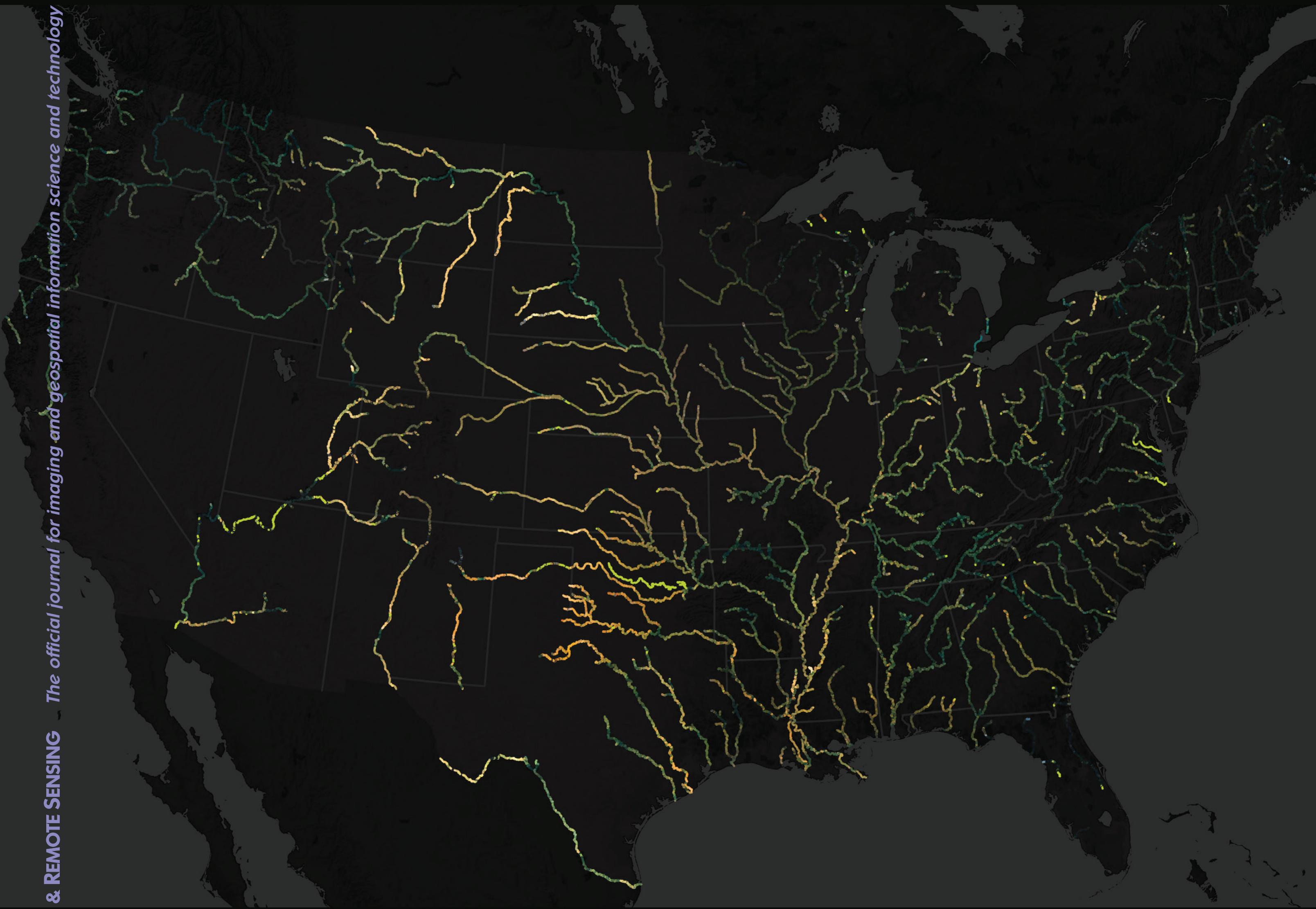
PE&RS

January 2022 Volume 88, Number 1



The official journal for imaging and geospatial information science and technology

Photogrammetric Engineering & Remote Sensing

ASPRS 2022 Annual Conference at Geo Week in Denver, CO, February 6 - 8, 2022

In 2022, ASPRS will transition back to a traditional face-to-face conference format as part of Geo Week 2022. However, we realized that our virtual ASPRS conference in 2021 reached many attendees and presenters who, regardless of COVID, would not be able to take part in Geo Week due to travel or cost constraints. Therefore, we are holding our 2022 ASPRS Annual Conference in two parts.

The February 6-8, 2022, conference in Denver, Colorado will be a live, in-person event. It will not be broadcast or recorded. Attendees can participate in:

- ASPRS technical sessions consisting of individual presentations, panel discussions, and a poster gallery
- ASPRS 2-hour and 4-hour workshops
- Shared Geo Week exhibit hall and social networking functions
- ASPRS Board of Directors, Council, Division, and Committee meetings
- ASPRS Annual Business Meeting, including
  o Presentation of ASPRS Awards and Scholarships
  o Installation of Officers
- Past Presidents and ASPRS Foundation Board of Trustees meetings (by invitation)
- Student and Early Career Professional Mentoring and Networking

ASPRS 2022 Virtual Technical Program online, March 21 - 25, 2022

A live webinar event consisting of oral presentations, panel discussions, and an online poster gallery. This event will be recorded and made available on-demand.

For information on registering and presenting visit **https://my.asprs.org/2022conference**

For additional information or questions, contact programs@asprs.org.

Photo by Andrew Coop on Unsplash

ASPRS 2022 Annual Conference Workshops

At Geo Week | February 6-8, 2022 | Denver, CO, USA

Aerial Triangulation and Data Processing for the Unmanned Aerial System (UAS)

Dr. Qassim Abdullah, PhD, CP, PLS, Vice President/Chief Scientist, *Woolpert, Inc.*
Dr. Riadh Munjy, Professor, *California State University*, Fresno

This workshop teaches participants to successfully design, plan and execute an aerial mission using unmanned aerial systems (UAS) and GPS-based aerial triangulation, including flight planning, ground control placement, camera calibration, and product generation. Participants will be introduced to mathematical basis of simultaneous bundle block adjustment.

February 6th, 8:00 AM to 12:15 PM Cost: $250

Fundamentals of Image Analysis in Google Earth Engine

Dr. Ge (Jeff) Pu, PhD, CMS, *NOAA Great Lakes Environmental Research Laboratory and Cleveland Water Alliance*

This workshop will provide an interactive exploration of Google Earth Engine (GEE) capabilities with examples of projects demonstrating the use of GEE in education undergraduate research and outreach followed by more advanced topics of GEE that includes image processing widget use and app building using an API based coding environment. Each participant will get at least 4 GEE activities for classroom use and several GEE API scripts that the participants can modify for their own use. The 4 activities will include image classification and accuracy assessment, image shadow detection and removal, time series analysis, advanced script sharing and app development.

Special Requirements: Laptop with WiFi Capability.

February 6th, 8:00 AM to 12:15 PM Cost: $250

Preparation for ASPRS Certification

Youssef Kaddoura, PhD Candidate/Research Scientist, *University of Florida*

In this workshop, attendees will review fundamental knowledge areas covered by ASPRS certification exams (photogrammetry, remote sensing, GIS, lidar, and UAS).

February 6th, 8:00 AM to 12:15 PM Cost: $250

Airborne Topobathy Lidar — Principles and Applications

Amar Nayeghandi, Senior Vice President, *Dewberry*
Nick Kules, Senior Geospatial Technology Manager, *Dewberry*
Christopher Parrish, Associate Professor, *Oregon State University*

Airborne laser (or lidar) bathymetry (ALB) is a technique for measuring depths of nearshore coastal waters, lakes, and rivers from a low-altitude aircraft, typically using using a scanning, pulsed laser beam. Based on three decades of operations, ALB has proven to be an accurate, cost-effective, rapid, safe, and flexible method for surveying in shallow water and on coastlines where sonar systems are less efficient and can even be dangerous to operate. This seminar will cover the principles and applications of this technology, including an overview of the history of this technology and an overview of the sensors available today.

February 6th, 8:00 AM to 12:15 PM Cost: $250

Practical Approach to Using the ASPRS Positional Accuracy Standards for Digital Geospatial Data

Dr. Qassim Abdullah, PhD, CP, PLS, Vice President/Chief Scientist, *Woolpert, Inc.*
Claire Kiedrowski, Executive Director, *Maine Library of Geographic Information*

This workshop provides an in-depth look at the ASPRS Positional Accuracy Standards to categorize positional accuracy of products derived from digital aerial cameras, manned and unmanned aerial systems, and all types of lidar including terrestrial, mobile, and airborne. The workshop will explain the basis for each accuracy measure adopted in the standards. Instructors will demonstrate practical application of these standards.

February 6th, 12:45 PM to 5:00 PM Cost: $250

Machine and Deep Learning Image Classification using ArcGIS Pro

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

This workshop introduces pixel- and object-based image classification using traditional machine learning algorithms as well as deep learning semantic segmentation using the UNet Model, including hands on-activities in ArcGIS Pro.

Special Requirements: Laptop with WiFi Capability.

February 6th, 12:45 PM to 5:00 PM Cost: $250

Planning for the New National Spatial Reference System and Vertical Datum

Barry Miller, Applied Researcher, *USGS*
Josh Nimetz, Senior Elevation Product Lean, *USGS*

The USGS National Map is the Nation's source for topographic, hydrographic, and cartographic geospatial data. These National datasets may span collection periods of many decades and exist in a variety of different coordinate reference systems. This workshop will focus on planning discussions underway within the USGS National Geospatial Program and anticipated difficulties in transforming existing data holdings to the new reference system and vertical datum.

February 6th, 12:45 PM to 2:45 PM Cost: $175

Lidar Survey with UAS: Project Planning and Flight Operations

Ryan Kelly, Senior Geospatial Manager, *Halff Associates*

This ASPRS workshop will use real world use cases to compare lidar systems to determine best fit for various applications, demonstrate proven best flight practices for collecting high accuracy data, explore control placement and targeting, and communicate standards to surveyors and customers.

