PE&RS

July 2023

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Photogrammetric Engineering & Remote Sensing

The official journal for imaging and geospatial information science and technology

ANNOUNCEMENTS

The National Oceanic and Atmospheric Administration has signed **Woolpert** to a $7 million contract to perform hydrographic surveying and collect bathymetric data in and around Nome, Alaska. These data will support commercial fishing, shipping channels, coastal resilience, scientific research, and Seabed 2030, a collaborative project that aims to map the world's ocean floor by 2030.

Woolpert will collect data over 1,874 square nautical miles in Northern Norton Sound, which stretches from Golovin Bay through Nome to Cape Woolley on the eastern edge of Alaska. Nome is adjacent to the Bering Strait and central to America's marine presence in the Arctic. The region serves as a major transit route for shipping traffic to the Port of Nome, which has supplied food, construction materials, equipment, and other goods for over 60 Alaskan communities for more than a century.

Regional hydrographic data was most recently collected in the 1930s. This project will update National Ocean Service nautical charting products and services and will support the Seabed 2030 Project. This collaborative effort between the Nippon Foundation and the General Bathymetric Chart of the Oceans aims to integrate and share all available bathymetric data to produce a definitive map of the world's ocean floor by 2030.

Woolpert has collected topographic, bathymetric, and hydrographic data in and around Alaska for decades and has an office in Wasilla. Multiple hydrographic survey vessels will be used to collect these data, including two large live-aboard ships and two Wave Adaptive Modular Vessels (WAM-Vs). The WAM-Vs will be used primarily in a force multiplication strategy in coordination with the larger vessels performing this work. A combination of the right tools and experience are critical for this contract.

"Hydrographic surveying in Alaska can be logistically challenging, and moving equipment requires a range of vehicles and aircraft," Woolpert Certified Hydrographer Dave Neff said. "Local knowledge and relationships are highly beneficial for any project in Alaska. Our work over the years both as Woolpert and eTrac, a Woolpert Company, has given us the scope and confidence to cost-effectively execute, while managing inherent regional risk. We're at home in Alaska, and we are excited to provide these needed data for Nome and all who rely on the region for goods and services."

This project will get underway in June and is expected to conclude in September.

NV5 Geospatial announced it has completed lidar data collection across 5,125 square miles of Eastern Massachusetts. The detailed data – collected as part of the U.S. Geological Survey (USGS) 3D Elevation Program (3DEP) and now publicly available from Massachusetts Bureau of Geographic Information (MassGIS) – uncovered 1,000 primary addresses and over 10,000 structures previously unidentified by imagery alone, offering insights the Commonwealth can use to support emergency services, property tax assessment and boundary infringement inquiries, and saving time and money required for additional boots-on-the-ground examinations.

The collection also provides useful elevation data to support infrastructure, transportation and utility projects; improve the accuracy and precision of hydrologic network mapping; and classify and manage structures and vegetation.

"This new lidar survey replaces data from about 10 existing ad hoc elevation mapping projects completed over the last 25 years by various public agencies, each with differences in coverage, accuracy and point density," said Peter Grace, GIS Analyst and 911 Team Lead for the Massachusetts Executive Office of Technology Services and Security (EOTSS).

In Spring 2021, the USGS, on behalf of MassGIS, contracted with NV5 Geospatial to acquire the eastern portion of Massachusetts at a QL 1 lidar specification, which is four times more detailed than previous specifications. As part of 3DEP, federal grant funds for the project were provided to a partnership coordinated by MassGIS, between the Massachusetts Department of Transportation, the Executive Office of Energy and Environmental Affairs (EEA), the Executive Office of Technology Services and Security (EOTSS), and the Cape Cod Commission.

"Our collaboration with the USGS and NV5 enabled us to deliver valuable data that can be applied in numerous ways," said Neil MacGaffey, retired director of MassGIS, who initially led the project. "This freely available data can help municipalities and state agencies improve infrastructure designs and gain a better understanding of structures in their jurisdiction, make communities more resilient, model stormwater volume and areas at risk from flooding more accurately, and ultimately minimize the spend for all interested parties valuable through economies of scale in data acquisition."

For more information about the MassGIS project and NV5 3DEP work, contact Drew Meren, Drew.Meren@nv5.com.

ACCOMPLISHMENTS

This March at its inaugural Tech Summit, Liberty Latin America recognized Esri with an Innovative Small Suppliers Award at the summit's 2023 Vendor Awards. The telecommunications company serving Latin America and the Caribbean honored Esri, the global leader in geographic information system (GIS) technology at the event which showcased the contributions made by key vendor partners.

The Summit focused on the critical importance of innovation in driving business opportunities and economic development across the region, as well as how Liberty Latin America is improving customer experience through automated tools, developing new products, growing fixed-mobile convergence, and providing next generation B2B solutions.

