 12/2005

T3 Global Strategies, Inc.
Bridgeville, Pennsylvania
https://t3gs.com/
Member Since: 6/2020

Terra Remote Sensing (USA) Inc.
Bellevue, Washington
www.terraremote.com
Member Since: 11/2016

Towill, Inc.
San Francisco, California
www.towill.com
Member Since: 1/1952

Woolpert LLP
Dayton, Ohio
www.woolpert.com
Member Since: 1/1985

SUSTAININGMEMBER**BENEFITS**

Membership

- ✓ Provides a means for dissemination of new information
- ✓ Encourages an exchange of ideas and communication
- ✓ Offers prime exposure for companies

Benefits of an ASPRS Membership

- Complimentary and discounted Employee Membership*
- E-mail blast to full ASPRS membership*
- Professional Certification Application fee discount for any employee
- Member price for ASPRS publications
- Discount on group registration to ASPRS virtual conferences
- Sustaining Member company listing in ASPRS directory/website
- Hot link to company website from Sustaining Member company listing page on ASPRS website
- Press Release Priority Listing in *PE&RS* Industry News
- Priority publishing of Highlight Articles in *PE&RS* plus, 20% discount off cover fee
- Discount on *PE&RS* advertising
- Exhibit discounts at ASPRS sponsored conferences (exception ASPRS/ILMF)
- Free training webinar registrations per year*
- Discount on additional training webinar registrations for employees
- Discount for each new SMC member brought on board (Discount for first year only)

Foreground-Aware Refinement Network for Building Extraction from Remote Sensing Images

Zhang Yan, Wang Xiangyu, Zhang Zhongwei, Sun Yemei, and Liu Shudong

Abstract

To extract buildings accurately, we propose a foreground-aware refinement network for building extraction. In particular, in order to reduce the false positive of buildings, we design the foreground-aware module using the attention gate block, which effectively suppresses the features of nonbuilding and enhances the sensitivity of the model to buildings. In addition, we introduce the reverse attention mechanism in the detail refinement module. Specifically, this module guides the network to learn to supplement the missing details of the buildings by erasing the currently predicted regions of buildings and achieves more accurate and complete building extraction. To further optimize the network, we design hybrid loss, which combines BCE loss and SSIM loss, to supervise network learning from both pixel and structure layers. Experimental results demonstrate the superiority of our network over state-of-the-art methods in terms of both quantitative metrics and visual quality.

Introduction

Building extraction aims to localize and segment the buildings in the remote sensing image. Specifically, it divides the image pixels into the foreground and background, that is, buildings and nonbuildings. Building extraction from remote sensing images plays an important role in the fields of urban planning, population estimation, land utilization analysis, building change detection, and so on. Recently, with the rapid development of deep learning methods and remote sensing technologies, significant progress has been made in building extraction.

The existing building extraction methods are divided mainly into two groups: traditional and deep learning–based methods. Traditional methods mainly rely on the handcrafted low-level features and heuristic priors, such as color (Sirmacek and Unsalan 2008), shadow (Ngo *et al.* 2016), shape (Zhang *et al.* 2017), edge (Ferraioli 2009), texture (Awrangjeb *et al.* 2011), and spectrum (Zhong *et al.* 2008). However, these features not only require prior professional knowledge but also are easily affected by sensors, imaging conditions, and position changes, which may limit their generalizability in different scenarios.

In recent years, the convolutional neural network (CNN) has boosted the development of computer vision tasks, such as object detection (Tian *et al.* 2019; Yang *et al.* 2019), saliency detection (Qin *et al.* 2019; Chen, Tan, *et al.* 2020; Chen, Xu, *et al.* 2020), semantic segmentation (Oktay *et al.* 2018; Huang *et al.* 2020; Zheng *et al.* 2020), building extraction, and building change detection. Compared to the traditional method, CNN has successfully broken the limits of traditional handcrafted features and has made remarkable achievements with its powerful feature extraction and presentation ability. Especially, the fully convolutional neural network (FCN) (Long *et al.* 2015) has attracted increasing interest in pixel-level dense estimation tasks, such as semantic segmentation, saliency detection, and building extraction. Compared with the original CNN, FCN not only supports dense estimates but also enables end-to-end training. Although existing networks have improved the accuracy, the complexity of remote sensing images still leads to some problems in building extraction.