February 6th, 12:45 PM to 2:45 PM Cost: $175

USGS 3DEP Data Validation

Dr. Milena Janiec, Applied Researcher, *USGS*

In support of 3DEP and the elevation theme of The National Map, USGS performs data validation on topographic data collected with remote sensing technologies, primarily airborne lidar. This workshop will focus on the USGS policies and processes related to validation of airborne lidar for 3DEP.

February 6th, 3:00 PM to 5:00 PM Cost: $175

Lidar Survey with UAS: Data Processing and Product Validation

Rusty Steel, Geospatial Director, *Halff Associates*

This workshop will demystify lidar data processing, identify common mistakes, demonstrate quality inspection methods, and show how to apply ASPRS Positional Accuracy Standards to validate results.

February 6th, 3:00 PM to 5:00 PM Cost: $175

INDUSTRYNEWS

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

ANNOUNCEMENTS

GeoCue is excited to announce that we are, once again, expanding our line of True View 3D imaging sensors (3DIS®). The True View 435 is our next-generation topography/wire grade lidar/imaging sensor. Featuring a 16 beam Hesai PandarXT LIDAR unit, world class Trimble Applanix APX-15 Position/Orientation System (POS) and dual GeoCue mapping cameras, the True View 435 is the highest performance 3D Imaging system available in its price class.

The True View 435 has a pulse repetition rate of 320,000 out-going pulses per second with an in-track field of view of +/- 15° of nadir. The sensor can detect up to two return pulses ("echoes") per outbound pulse. This provides excellent look angles for collecting power pylons/towers as well as superb, multiangle penetrating power in vegetated areas. Like all True View 3DIS, the True View 435 features dual oblique cameras, providing a cross-track image field of view of 120°. Similar to our industry standard True View 515, the True View 435 has sufficient sensitivity to detect distribution wires at an altitude of 75 m.

The True View 435 includes complete post-processing software featuring GeoCue's unique on-the-fly lidar point colorization algorithm, producing stunning 3D colorized point clouds. Through our teaming with BayesMap Solutions LLC, StripAlign for EVO (SAfE) is available as a purchased optional module or under a pay-as-you-use ("metered") plan. SAfE performs geometric correction for those occasional large projects that might exhibit dynamic geometric errors. Also available in the post-processing suite is Metashape for EVO (MfE), used in generating image orthomosaics based on lidar surfaces.

The True View 435 is upgradable to a True View 515, should you encounter situations where higher point densities are required.

The True View 435 is immediately available from GeoCue or GeoCue authorized resellers.

With the goal of giving surveyors a better understanding of the topographic data captured by drone mapping sensors, Virtual Surveyor has unveiled Profile View functionality in Version 8.4 of its popular surveying software. Profile View enables users to generate an elevation profile simply by drawing an onscreen traverse across any part of the data set created from drone imagery or lidar point clouds.

"For comprehensive understanding of the terrain, surveyors need to view their elevation data in 2D, 3D and in profile," said Tom Op 't Eyndt, Virtual Surveyor CEO. "The Virtual Surveyor software now offers all three types of viewing so users can look at their data from any angle and perspective."

Virtual Surveyor is a robust surveying software that bridges the gap between drone photogrammetric processing applications and engineering design packages, enabling surveyors to derive topographic information from drone data needed by engineers for construction, mining, and excavation projects. The software presents an interactive onscreen environment with drone orthophotos, digital surface models (DSMs), and/or lidar point clouds where users generate CAD models, create cut-and-fill maps, and calculate volume reports.

The Profile View allows users to draw straight or curved lines to cut across the terrain surface or follow an irregular feature, such as a road. The elevation profile is displayed in a new window that opens on screen. Profile View functionality will be valuable for surveyors working in any application related to construction, surface mining, landfill, and other types of excavation.

Current subscribers to Virtual Surveyor will see their software updated to Version 8.4 automatically. To start a free 14-day trial of Virtual Surveyor and to view details of the Valley, Ridge and Peak pricing plans, visit www.virtual-surveyor.com.

Applanix, a Trimble Company (NASDAQ: TRMB), and the National Oceanic and Atmospheric Administration (NOAA) recently collaborated to provide critical information to first responders in the wake of Hurricanes Henri and Ida. Applanix's high-accuracy direct georeferencing (DG) technology enabled NOAA to quickly collect aerial mapping imagery to provide valuable disaster remediation information to first responders, and demonstrate the value of cutting-edge mapping technology in preparing for and responding to emergency situations such as hurricanes, tornadoes and other disasters.

Within hours of Hurricanes Henri and Ida making landfall, NOAA's National Geodetic Survey collected post-storm imagery using the latest generation Digital Sensor System (DSS). The sixth generation DSS, designed and manufactured for Applanix by Lead'Air, is the most powerful to date, thanks to several new features introduced within the solution:

- Simultaneous full color and near-infrared image capture using high-performance Phase One iXM 100 MP NIR and 150 MP RGB cameras,
- Option to fly the cameras in wide coverage oblique or traditional overhead (straight line down) mode for mapping with uninterrupted measurement,
- Embedded Trimble AP60 global navigation satellite system-inertial (GNSS-inertial) OEM DG solution for mapping without the need for ground control or aerial triangulation,
- Applanix POSPac™ post-processing software featuring

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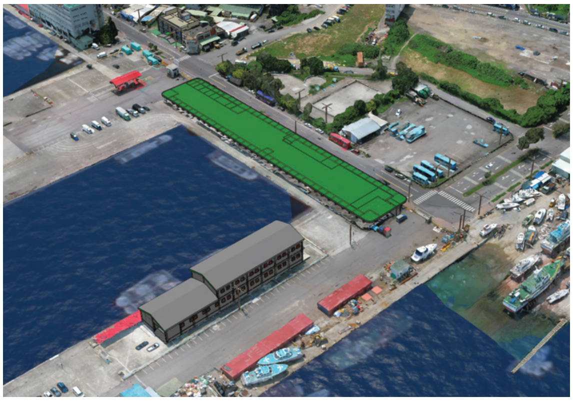


COLUMNS

ANNOUNCEMENTS

DEPARTMENTS

See the Cover Description on Page 4

COVER DESCRIPTION

Much like the sky, rivers are rarely painted one color. Across the world, they appear in shades of yellow, green, blue, and brown. Subtle changes in the environment can alter the color of rivers, though, shifting them away from their typical hues. New research shows the dominant color has changed in about one-third of large rivers in the continental United States over the past 35 years.

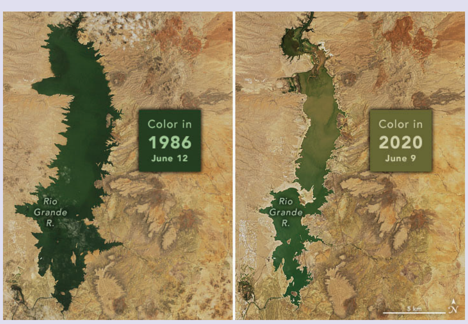
"Changes in river color serve as a first pass that tell us something is going on nearby," said John Gardner, the study's lead author and a hydrologist at the University of Pittsburgh. "There are a lot of details to parse out on what is causing those changes, though."

The figure above shows data from the first map of river color for the contiguous United States. The rivers are colored as they would approximately appear to our eye. Gardner and colleagues built the map from 234,727 images collected by Landsat satellites between 1984 and 2018. The dataset includes 67,000 miles (100,000 kilometers) of waterways of at least 200 feet (60 meters) wide. Around 56 percent of rivers were dominantly yellow over the course of the study and 38 percent were dominantly green. The team has released an interactive map where the public can further investigate color trends in individual rivers.

It is not unusual for rivers to change colors, explained Gardner. They change all the time because of fluctuations in flow, concentrations of sediments, and the amount of dissolved organic matter or algae in the water. For example, yellow-tinted rivers are typically sediment-laden but low in algae. Blue water, which is usually easier to see through, has little algae and sediment. Green water usually has algae as its dominant feature.

"We are seeing an increase in the frequency of color changes," said Gardner. In the study, the team found around 21 percent of rivers became greener, most commonly in the western United States. Around 12 percent of the rivers shifted towards yellow, many in the eastern United States.

The scientists found that the most extreme examples are often found near man-made reservoirs. In fact, the rivers with the fastest rate of color change were twice as likely to be located within 15 miles (25 kilometers) upstream or downstream of a dam and within the boundaries of an urban area.



The images to the left show color changes from 1986 (Landsat 5) to 2020 (Landsat 8) along the Rio Grande River near the Elephant Butte Reservoir in New Mexico. Gardner explained that changes in a reservoir's surface area can affect river color. When reservoirs contract, the upstream end of reservoirs become sediment-laden rivers again. Gardner is currently working to estimate suspended sediment concentrations based on the Landsat dataset. The goal is to explore how human activities, such as construction of dams or land use, may be affecting sediment loads.

From his own observations, Gardner also noticed more occurrences of algal blooms in rivers. In 2015, an algal bloom stretched across more than 650 miles (1,000 kilometers) of the Ohio River for three weeks, painting portions of the river green. Researchers have typically focused on algal blooms in lakes, but this dataset could help scientists quantify some trends in river chlorophyll concentrations.

"Our findings do not indicate if the color changes are good or bad in terms of water quality, but we showed that we can detect some trends," said Gardner. "The next step is to investigate what humans are doing to cause those changes and whether it's an improvement or degradation."

For more information visit https://landsat.visibleearth.nasa.gov/view.php?id=147999.

NASA Earth Observatory images by Joshua Stevens, using data courtesy of Gardner, J., et al. (2020) and Landsat data from the U.S. Geological Survey. Story by Kasha Patel.

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GIS Tips & Tricks

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

Disappearing Layers? – Here's a Quick Fix

For those who have been following this column, I frequently turn to my work colleagues or my students for Tips & Tricks with various GIS software packages. This month's "tip" originated with an issue encountered by several of my students. While I encourage them to use the Esri Basemaps for their work and, of course, although I advise them to use the "light gray" or other simple basemaps as backgrounds for their data, many prefer to use images as backgrounds for their maps.

After making multiple maps over a period of several weeks, the students started noticing that vector layers (feature classes or shapefiles) would disappear. When the image basemap was disabled, the vector layers would suddenly reappear. I call this the "Disappearing Layer Syndrome". After several frustrating trials, they could not make both the vectors and the basemap appear simultaneously on their maps. What could be happening?

If you have ever had this syndrome, or when your GIS software starts to run really slowly the solution is really simple. What is happening is that the computer's memory cache dedicated to software has been consumed. To repair the issue, just clear the cache manually.

For ArcGIS Desktop

To manually clear the cache in ArcGIS, Use the Customize | ArcMap Options (as in Figure 1).

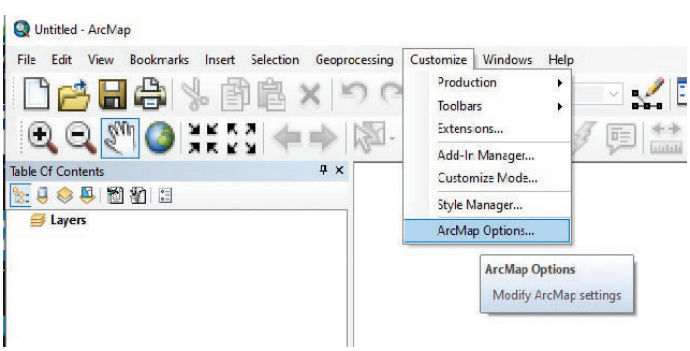

Figure 1. Selecting the ArcMap Options in ArcGIS 10.8.

And then choosing the "Display Cache" Tab from the menu options. As in Figure 2, this tab will show you how much memory is being used and by pressing the "Clear Cache" button, you will manually clear the cache. I recommend checking this area regularly, and clearing the cache when the "Currently Used" value exceeds 200 MB. Of course, you can experiment on your computer to find the optimum cache size.

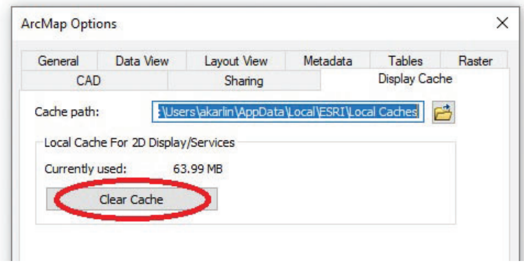

Figure 2. The Display Cache Tab on the ArcMap Options window shows that I am currently using about 64MB of memory.

For ArcGIS Pro

Use the "Project" tab and select "Options" to activate the Options menu. Then choose "Display" to show the display options. In the example below (Figure 3), my application is currently using almost 500 MB of cache (remember, this is ArcGIS Pro, a 64-bit application). By checking the box, it will clear that memory.

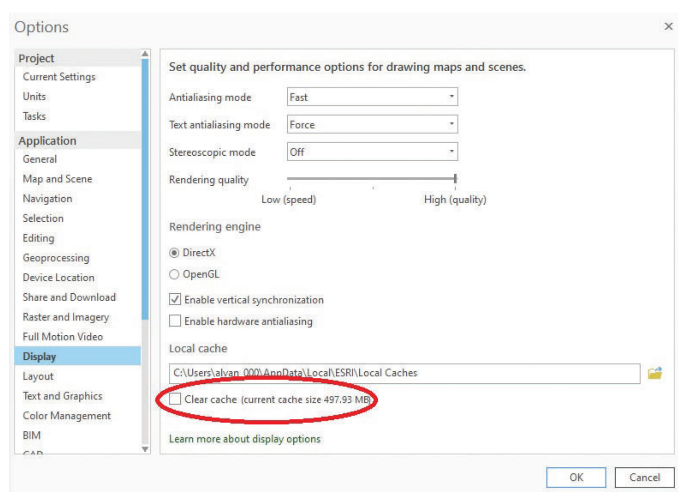

Figure 3. Using the Options | Display menu to clear the cache in ArcGIS Pro.

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0099-1112/22/5-13

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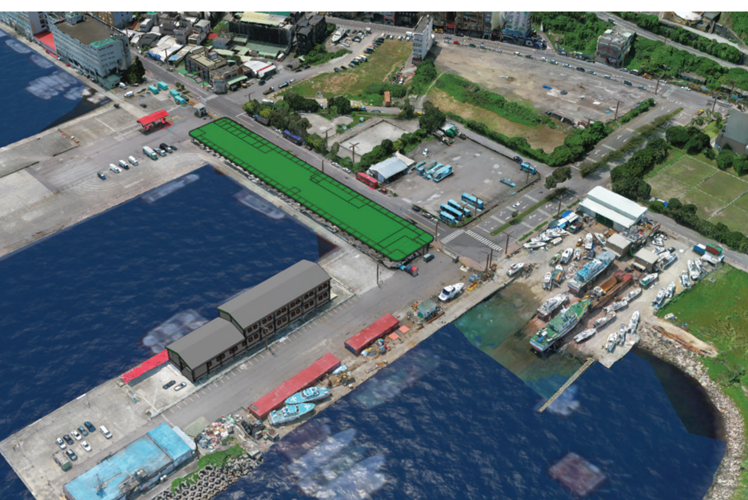
The Arrival of Disappearance and The Map of the Future

By Lawrie Jordan
Esri Corporate Director, Imagery and Remote Sensing

Recently a long-time friend offered me a ride in his new Tesla, and as a car buff I naturally jumped at the chance. The vehicle's high-resolution map display, combined with its extensive array of advanced remote sensors and processors, elegantly simple situational awareness, feature identification, and spatial agility for autonomous operation, made me feel like I was actually sitting inside a modern "GIS on wheels." This remarkable integration of multiple technologies is giving us a front seat view into the transformation of society's future mobility, in much the same way that GPS has transformed society into now being "never lost." This experience started me wondering whether this might be a metaphor for the rapidly accelerating evolution and integration of GIS and remote sensing, and what we might see just around the corner in mapping technology.



A digital twin of a fishing port created using Site Scan for ArcGIS.

The Great Disappearing Act

Some readers will fondly remember (ok, maybe not so fondly) the early days of computing, when mainframes were incarcerated in refrigerated cells and required specialized knowledge to operate. They were entities unto themselves, monolithic in size, cumbersome to interact with through punched cards and 9-track tapes, and they catered to an esoteric group possessing rarified skills.

A major jailbreak occurred in the early 1970's when the machines escaped from their cells and began to get smaller. And more powerful. And more accessible. These 32-bit mini-computers of the 70's such as the Vax, PDP, Sun Microsystems, Prime, and others soon gave way to a new generation of personal computers in the early '80s, bringing the machines into the homes of people. Much of this new audience had little or no technical background, and had little interest in computers per se—they were just interested in what the machines could do. Moore's law accelerated, and microchips began to migrate into automobiles, appliances, thermostats, and lots of other devices

Computers were soon everywhere, and interestingly, they were no longer called "computers," as they were often hardly even noticeable. They reached maturity even as they vanished from sight. Conveniently, the massive data sets they needed to access and operate on, including imagery and maps, also "disappeared" into the cloud and became instantly available at scale. Having seen this unfold over the last few decades, I would assert that a technology has truly arrived when it actually disappears, and becomes a new normal and an expectation in everyday life. Nowhere is this more evident than in the smart phone. We all carry around these cleverly disguised super-computers with their ever-expanding library of apps, using them daily at work and at home, and few could imagine life without one today. The "computer" as we once knew it has truly arrived through its disappearance.

The Illusion of Simplicity

All of the great benefits of technology aside, a fundamental requirement for adoption of any tech at scale is that it must be easy to use by non-technical users. The GPS system mentioned earlier is a shining example of what I refer to as "The Illusion of Simplicity." Society was forever changed when several of the most complex technologies ever invented in human history converged to form the GPS-based navigation system.

Initially developed by and for the military, the combination of a GPS satellite constellation, topologically structured intelligent maps, address matching, and advanced routing algorithms all formed a new foundation for how global society navigates from place to place. This appears to the user as being elegantly simple – it knows where you are, takes you where you want to go, helps you if you get lost, gives you options for routing, and all of this in turn-by-turn instructions in a choice of different voice types. Push the "Home" button and you're never lost – it just works.

Although enormously complicated behind the curtain, thanks to this "illusion of simplicity" in interface design, both the GPS system and smart phones have been adopted globally by professionals and consumers alike. I would assert that this aspect of simplicity will be a key element going forward in the next generation of GIS adoption at scale.

The Power of Three

The early years of GIS and Remote Sensing technologies saw the two as linked but co-evolving along parallel but separate trajectories. GIS spoke the language of points, lines, and polygons, while Imagery was measured out in pixels, rasters, and point clouds. Today, modern GIS systems fully integrate Imagery and Remote Sensing capabilities at all levels.

GIS and building information modeling (BIM) software were also linked—tentatively, at first, and more directly as the years progressed. Many of the overall objectives of the technologies were, of course, quite similar. Gradually, GIS, Remote Sensing, and BIM each became more fluent in the language spoken by the other, including the recent development of the GeoBIM concept and related products. As GIS continues to evolve and integrate these essential elements, the glass walls that once separated the three are beginning to "disappear", setting the stage for a new "arrival" and an expanded definition of "what is a map," and "what I can do with it." Simply stated, these three technologies are "better together," and collectively they deliver to us a compelling Geographic Advantage.