On the one hand, the background of remote sensing image is complex, and the scale of buildings is different, which makes it difficult to extract buildings accurately. To resolve this problem, most of the algorithms use multi-cascade methods to extract targets. However, these approaches may introduce noise from the background remaining in the shallower layer, resulting in the over-segmentation of buildings. This leads to the first question: how to suppress noisy information while improving the sensitivity of the model to the foreground buildings so as to reduce the false positives of buildings.

On the other hand, the response values of different regions of remote sensing images are different. Most existing networks tend to learn regions that have high response values and ignore regions with low response values, which makes it difficult to capture complete information about building boundaries and building regions. Hence, the second question is how to enhance detailed information in order to make the building extraction results more complete.

To address the above problems, we propose a novel foreground-aware refinement network for building extraction called FAR-Net, which achieves accurate building extraction with high-quality boundaries.

The main contributions of this work are the following:

- We propose a foreground-aware refinement network for more accurate building extraction. Extensive experiments demonstrate that the proposed method achieves state-of-the-art results on both WHU and Inria data sets.
- We propose the foreground-aware module to improve the sensitivity of the network to the foreground pixel. It is composed of attention gate blocks, which allow our network to select the spatial features by the gating signal and further suppress background information in nonbuilding regions. Through this module, the network enhances the sensitivity of the building and reduces the false positive of buildings.
- We design the detail refinement module to guide network learning based on the reverse attention mechanism. This module focuses on the undetected regions and aggregates more detailed features, which leads to higher completeness and accuracy of the details of building boundaries and regions.

Related Work

Traditional methods rely on handcrafted features, which require experienced professionals and a large number of material resources. The emergence of deep learning achieves automatic extraction and learning

Zhang Yan is with the School of Computer and Information Engineering, Tianjin Chengjian University, Tianjin, China, and the Tianjin Intelligent Elderly Care and Health Service Engineering Research Center, Tianjin, China.

Wang Xiangyu, Zhang Zhongwei, and Sun Yemei are with the School of Computer and Information Engineering, Tianjin Chengjian University, Tianjin, China (gucaszzw@163.com).

Liu Shudong is with the School of Computer and Information Engineering, Tianjin Chengjian University, Tianjin, China, and the Tianjin Intelligent Elderly Care and Health Service Engineering Research Center, Tianjin, China.

Contributed by Ahmed Abd El-Latif, February 5, 2022 (sent for review May 23, 2022; reviewed by Michael J. Campbell, Xun Geng).

Photogrammetric Engineering & Remote Sensing
Vol. 88, No. 11, November 2022, pp. 731–738.
0099-1112/22/731–738

doi: 10.14358/PERS.21-00081R2

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT IS ONLY AVAILABLE TO ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT IS ONLY AVAILABLE TO ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

PEER-REVIEWED CONTENT
IS ONLY AVAILABLE TO
ASPRS MEMBERS AND SUBSCRIBERS

FOR MORE INFORMATION VISIT
MY.ASPRS.ORG

*quantity depends on membership level

PE&RS 2023 Advertising Rates & Specs

THE MORE YOU ADVERTISE THE MORE YOU SAVE! *PE&RS* offers frequency discounts. Invest in a three-times per year advertising package and receive a 5% discount, six-times per year and receive a 10% discount, 12-times per year and receive a 15% discount off the cost of the package.