The Map of the Future

Einstein famously once said "If I can't see it I can't understand it." We see in 3D, and this helps us to better understand everything around us. The vast majority of maps created in the early days of GIS were based at some early point in their creation on imagery of some type. Features were digitized and the image was abstracted to form a simplified 2D line drawing with just the features of interest. With the advent of stereo imagery, LiDAR sensors, drone technologies, 3D meshes, structure from motion, game engine processors, and other capabilities, GIS systems today have become 3D, and this has greatly assisted in solving certain classes of geospatial problems and design challenges that can only be understood and addressed in 3D, notably in dense urban settings.

I would submit that a new and expanded definition of a "map" would be based on a synthesis of all of the items discussed above, and the two graphic illustrations here give us a preliminary glimpse. Specifically, I would describe this "Map of the Future" as a photo-realistic, intelligent, 3D image that includes full GIS attributes, which I can interrogate, fly

3D mesh of Zurich, Switzerland creating using Site Scan for ArcGIS.

around and through, visualize in any format and dimension that makes sense to me, and have available anytime on any device. Plus, its architecture is designed to be infinitely scalable in any coordinate system, including underground and ocean floor. This leverages the power of three above (GIS, Remote Sensing, and BIM) and is wrapped in an envelope of simplicity.

Since all of the capabilities listed above to create this "Map of the Future" exist today in modern GIS systems, you might reasonably ask the question "So, what's missing?"

So What's Missing?

A new language. We need a new language to describe these maps of the future. Our time-honored traditional language of map scales (ie. 1:24,000) and resolution (ie. 30 cm. pixels) is simply inadequate to describe and accurately communicate information about a high-resolution 3D image from multiple viewing angles. For example, what is the "scale" of a perspective view? Well, you could say that it's infinitely variable based on certain parameters, but that's not really very helpful in the end. Further, I don't think that the "level-of-detail" ontology (ie. "LOD-1" for solid blocks, "LOD-2" for adding roof detail, etc.) is sufficient when we can now produce exquisite drone-based 3D meshes and "Digital Twins" in remarkable detail, as shown in these examples.

I think exploring the need for a new and expanded language in mapping could be a great area of focus that our professional organization (ASPRS) in partnership with the Academic community and industry could provide much needed leadership.

So, in brief conclusion, it's my sense that we're just at the beginning of an entirely new and bright chapter in the geospatial community, with some old barriers in the road "disappearing" and some remarkable new "arrivals" just around the corner on the road ahead. This promises to be a ride worth taking!

continued from page 2

- the Trimble post-processed CenterPoint® RTX™ correction service (PP-RTX) for centimeter-level mapping without GNSS reference stations,
- In-air development of raw imagery to JPEG-ready files for creating map products immediately upon landing, and
- Lead'Air's innovative X-Track flight management, which enables the system to be flown outside of planned flight lines to follow roads, rivers and coastlines.

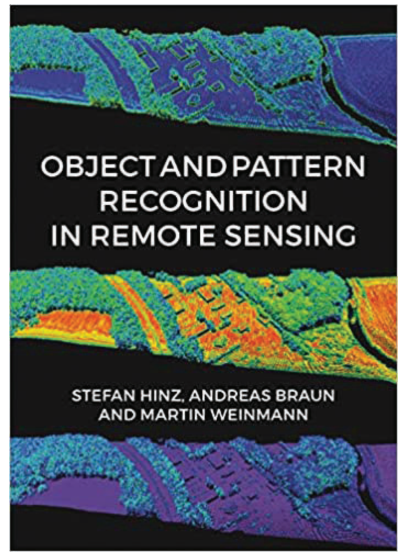
Applanix's DG technology suite provides direct GNSS inertial georeferencing, meaning that all pixels in the aerial images taken by NOAA are mapped at their exact location on the ground.

"We have worked with Applanix for nearly 20 years," said Michael L. Aslaksen Jr., chief of the remote sensing division of NOAA's National Geodetic Survey. "The level of sophistication they bring to aerial imagery and mapping keeps our team at the forefront of the industry. Their customer support team is always open to new ideas, new innovations and doing whatever it takes to get the job done."

First responders have access to this imagery and mapping within 24 hours via the cloud (as does anyone at https://storms.ngs.noaa.gov/; zoom in for the detailed images) and can map detailed response plans based on highly accurate data highlighting where the greatest need lies. Access to this turnkey emergency response imagery is available to any federal agency, municipality, insurance companies and other entities who depend on highly accurate information to plan for and recover from disasters.

CALENDAR

- 1-3 February, 2022, **URIS LEAP Conference**. For more information, visit www.urisa.org/leap.
- 6-8 February 2022, **Geo Week 2022**, Denver, Colorado. For more information, visit www.geo-week.com/.



Object and Pattern Recognition in Remote Sensing

Edited by Stefan Hinz, Andreas Braun and Martin Weinmann.

Whittles Publishing, Dunbeath, Caithness, UK. 2021. xiii and 350 pp, 88 color and 37 black and white illustrations, 18 tables, index. Hardcover. ISBN 978-1-84995-128-9. $183.96. £90.00; Amazon $107.73.

Reviewed by Stewart Walker, sole proprietor, photogrammetry4u, San Diego, California.

Many geospatial luminaries have emerged from the academic apparatus in Karlsruhe. Of the 16 contributors to *Object and Pattern Recognition in Remote Sensing* book, all but Franz Rottensteiner are educated and/or work at Karlsruhe Institute of Technology (KIT). They provide a condensed, masterly review of a considerable body of material representing many strands of remote sensing research. The subtitle is *Modelling and Monitoring Environmental [sic] and Anthropogenic Objects and Change Processes*.

Stefan Hinz, head of KIT's Institute for Photogrammetry and Remote Sensing (IPF), is well known and is president of ISPRS Technical Commission I (Sensor Systems). It's appropriate, therefore, that a foreword has been contributed by ISPRS president Christian Heipke, giving perspective, in terms of both remote sensing and photogrammetry and also the eminence of KIT.

The book is in three parts. The first, "Methodology," begins with an introduction by Hinz, setting the stage. He proceeds with Chapter 2, "Object Data and Sensor Modelling" a readable synthesis of vast amounts of material, and includes a large number of references at the end of the chapter - this happens with every chapter and immeasurably increases the book's value. This excellent review material continues with Chapter 3, by Martin Weinmann, "Feature Extraction from Images and Point Clouds: Fundamentals, Advances and Trends." Andreas Braun joins Weinmann for Chapter 4, "A Short Survey on Supervised Classification in Remote Sensing." Rottensteiner takes the helm for Chapter 5, "Context-based Classification" and Uwe Weidner completes the section with Chapter 6, "Toward a Framework for Quality Assessment in Remote Sensing Applications." These syntheses, complemented by the ample references, are invaluable and justify buying the book - yet little of the work cited dates from later than 2010.

Part II, "Applications," summarizes research done in Karlsruhe. Chapter 7, "From Raw 3D Point Clouds to Semantic Objects" (Weinmann, Sven Wursthorn, Boris Jutzi), focuses on terrestrial laser scanning and range cameras. The coverage of point cloud matching and registration is very useful, as is the material on feature extraction and scene interpretation. The references again are not new, however, and the datasets were last accessed in 2013. Hinz returns to the stage, with Jens Leitloff, with Chapter 8, "Traffic Extraction and Characterization from Optical Remote Sensing Data," full of well explained, interesting work based on still images rather than video. The tell-tale is a footnote, "Updated and revised version of (Hinz et al. 2008)": the material is mature and the update refers mainly to work published 2009-14. Chapter 9, "Object Extraction in Image Sequences" by Florian Schmidt and Hinz, summarizes strong work on the detection of persons from aerial photography with a frequency of 2 Hz, though this is hardly representative of fast-cycling modern cameras or the role of UAVs. Yet, like much of the material in this book, the cohesive, lucid presentation, drawing on extensive literature, provides understanding and background. Chapter 10, "A Process-based Model Approach to Predict Future Land-Use Changes and Link Biodiversity with Soil Erosion in Chile," by Andreas Braun and Callum Banfield, is based on the first author's PhD thesis and the second author's MS thesis, both at KIT in 2013. This shorter chapter is practical and gives a useful account of the challenges and solutions within a particular research theme.

The book then change sensors. Chapter 11, "Interferometric

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SAR Image Analysis for 3D Building Reconstruction," by Antje Thiele, Clémence Dubois and Hinz, takes up from Hinz's initial comments on SAR in Chapter 2 and quickly dives deep with descriptions of how buildings can be extracted from the data. Chapter 12, "Detection and Classification of Collapsed Buildings after a Strong Earthquake by Means of Laser Scanning and Image Analysis," by Miriam Hommel and Thomas Vögtle probes the practicalities of assessing damage from point clouds and imagery. This is a fascinating read and one is conscious of the human tragedies behind the science. Ulrike Sturm-Hentschel, Braun and Hinz end the section with Chapter 13, "A Settlement Process Analysis in Coastal Benin: Confronting Scare Data Availability in Developing Countries," reporting high-quality research work, using, for example, QuickBird data. The authors' complaints about lack of data, however, are less worrisome in 2021, since the constellations of multiple satellite operators provide a plethora of information with shorter and shorter repeat times.

The book is drawn together in Part III, "Conclusion." This material is more up to date than Part II. Chapter 14, "Benchmarking: a basic requirement for effective performance evaluation," by Weinmann and Braun, stresses the importance of standard data sets for assessing new approaches and gives several examples. Seven authors worked on Chapter 15, "Remote sensing and computer vision image analysis: summary and recent trends." This title confirms that the emphasis is less on photogrammetry than some readers would perhaps prefer. Sometimes whimsical, with glimpses of humor, this chapter weaves the book's threads into fabric. It levers the book into the second half of the 2010s and is a perceptive assessment of trends. The authors' experiences and involvements shine through and there is acuity as well as description.

Your reviewer's unease with the currency of the material, nevertheless, resurfaced in the final chapter. There is excellent but brief coverage of deep learning, for example, which gave your reviewer more insight than many of the heavy papers on the subject with which he has grappled. Yet between this (pages 338-339) and the comments on page vii in Heipke's foreword and pages 6-7 in Hinz's introduction, the topic is barely mentioned. How I wish there had been much more on this topic! There is an insight on page 339 that the authors "finalized the book in 2018/19," which suggests that the final steps to publication were lengthy ones. There is a remark on page 336 about "recent reviews" of multiple classifier systems that were published in 2002 and 2007.

Object and Pattern Recognition in Remote Sensing is a fine, well produced book, a real pleasure to use. The Scottish firm, Whittles Publishing, has incorporated both monochrome and color graphics that are attractive, though sometimes on the small side (the legend of figure 10.3 has a 3-point font!). There are few typos, though tighter editing would have eliminated some minor curiosities in language. Though rather advanced for students new to remote sensing, it will certainly serve the lecturers, practitioners, researchers, advanced undergraduates, and postgraduates that the publisher's blurb on the back cover suggests are the target market. While the absence of material on the last ten years, particularly in Part II, must remain a demerit until the second edition, the excellence of Parts I and III should convince doubters to purchase this book.

Grids & Datums

BY Clifford J. Mugnier, CP, CMS, FASPRS

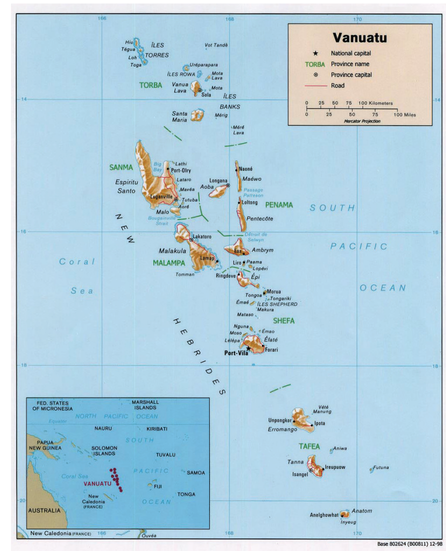
REPUBLIC OF VANUATU

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 the Republic of Vanuatu was originally printed in 2004 but contains updates to their coordinate system since then.

Inhabited for thousands of years by Melanesians before discovery by the Portuguese navigator Pedro Fernandes de Queirós, the islands were forgotten for 160 years and were then visited by the French navigator Louis-Antoine de Bougainville in 1768. The English mariner Captain James Cook explored the islands in 1774 and named it the New Hebrides. "The British and French, who settled the New Hebrides in the 19th century, agreed in 1906 to an Anglo-French Condominium, which administered the islands until independence in 1980." What the World Factbook doesn't say is that the local people referred to it as the Pandemonium! Vanuatu \ vän-, -wä-tü \, is a group of more than 80 islands in the southwest Pacific Ocean northeast of New Caledonia and west of Fiji (*PE&RS,* October 2000). With a land area of 12,200 km^2, the republic is slightly larger than Connecticut.

Vanuatu has a tropical climate, the terrain is comprised mostly of volcanic mountains with narrow coastal plains, the lowest point is the Pacific Ocean, and the highest point is Tabwemasana (1,877 m) on the island of Espiritu Santo. The total coastline is 2,528 km and its maritime claims are based (naturally) on archipelagic baselines. The exclusive economic zone is 200 nautical miles (NM), the territorial sea is 12 NM, the contiguous zone is 24 NM, and the continental shelf claim is 200 NM or to the edge of the continental margin – all of these claims are customary and are recognized under the International Law of the Sea.

In the Vanuatu Geodetic Control Network Report by Bakeeliu, Kanas, and Kalsale in June 2001, the network that began in the 1960s was generally detailed to the present. The Institute Géographique National (IGN) of France started their network in the 1960s. "The IGN network was made in two blocks, one of which covers the islands of Santo, Aoba, Pentecost, Maewo, Ambrym, Malekula Epi, Éfaté in the northern part of Vanuatu while the other block covers Erromango, Tanna, Anatom and the nearby small islands in the south. The islands left out were the Banks and Torres group in the far north of Vanuatu." The report continues, "The IGN [*datum – Ed.*] was based on the astronomical observation made at Bellevue on Éfaté." (Note that another common spelling for the island of Éfaté is Île Vaté). The Vanuatu (IGN) 1960 Datum origin coordinates at Bellevue are Φ_o = 17°44´17.40˝ South, Λ_o = 168°20´33.25˝ East of Greenwich, and the ellipsoid of reference is the International 1909 (Madrid 1924) where a = 6,378,388 m, and $^1/_f$ = 297. The National Geospatial Intelligence Agency (NGA) lists the transformation parameters from The Vanuatu (IGN) 1960 Datum (Bellevue) to the WGS84 Datum as Δa = –251m, Δf = –0.14192702, ΔX = –127m±20m, ΔY = 769m ±20m, and ΔZ = +472m±20m. This relation is based on observations at three stations. John W. Hager, retired from what is now NGA says, "The transformation states that



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it is for the islands of Éfaté and Erromango but my notes imply that the trig list applies from Éfaté to Espiritu Santo. Source for this is 'Loose Minute, MCE Ht/KHG/PL, 10 July 1970 with one page from I.G.N. Trig list.' I don't remember what all the letters mean but it was a letter from the British Military to U.S. Army Topographic Command." Hager also commented that, "Pier Observation Spot, Vila Harbor, Éfaté Island. I have no data but questioned for my further investigation whether is was Fila or Vila, Fila possibly being a corruption of Éfila." Presumed datum point is S. T. 1 (Service Topographique) at latitude 15°17´16˝S., longitude 16758´34˝E. This was taken from 'Traverse Around Perimeter of Aoba Island,' 30 Sept. 1969." He found a 1949 IGN reference to a local grid for the Aoba Island Datum where False Northing = 12,000 meters and False Easting = 18,000 meters. According to Hager, "the only odd map projection I find is for Nouvelles Hébrides, Fuseau Calédonie-Hébrides, Gauss projection, [*Transverse Mercator – Ed.*], International ellipsoid, meter, latitude of origin = equator, longitude of origin = 167°E, scale factor unknown but probably unity, false northing (y) = 2,600,000 meters, false easting (x) = 1,000,000 meters. This is from 'Catalogue de Cartes en Service Publiées par l'Institute Géographique National,' Paris, 1 July 1949."

Referring back to the Vanuatu Geodetic Control Network Report, "The adjustment used by DOS [*Directorate of Overseas Surveys, UK – Ed.*] was initiated from the same points as the IGN however the astronomical observations and adjustment was done separately. The DOS adjustment covers the islands of Santo, Aoba, Maewo, Pentecost, Ambrym, Malekula and Pamma in the north and Éfaté, Erromango, Tanna, Anatom and Futuna in the south. The DOS however extended its triangulation further throughout the country covering and strengthening the network to other islands, except Bank and Tores in the far north. This adjustment was used for mapping as well as cadastral. DOS adjustment uses the same scale factor of one (1.00000) throughout the country, though each island has its own origin."

Continuing, early in the "1980s the Vanuatu Government attempted to connect the DOS north and south block using traverse methods with the introduction of Telurometer distance measurements. However, it was found that there was some discrepancy between the two blocks. It was uncertain then that the error was in the traverse observation or the astronomical observation of the two blocks. It was also difficult to undertake alternative method of triangulation as the sights between Epi and Emae islands was very difficult. It was seen that it may be easier if a triangulation was done through the islands between the two blocks, however for some reason this was not done. The technology at that time may also be the cause of the inaccuracy of the observations. In mid 1990s the Australian Government assisted the Vanuatu Government by providing funds, technology and human resources through the Australian Defense Cooperation to run a Doppler network that covers the whole country. This has enabled the Vanuatu Government to anticipate the strengthening of the country's survey control network on the WGS72 spheroid. The network was produced to control the aerial photography of the country. For cadastral purposes the DOS geodetic adjustment is still maintained."

I asked Russell Fox, now retired from the International Geodetic Library of the Ordnance Survey International, United Kingdom, if he had anything to help me on my column on Vanuatu. To my (usual) surprise, he certainly did have something. Fox had worked there for three years! "The Condominium (known as the Pandemonium locally) was a strange form of government, the British and French running parallel but separate administrations in the same territory (so not analogous with St. Maarten/St. Martin). There were French and British police forces, hospitals, schools, etc. Residents had to use "their" facilities. Citizens of countries other than Britain (& Commonwealth) or France had to opt for either honorary British or honorary French status and use the appropriate services. This split the local people also, half of whom were educated in the French milieu and half in British traditions. There was "trouble in paradise," as the newspapers put it, during the immediate pre-and post-independence period, as the more radical and pro-independence English-speaking ni-Vanuatu jostled for power with the French speakers and French settlers, who preferred the status quo (not least because French plantation owners would be most affected by proposed changes in land tenure)."

Fox continued, "I worked in Vanuatu from 1983-86. Independence had come in 1980, so I did not personally witness this, but one of the Survey Department's tasks pre-independence was to measure the heights of the flagstaffs at the British and French Residencies in Port Vila. There would have been a diplomatic incident if either the Union Jack or the Tricoleur had been flown slightly higher than the other! The Condominium was the result of Anglo-French rivalry in the Pacific during the late 19th century; I believe that the Australian colonies were particularly keen to avoid a French takeover of the New Hebs as well as New Caledonia and they lobbied the British Govt. to do something about it. The answer was Condominium, if only to avoid an Anglo-French war. Another Condominium was the Anglo-Egyptian Sudan. The WWII US presence in the New Hebs was still evident in the 1980s, with 6-wheel trucks on plantations, USN dustbins [galvanized trash cans?] being used as water containers and metal plates from airfield runways being used as property fences." [*I remember seeing the same things when I lived in Panamá – Ed.*]

"The main post-1978 survey activities I know of were: 1980 – A dozen Doppler stations were observed by 512 Specialist

Team, Royal Engineers. 1983-86 'Operation Algum' – major support for the Survey Department was received from the Royal Australian Survey Corps. This involved a Doppler campaign throughout the islands, new aerial photography, readjustment of the DOS and IGN trig networks on WGS84 and setting up a map production facility in the Survey Department. 1980s-1990s New Editions of the DOS 1:1,000,000 map were produced by the Survey Department, also a new 1:50,000 series. The Vanuatu Map Grid was introduced, a national TM projection to replace the assorted island grids that existed previously. The Survey Department produced a brief paper in about 1976/77 that discussed the significant differences between DOS and IGN positions in the New Hebs (nearly a km in the northern islands if I recall correctly). Those discrepancies weren't solved – or circumvented – until OP Algum, but the Survey Department did develop a TM grid (called Éfaté TM 77) for the main island, Éfaté or (Vaté), in 1977 to improve the control situation there by unifying disparate surveys and replacing the old Cassini grid. Both DOS and IGN used International Spheroid, but had datums in different places, and trig block boundaries in different places – the DOS North Block was islands North of Éfaté, and South Block was Éfaté and islands south. IGN had a North Block (Éfaté and islands North) and South Block (Erromango to Aneityum). I think the most northerly island in the New Hebs, the Banks and Torres Islands, were not reached by either the DOS or IGN networks and had local astro fixes only."