	Sustaining Member Exhibiting at a 2023 ASPRS Conference	**Sustaining Member**	**Exhibitor**	**Non Member**
All rates below are for four-color advertisments				
Cover 1	$1,850	$2,000	$2,350	$2,500
In addition to the cover image, the cover sponsor receives a half-page area to include a description of the cover (maximum 500 words). The cover sponsor also has the opportunity to write a highlight article for the journal. Highlight articles are scientific articles designed to appeal to a broad audience and are subject to editorial review before publishing. The cover sponsor fee includes 50 copies of the journal for distribution to their clients. More copies can be ordered at cost.				
Cover 2	$1,500	$1,850	$2,000	$2,350
Cover 3	$1,500	$1,850	$2,000	$2,350
Cover 4	$1,850	$2,000	$2,350	$2,500
Advertorial	1 Complimentary Per Year	1 Complimentary Per Year	$2,150	$2,500
Full Page	$1,000	$1,175	$2,000	$2,350
2 page spread	$1,500	$1,800	$3,200	$3,600
2/3 Page	$1,100	$1,160	$1,450	$1,450
1/2 Page	$900	$960	$1,200	$1,200
1/3 Page	$800	$800	$1,000	$1,000
1/4 Page	$600	$600	$750	$750
1/6 Page	$400	$400	$500	$500
1/8 Page	$200	$200	$250	$250
Other Advertising Opportunities				
Employment Promotion	$500 (30 day web + 1 email) $300 (30 day web)	$500 (30 day web + 1 email) $300 (30 day web)	$500 (30 day web + 1 email) $300 (30 day web)	$500 (30 day web + 1 email) $300 (30 day web)
Dedicated Content Email blast	$3000	$3000	$3000	$3000
Newsletter Display Advertising	1 Complimentary Per Year	1 Complimentary Per Year	$500	$500
PE&RS Digital Edition Announcement E-Mail	$1000	$1000	$1000	$1000

A 15% commission is allowed to recognized advertising agencies

Ad Size	**Width**	**Height**
Cover (bleed only)	8.625"	11.25"
Full Page (bleed)	8.625"	11.25"
Full Page (trim)	8.375"	10.875"
2/3 Page Horizontal	7.125"	6.25"
2/3 Page Vertical	4.58"	9.625"
1/2 Page Horizontal	7.125"	4.6875"
1/2 Page Vertical	3.4375"	9.625"
1/3 Page Horizontal	7.125"	3.125"
1/3 Page Vertical	2.29"	9.625"
1/4 Page Horizontal	7.125"	2.34"
1/4 Page Vertical	3.4375"	4.6875"
1/8 Page Horizontal	7.125"	1.17"
1/8 Page Vertical	1.71875"	4.6875"

- Publication Size: 8.375" × 10.875" (W x H)
- Live area: 1/2" from gutter and 3/8" from all other edges
- No partial page bleeds
- Publication Style: Perfect bound
- Printing Method: Web offset press
- Software Used: PC InDesign
- Supported formats:
  TIFF, EPS, BMP, JPEG, PDF, PNG
  PC InDesign, Illustrator,
  and Photoshop

Send ad materials to:
Rae Kelley
rkelley@asprs.org

Ship inserts to:
Alicia Coard
Walsworth
2180 Maiden Lane
St. Joseph, MI 49085
888-563-3220 (toll free)
269-428-1021 (direct)
269-428-1095 (fax)
alicia.coard@walsworth.com

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" × 11 1/4", Trim: 8 3/8" × 10 7/8"

PRICING

	Sustaining Member Exhibiting at a 2023 ASPRS Conference	Sustaining Member	Exhibitor	Non Member
Cover 1	$1,850	$2,000	$2,350	$2,500

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.

Vendor Seminars	
Fee	$2,500 (no discounts)

DIGITAL ADVERTISING OPPORTUNITIES

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.

Employment Opportunity	Net Rate
30-Day Web + 1 email	$500/opportunity
Web-only (no email)	$300/opportunity

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%**

Newsletter vertical banner ad	Net Rate
180 pixels x 240 pixels max	$500/opportunity

DEDICATED CONTENT EMAIL BLAST

Send a dedicated email blast to the ASPRS email list. Advertiser supplies HTML (including images). Lead time: 14 days.

Materials	Net Rate
Advertiser supplies HTML, including images.	$3000/ opportunity

PE&RS Digital Edition

Digital Edition Announcement E-Mail: 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.

Digital Edition Opportunities	Net Rate
E-mail Blast Sponsorship*	$1,000