The National Geospatial Intelligence Agency (NGA) lists the transformation parameters from the Santo (DOS)1965 Datum (Espiritu Santo Island) to the WGS84 Datum as: $\Delta a = -251$m, $\Delta f = -0.14192702$, $\Delta X = +170\text{m} \pm 25\text{m}$, $\Delta Y = +42\text{m} \pm 25\text{m}$, and $\Delta Z = +84\text{m} \pm 25\text{m}$. This relation is based on observations at one station. Thanks to John W. Hager; Russell Fox; Tony Kanas, surveyor; and, the Vanuatu Department of Land Surveys for their generous assistance.

Vanuatu Update

In 2014, the U.S. Department of State published No. 137 Limits in the Seas, *Vanuatu: Archipelagic and other Maritime Claims and Boundaries*. Coordinates are shown to four decimal places of arc seconds, and all connecting lines are defined as geodesics. No datum, ellipsoid, nor International Terrestrial Reference Frame date is stated.

Vanuatu Geodetic Control Network Report, Mike Bakeoliu, Tony Kanas, Moses Kalsale, 09 June 2001.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for GeoInformatics (C^4G).

This column was previously published in *PE&RS*.

GIS Tips & Tricks, *continued from page 5*

In GQIS and other GIS software—QGIS and several other GIS software packages allow you to clear the cache through Python or directly through the command line. For QGIS, the command would look like:

```
rm -rf ~/.qgis2/cache/data7
```

Here is a link for additional help for QGIS:

https://gis.stackexchange.com/questions/356704/how-to-clear-the-cache-of-qgis-3-10-with-python

It is that easy to solve the "Disappearing Layer Syndrome".

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.

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Improving Urban Land Cover Mapping with the Fusion of Optical and SAR Data Based on Feature Selection Strategy

Qing Ding, Zhenfeng Shao, Xiao Huang, Orhan Altan, and Yewen Fan

Abstract

Taking the Futian District as the research area, this study proposed an effective urban land cover mapping framework fusing optical and SAR data. To simplify the model complexity and improve the mapping results, various feature selection methods were compared and evaluated. The results showed that feature selection can eliminate irrelevant features, increase the mean correlation between features slightly, and improve the classification accuracy and computational efficiency significantly. The recursive feature elimination-support vector machine (RFE-SVM) model obtained the best results, with an overall accuracy of 89.17% and a kappa coefficient of 0.8695, respectively. In addition, this study proved that the fusion of optical and SAR data can effectively improve mapping and reduce the confusion between different land covers. The novelty of this study is with the insight into the merits of multi-source data fusion and feature selection in the land cover mapping process over complex urban environments, and to evaluate the performance differences between different feature selection methods.

Introduction

In recent years, with the rapid development of the economy and the improvement of urbanization, the large area of hardened land has been squeezing the urban ecological space. The urban heat island effect has become increasingly prominent, and problems such as air pollution and environmental damage have become increasingly serious threats to our living environment (Kuang *et al.* 2015; Li *et al.* 2011; Shao *et al.* 2020a). High-precision urban land cover (ULC) data is an important foundation for rational development and dynamic monitoring of land resources (Chen *et al.* 2021a). It also plays a key role in climate assessment, temperature change, environmental protection and other research, and provides scientific basis for urban planning, management and sustainable development (Huang and Wang 2020; Lazzarini *et al.* 2015; Li *et al.* 2017; Zhang and Sun 2019).

Remote sensing data, with the advantages of low cost and high efficiency, has become the main data source for land cover mapping (Friedl *et al.* 2002; Gallego 2004; Griffiths *et al.* 2019; Khatami *et al.* 2016). Basic research usually only uses optical remote sensing data to distinguish land covers according to the spectral feature differences between different classes (Shih *et al.* 2019). However, due to the complex distribution of land covers and highly mixed spatial pattern in urban areas, there are many phenomena of "different body with same spectrum" or "same body with different spectrum". Therefore, ULC mapping based only on spectral features of optical remote sensing data cannot completely identify the effective information of targets, and the accuracy of mapping results is difficult to guarantee (Hodgson *et al.* 2003; Weng *et al.* 2009). In addition, the quality of optical remote sensing images is easily affected by meteorological conditions, and the images obtained during rainy or cloudy weather are not suitable for land cover mapping. Fusing multi-source remote sensing data and giving full play to the advantage of different data is an effective way to further improve ULC classification accuracy (Ty *et al.* 2016; Prins and Niekerk 2020). Synthetic aperture radar (SAR) can observe the geometric and dielectric properties of the Earth's surface through clouds, fog and haze. Previous studies have shown that the fusion of optical remote sensing data and SAR data can realize information complementation, thus reducing the confusion between different land covers and improving the ULC classification accuracy (Joshi *et al.* 2016; Shao *et al.* 2016; Shao *et al.* 2020b; Symeonakis *et al.* 2018; Tabib Mahmoudi *et al.* 2019; Zhang and Xu 2018; Zhang et al 2018). However, the fusion of multi-source data will also lead to the increase of input feature dimension, the increase of noise, and calculation amount in the classification model, which will result in the decline of the stability and interpretability of the model (Georganos *et al.* 2018). Hence, how to obtain a concise subset from multi-dimensional data that can balance classification accuracy and model interpretability is a crucial issue.

As a part of data mining, feature selection aims at selecting subsets according to the importance of each feature to reduce complexity while maintaining or improving the performance of the model (Cai *et al.* 2018; Guyon and Elisseeff 2003). In the research of land cover mapping, feature selection methods based on filtering, wrapping and tree model all have been applied (Pal 2005; Sesnie *et al.* 2008; Zhang and Yang 2020; Zhou *et al.* 2018). However, due to the different standards of the feature selection methods, the mapping results will be different. There is no consensus on the preference of feature selection methods in land cover mapping research, and the effects of different feature selection methods still need to be compared.

In this study, the Futian District of Shenzhen City was selected as the study area. Considering the complexity of land

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Contributed by Alper Yilmaz, June 1, 2021 (sent for review July 14, 2021; reviewed by John van Genderen, Hongsheng Zhang).

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Examining the Integration of Landsat Operational Land Imager with Sentinel-1 and Vegetation Indices in Mapping Southern Yellow Pines (Loblolly, Shortleaf, and Virginia Pines)

Clement E. Akumu and Eze O. Amadi

Abstract

The mapping of southern yellow pines (loblolly, shortleaf, and Virginia pines) is important to supporting forest inventory and the management of forest resources. The overall aim of this study was to examine the integration of Landsat Operational Land Imager (OLI) optical data with Sentinel-1 *microwave C-band satellite data and vegetation indices in mapping the canopy cover of southern yellow pines. Specifically, this study assessed the overall mapping accuracies of the canopy cover classification of southern yellow pines derived using four data-integration scenarios: Landsat OLI alone; Landsat OLI and* Sentinel-1*; Landsat OLI with vegetation indices derived from satellite data—normalized difference vegetation index, soil-adjusted vegetation index, modified soil-adjusted vegetation index, transformed soil-adjusted vegetation index, and infrared percentage vegetation index; and 4) Landsat OLI with* Sentinel-1 *and vegetation indices. The results showed that the integration of Landsat OLI reflectance bands with* Sentinel-1 *backscattering coefficients and vegetation indices yielded the best overall classification accuracy, about 77%, and standalone Landsat OLI the weakest accuracy, approximately 67%. The findings in this study demonstrate that the addition of backscattering coefficients from* Sentinel-1 *and vegetation indices positively contributed to the mapping of southern yellow pines.*

Introduction

Southern yellow pines such as loblolly pine (*Pinus taeda*), Virginia pine (*P. virginiana*), and shortleaf pine (*P. echinata*) are softwood forest vegetation species commonly found in the southeastern United States. These pine species are commercially marketed and provide economic benefits to the country. For example, loblolly and shortleaf pines are usually grown for pulpwood and sawlogs, whereas Virginia pine is usually grown as Christmas-tree species (English *et al.* 2004; Young *et al.* 2007).

The mapping of softwood forest vegetation species such as loblolly, shortleaf, and Virginia pines is important for effective management of forest resources (Xie *et al.* 2008; Ke *et al.* 2010; Deng *et al.* 2011; Shang and Chisholm 2014; Roth *et al.* 2015). For example, updated digital maps of forest vegetation species and canopy cover are continually being sought by forest managers and policy makers to support management decisions and policies (Skidmore *et al.* 1997; Rozenstein and Karnieli 2011). Furthermore, forest vegetation canopy cover maps can help to understand tree-species ecology for community dynamics as well as species inputs into the ecosystems (van Ewijk *et al.* 2014). They can also be used as inputs for modeling and other forest management and planning activities such as harvesting, regeneration, and fire management (van Aardt and Wynne 2007; Hamilton *et al.* 2021).

The spectral information of satellite remotely sensed data, such as Landsat Operational Land Imager (OLI) optical data and *Sentinel-1* C-band synthetic-aperture radar (SAR) sensor data, make them feasible and cost-effective in mapping forest vegetation canopy cover compared to traditional field-survey methods over large geographic areas (Xie *et al.* 2008; Shang and Chisholm 2014; Vincent *et al.* 2019). However, because many individually sensed images have either high spatial resolution or high spectral resolution, there is a need to integrate satellite remotely sensed data to improve image classification. For example, Jiménez *et al.* (2017) and Fatoyinbo and Armstrong (2010) integrated Landsat Enhanced Thematic Mapper Plus with lidar and National Forest Inventory data to map aboveground forest cover and biomass, and found a more accurate estimation of aboveground forest biomass using this data-integration method. Wan *et al.* (2021) integrated multispectral *Sentinel-2* image data with high-spatial-resolution aerial images for tree-species classification of forest stands. They classified and mapped 11 forest vegetation species stands and found an increase in overall mapping accuracy after data integration. Furthermore, Biswas *et al.* (2020) evaluated the contribution of three satellite data sources—Landsat OLI, *Sentinel-1*, and *Sentinel-2*—in mapping diverse forest vegetation types in Myanmar. They found that using a combination of *Sentinel-1* and *Sentinel-2* data produced the highest accuracy (89.6%), followed by *Sentinel-2* alone (87.97%) and Landsat OLI (82.68%).

Satellite-derived vegetation indices are useful indicators of forest biophysical condition and can be integrated with satellite remotely sensed data to further improve the discrimination of forest vegetation and canopy cover. This is because spectral vegetation indices measure the photosynthetic size of plant canopies. Furthermore, they are used as indicators to monitor variations in temporal and spatial characteristics of vegetation structure and density (Xue and Su 2017; Akumu *et al.* 2021). For example, Prabhakara *et al.* (2015)

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Augmented Sample-Based Real-Time Spatiotemporal Spectral Unmixing

Xinyu Ding and Qunming Wang

Abstract

Recently, the method of spatiotemporal spectral unmixing (STSU) was developed to fully explore multi-scale temporal information (e.g., MODIS–Landsat image pairs) for spectral unmixing of coarse time series (e.g., MODIS data). To further enhance the application for timely monitoring, the real-time STSU (RSTSU) method was developed for real-time data. In RSTSU, we usually choose a spatially complete MODIS–Landsat image pair as auxiliary data. Due to cloud contamination, the temporal distance between the required effective auxiliary data and the real-time data to be unmixed can be large, causing great land cover changes and uncertainty in the extracted unchanged pixels (i.e., training samples). In this article, to extract more reliable training samples, we propose choosing the auxiliary MODIS–Landsat data temporally closest to the prediction time. To deal with the cloud contamination in the auxiliary data, we propose an augmented sample-based RSTSU (ARSTSU) method. ARSTSU selects and augments the training samples extracted from the valid (i.e., non-cloud) area to synthesize more training samples, and then trains an effective learning model to predict the proportions. ARSTSU was validated using two MODIS data sets in the experiments. ARSTSU expands the applicability of RSTSU by solving the problem of cloud contamination in temporal neighbors in actual situations.

Introduction

Mixed pixels have been considered one of the main factors restricting the reliability of land cover mapping in remote sensing (Schowengerdt 1997; Lin *et al.* 2019; Wu *et al.* 2019, 2021). For more reliable interpretation of mixed pixels, scholars have increasingly devoted attention to spectral unmixing (also known as soft classification; Settle and Drake 1993). Spectral unmixing can predict the proportions of land cover classes in mixed pixels and can provide more detailed land cover information than traditional hard classification (Foody 2002; Atkinson 2005). In recent years, a series of methods for spectral unmixing have been developed. It is beyond the scope of this article to review these works, but readers can refer to several reviews (Keshava and Mustard 2002; Quintano *et al.* 2012; Heylen *et al.* 2014; Shi and Wang 2014; Bhatt and Joshi 2020).

The main factors affecting the reliability of spectral unmixing include the extraction of pure end members (i.e., the representative spectrum of each land cover class) and the intraclass spectral variation (i.e., the same land cover class presenting different spectra; Zhang *et al.* 2019). Although a number of multiple end member-based methods have been proposed for the problem of intraclass spectral variation (Roberts *et al.* 1998; Bateson *et al.* 2000), the extraction of a large number of end members is still a huge challenge, especially in areas with great heterogeneity. Spectral-unmixing methods based on machine learning do not require pure end members, but they still need a great deal of supervised information (i.e., the proportion of each land cover class in the mixed pixels) to train learning models. Moreover, most of the spectral-unmixing methods are carried out using images on a single day, and the few studies on handling time-series data are not suitable for dynamic monitoring (Zurita-Milla *et al.* 2011; Deng and Zhu 2020). To enhance the reliability of spectral unmixing, in our previous work (Q. Wang *et al.* 2021a), we proposed a spatiotemporal spectral-unmixing (STSU) method for spectral unmixing of MODIS time series, which explores the multi-scale spatiotemporal information in auxiliary MODIS–Landsat pairs. STSU detects land cover change and extracts supervised information of mixed spectra in MODIS images at the prediction time, so as to construct training samples to train learning models. The STSU model needs MODIS–Landsat data both before and after the prediction time, which is suitable for handling historical time-series data. For areas where the land cover changes rapidly, it is necessary to exploit real-time images for timely monitoring—that is, it is of important application value to investigate spectral unmixing of real-time data.

In response to these requirements, Q. Wang *et al.* (2021b) proposed a real-time spatiotemporal spectral-unmixing (RSTSU) method. Different from STSU, RSTSU was designed for real-time data, and needs only the coarse–fine spatial-resolution image pair before the real-time data. Moreover, RSTSU performs change detection on two coarse-spatial-resolution images to extract unchanged pixels at the prediction time as training samples, and trains an effective machine-learning model. Based on the trained model, the proportion of all pixels in the real-time coarse image can be predicted.

Under normal circumstances, in the RSTSU method, spatially complete (e.g., without cloud contamination) auxiliary data at the previous time are required. Therefore, the time interval between the effective auxiliary data and the prediction data is usually longer than expected, and the land cover in the two images may change greatly. Correspondingly, there can be greater uncertainty in the unchanged pixels extracted by change detection. Thus, to enhance the reliability of training samples, we should choose the data temporally closest to the prediction time. However, the image at the closest time is susceptible to cloud contamination (Chen *et al.* 2017; Q. Wang *et al.* 2020; Q. Wang, Wang *et al.* 2021), leading to missing data in part of the image. Meanwhile, due to the reduction in the number of effective auxiliary data, the number of extracted training samples is also reduced, imposing a negative effect on the training process and thereby affecting the final spectral-unmixing predictions. It should be noted that a number of methods have been developed for cloud removal, but most of them need temporally close data with spatially complete coverage (Shen *et al.* 2015; Gao and Gu 2017; Goward *et al.* 2019).

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Effect of Locust Invasion and Mitigation Using Remote Sensing Techniques: A Case Study of North Sindh Pakistan

Muhammad Nasar Ahmad, Zhenfeng Shao, and Orhan Altan

Abstract

This study comprises the identification of the locust outbreak that happened in February 2020. It is not possible to conduct ground-based surveys to monitor such huge disasters in a timely and adequate manner. Therefore, we used a combination of automatic and manual remote sensing data processing techniques to find out the aftereffects of locust attack effectively. We processed MODIS-normalized difference vegetation index (NDVI) manually on ENVI and Landsat 8 NDVI using the Google Earth Engine (GEE) cloud computing platform. We found from the results that, (a) NDVI computation on GEE is more effective, prompt, and reliable compared with the results of manual NDVI computations; (b) there is a high effect of locust disasters in the northern part of Sindh, Thul, Ghari Khairo, Garhi Yaseen, Jacobabad, and Ubauro, which are more vulnerable; and (c) NDVI value suddenly decreased to 0.68 from 0.92 in 2020 using Landsat NDVI and from 0.81 to 0.65 using MODIS satellite imagery. Results clearly indicate an abrupt decrease in vegetation in 2020 due to a locust disaster. That is a big threat to crop yield and food production because it provides a major portion of food chain and gross domestic product for Sindh, Pakistan.

Introduction

Locusts are a species of insects that are and have been threatening food security in the history of humankind. Many international organizations are working on the prevention of locust plagues because it directly damages massive crop and cultivated areas. In a report of the United Nations Food and Agriculture Organization (FAO), locusts travel in clusters (Ma *et al.* 2005) with a count of approximately more than 80 million per square kilometer. It is an overall estimate that 10% of the livelihood (Latchininsky 2013) of the world population is affected by locust disaster each year. FAO also initiated the Desert Locust Plague Prevention Programme, which supports information on a global scale and gives early warning systems on agriculture and food security (Hielkema *et al.* 1986).

To prevent the locust invasion, early identification, prompt control, and continuous information of locust population (Michael *et al.* 2017) is required along with the condition of vegetation and rainfall data. Sufficient precipitation gives the necessary soil moisture for supporting the advancement of dense vegetation (Hielkema and Snijders 1994), which is used by the locusts as a source of food and shelter.

Remote sensing satellite products are permitting researchers to monitor locust disasters using both moderate- and high-resolution imagery. Remote sensing satellite products are suitable to identify locust populations on a large topographical scale for estimating areas invaded due to locust disaster (Ji *et al.* 2004). The use of satellite products for monitoring locust habitat is very advantageous (Bryceson and Wright 1986; Justice *et al.* 1985; Tappan *et al.* 1991). It involves determining reflected interaction between spectral radiance and green-leaf vegetation cover (Tuckler *et al.* 1985) that can be extracted from satellite data. Dynamic properties of satellite imagery have proved that it has the potential to detect the effects of locusts on vegetation and for determining the crop losses (Dottavio and Williams 1983; Rencz and Nemeth 1985; Wewetzer *et al.* 1993).

The Advanced Very High-Resolution Radiometer (AVHRR) can provide exceptional results compared with other satellite products. AVHHR sensors are based on environmental polar-orbiting that is provided by the National Oceanic and Atmospheric Administration (NOAA) and has a significant capability to identify such ecological phenomenon on a regional scale (Hielkema and Snijders 1994). However, there is a limitation on data availability because very high-resolution and high-frequency data is required to monitor locust movement, which can be achieved by installing more satellites to enhance the capability of satellite imagery.

In moderate-resolution satellites and open-source data, normalized difference vegetation index (NDVI) has more potential for early detection and monitoring of epidemic regions (Cherlet and Hielkema 1989; Ma *et al.* 2005). In a report, the Australian Plague Locust Commission discussed the strength of NDVI products because it principally focuses on red and near-infrared spectral bands, which is very speedy and efficient (Kriegler *et al.* 1969) for the detection of vegetation change. MODIS is providing NDVI products with a high temporal resolution that covers the globe and monitor Earth's vegetation activities (Ji *et al.* 2004; Huete *et al.* 1999) in 1–2 days. It is available in a moderate spatial resolution from 250 meters to 1 kilometer. That supports research applications primarily related to vegetation loss and change detection. For example, dense vegetation has a higher reflectance value in the near-infrared region as compared with the green area. Additionally, more applications are necessary to control the locust attack on a large-scale (Latchininsky and Sivanpillai 2010; Beck *et al.* 2006) because it also affects our environment and can be more harmful in future.

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Call for Submissions

AI-Based Environmental Monitoring with UAV Systems

Photogrammetric Engineering and Remote Sensing (*PE&RS*) is seeking submissions for a special issue on AI-Based Environmental Monitoring with UAV Systems.

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

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

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

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

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

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

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

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Remote Sensing and Human Factors Research: A Review

Raechel A. Portelli and Paul Pope

Abstract

Human experts are integral to the success of computational earth observation. They perform various visual decision-making tasks, from selecting data and training machine-learning algorithms to interpreting accuracy and credibility. Research concerning the various human factors which affect performance has a long history within the fields of earth observation and the military. Shifts in the analytical environment from analog to digital workspaces necessitate continued research, focusing on human-in-the-loop processing. This article reviews the history of human-factors research within the field of remote sensing and suggests a framework for refocusing the discipline's efforts to understand the role that humans play in earth observation.

Introduction

Understanding the earth's physical and cultural environments is critical for facing today's biggest challenges, such as climate change (Reichstein *et al.* 2019) and food security (Wen *et al.* 2021). Unfortunately, data collection currently outpaces knowledge generation (Maxwell *et al.* 2018). Therefore, remote sensing is becoming more reliant on artificial intelligence (AI) to facilitate different components of the image-analysis pipeline. However, even though these increasingly computer-based methods have improved the accuracy of data products for a range of applications—including agriculture, environmental epidemiology (VoPham *et al.* 2018), and sustainable development (Holloway and Mengersen 2018)—AI systems are notoriously brittle when presented with novel cases (Tuia *et al.* 2016).

Understanding human performance and barriers to success in interpretation has essential implications for the further development of geospatial AI. First, for as long as computational methods have been in development, human operator performance has served as a benchmark for computational image-analysis algorithms. Second, integrating human knowledge and domain expertise leads to improved outcomes in terms of increased reliability and robustness. Third, humans have cognitive abilities, such as contextualization, that scientists have yet to replicate adequately in a computational methodology. For these reasons, the research community must continue to be inclusive of human-oriented research.

The concept of human-extended machine cognition suggests a system that integrates human agents' activity with a collection of machine-based processing routines with the intent of leveraging the strengths of the two cognitive systems (Smart 2018). Human cognition is efficient and flexible when faced with visual tasks (Crowe 1998). The field of visual analytics has rallied around the idea that interactive visual interfaces enhance human visual interpretation, supporting discovery, hypothesis making, testing, and verification (Yusoff and Salim 2020). Geographic information scientists have proposed these types of systems in the past, but adoption by scientists in earth-observation research has been limited. Despite this, human-factors research concerning image interpretation is still carried out, although many studies are ancillary to a considerable amount of computationally focused scientific research.

We argue that the relegation of human-factors research to the fringe of earth-observation science is wholly at odds with other image-based sciences, thereby limiting possible innovation. However, science is supported by prior work, which suggests a need for a review of that body of work. Two previous research volumes addressing human factors relating to image analysis were published by Hoffman and Markman (2001) and White *et al.* (2018). Both volumes contain research perspectives and reports on recent expertise and perceptual-skill research from psychologists, remote sensing professionals, and geographic scientists. The earlier volume leans strongly toward terrain analysis, whereas the second volume introduces more cartographically oriented research. Many of the studies reported in those volumes are represented here through their peer-review publications.

This article reviews cognitive research in earth-observation remote sensing, its impact on computational methods of image analysis, and a conceptual model of the current research landscape. It presents the critical challenges that a cognitively informed approach to earth observation faces and the research questions addressing those challenges.

Background

In remote sensing image analysis, cognitive research is rooted in air photointerpretation training (Bianchetti and MacEachren 2015). The *Stanford Encyclopedia of Philosophy* defines *cognitive science* as the "interdisciplinary study of mind and intelligence, embracing philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology" (Thagard 2019). Cognitive science is an essential component of understanding geospatial data (Raubal 2018). Cognitive geographic information science is motivated by improving the usability, efficiency, equity, and profitability of geospatial data, and cuts across numerous geospatial applications (Montello 2009).

The earliest consideration of human factors of image interpretation informed the training of new interpreters during World War I (Campbell 2008). There was a need to select and train the best candidates. Tools such as the Army Individual Test of General Ability were established to evaluate recruits' prior experience and individual qualities. While air photointerpretation was relatively new at the onset of World War I,

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Multi-View Urban Scene Classification with a Complementary-Information Learning Model

Wanxuan Geng, Weixun Zhou, and Shuanggen Jin

Abstract

Traditional urban scene-classification approaches focus on images taken either by satellite or in aerial view. Although single-view images are able to achieve satisfactory results for scene classification in most situations, the complementary information provided by other image views is needed to further improve performance. Therefore, we present a complementary information-learning model (CILM) to perform multi-view scene classification of aerial and ground-level images. Specifically, the proposed CILM takes aerial and ground-level image pairs as input to learn view-specific features for later fusion to integrate the complementary information. To train CILM, a unified loss consisting of cross entropy and contrastive losses is exploited to force the network to be more robust. Once CILM is trained, the features of each view are extracted via the two proposed feature-extraction scenarios and then fused to train the support vector machine classifier for classification. The experimental results on two publicly available benchmark data sets demonstrate that CILM achieves remarkable performance, indicating that it is an effective model for learning complementary information and thus improving urban scene classification.

Introduction

With the rapid development of remote sensing technology, traditional pixel-level image analysis has been unable to meet the needs of high-level image-content interpretation due to increasing spatial resolution, and urban scene classification has therefore been a hot topic in the remote sensing field (Zhou *et al.* 2018). Scene classification is assigning a specific label to each image according to its content (Kang *et al.* 2020), providing relatively high-level interpretation of a remote sensing image compared with pixel- and object-based classification (Xia *et al.* 2017). It is a practical application of high-resolution remote sensing image processing, which can provide data support for land planning and utilization (K. Xu *et al.* forthcoming), and is widely used in urban functional zoning planning (Huang *et al.* 2018), natural-disaster monitoring (Attari *et al.* 2018), and object detection (Schilling *et al.* 2018). Though the literature has developed a large number of scene-classification approaches—including handcrafted methods and ones based on deep learning—which can achieve remarkable performance, there are still problems to be solved.

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On one hand, a high-resolution remote sensing image has rich spatial information and a complex background, making it difficult to extract powerful features for scene classification (T. Tian *et al.* 2021), and accordingly results in worse performance. On the other hand, most of the existing scene-classification approaches focus on images taken from a single view, such as satellite or aerial, but it has been demonstrated that the complementary information provided by other views is able to further improve classification performance (Machado *et al.* 2021), as shown in Figure 1. It is notable that scene classification of an aerial image can benefit from the complementary information provided by a ground-level image, and vice versa. For instance, we cannot obtain the correct classification result of an airport unless both aerial and ground-view images are exploited. In recent work by Machado *et al.* (2021), early and late fusion based on a convolutional neural network (CNN) are exploited to perform multi-view scene classification. More specifically, the early fusion is conducted by fusing the convolutional features of each view via a concatenation layer, whereas the late fusion is conducted by combining the prediction result of each view achieved by an individual CNN. Both early and late fusion have been proven effective for scene classification, but for early fusion, the concatenation layer is inserted in the first several convolutional layers, which cannot integrate the high-level features of each view image. For late fusion, an individual CNN must be trained for the prediction of each view image, and the training process is time-consuming and totally separated. We therefore raise the question: *Is it possible to learn complementary information via feature-level fusion and perform multi-view classification using a single* CNN *framework*?

Inspired by cross-view geo-localization (Vo and Hays 2016; T. Tian *et al.* 2021), in this article we extend our previous work (Geng *et al.* 2021) and propose a complementary information-learning model (CILM) for multi-view urban scene classification of aerial and ground-level images. The proposed CILM is a two-branch network trained using a unified loss to enhance the performance. Once CILM is trained, the high-level features of each view image are extracted and then combined to train a support vector machine (SVM) classifier to perform the final prediction. It should be noted that our work is different from that of Machado *et al.* (2021) in that, although both approaches take aerial and ground-level image pairs as input, for Machado *et al.* aerial and ground-level images in each pair are from the same location and the same class, whereas we ignore the location and the class of image pairs. Therefore, we explored how the information provided by pairs of images from different locations can benefit urban scene classification. Also, in our work, CILM is regarded as a feature extractor for extracting high-level features of each view image, which is not exploited for prediction. And we train an SVM classifier

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