Esri's GIS software is used by Liberty Latin America to improve the operations of its various regional departments which are spread out across the region as well as in the Caribbean. The company was able to expand service at scale, while increasing collaboration. Deploying the Esri apps, ArcGIS Survey123 and ArcGIS Collector, they were able to solve complex business challenges related to mobile data gathering in new and innovative ways. All these new implementations saved Liberty Latin America time and money for customers, while also establishing them as a leader in the industry, providing service where it is needed most.

"This first Tech Summit aligns perfectly with our company's purpose of connecting communities and changing lives," said Aamir Hussain, Liberty Latin America's Chief Technology and Product Officer. "Our focus on driving growth through innovation is essential to stay ahead in today's fast-paced world. We are thrilled to showcase our cutting-edge products and solutions and learn from industry-leading speakers. With the collective wisdom and insights gained from this event, we look forward to driving innovation that will create a positive impact across our region."

Liberty Latin America showcased its products and services at the summit, including Hybrid Cloud, Private Networks, Always On connectivity, Next-Gen Unified Communications, Video Analytics, its portfolio of 5G Handsets, and how e-SIM will be deployed across the region. In addition, the company shared how it is preparing its fixed networks to deliver higher speeds, enhancing mobile performance through a new wireless core, and enabling IT transformation.

Esri was one of five suppliers to be recognized for their contributions to Liberty Latin America's telecom service innovations.

ASPRS & GEO WEEK — STRONGER TOGETHER IN 2024

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Exciting News! For the first time in 2024, Geo Week will offer attendees a single comprehensive conference pass that provides access to Geo Week conference sessions and ASPRS conference sessions.

By uniting these two premier conferences, Geo Week offers an unprecedented opportunity for professionals engaged in photogrammetry, remote sensing, GIS, and related technologies to extract maximum value from attending. You'll gain insights through technical deep-dives, stay informed with the latest project updates, delve into real-world case studies, explore cutting-edge hardware and software applications, acquire essential workflow best practices, and more.

The conference pass includes entry to the Exhibit Floor, select networking events, the Geo Week Awards Ceremony, and the new Student Hub featuring student presentations and posters. In addition to the main conference programming, ASPRS will host pre-show workshops for an additional fee.

As always, ASPRS members will receive a member discount that will be available on the ASPRS website when registration opens in October. The Conference Program will be posted in late October. Find all event updates at www.geo-week.com.

SAVE THE DATE!

PE&RS
PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING
The official journal for imaging and geospatial information science and technology
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401 **SectorInsight.com—The Journey from a Ph.D. to a Successful Company**
By Kevin Lim, Ph.D.

COLUMNS

ANNOUNCEMENTS

Call for *PE&RS* Special Issue Submissions

DEPARTMENTS

See the Cover Description on Page 400

COVER DESCRIPTION

Perched on the Qinghai-Tibetan Plateau in western China, Qinghai Lake is a biodiverse outpost within the arid steppe—and a sensitive indicator of the region's climatic shifts. The lake's fluctuating water level serves as a de facto gauge of climate change in this high-altitude watershed.

Recent changes in the lake level are apparent in this pair of satellite images, captured by the Thematic Mapper (TM) on Landsat 5 on July 29, 2010 (above), and by the Operational Land Imager-2 (OLI-2) on Landsat 9 on July 22, 2022 (cover). Sand spits stretching nearly 25 kilometers (15 miles) once cleared the water's surface and cordoned off lakes within the lake. However, they were mostly submerged by 2022.

Researchers measuring water levels in Qinghai Lake reported that the level declined steadily at an average rate of 8 centimeters (3 inches) per year from 1961 to 2004. At that point, the trend reversed, and the lake started rising at 18 centimeters (7 inches) per year through the end of the study period in 2019.

The striking turnaround coincided with trends of warming and wetting, according to the authors. Lake levels declined prior to 2004 primarily due to decreased river runoff. The subsequent rise in lake levels was driven by increasing precipitation and river runoff, as well as decreasing evaporation. (There is no outflow from the lake.) Though less evaporation doesn't intuitively track with warming temperatures, the researchers note that temperature increases were more significant in winter months, when the lake was covered with ice, than in summer months. Summers saw more precipitation, which meant more cloudy days, higher humidity, and therefore less evaporation.

The evolution of the sand spit is one of the more dynamic effects of the lake's fluctuations. When water levels were lower, more lakebed sediments were exposed to the prevailing westerly winds, which swept the sediments to the eastern shore of the lake. As dunes built up there, they divided Qinghai Lake into several sub-lakes, including Shadao Lake (centered in the top-left image) and Haiyan Bay (toward the bottom-right of the wider view). These lakes appear isolated from Qinghai Lake in the 2010 image but were mostly reincorporated in 2022.

The importance of Qinghai Lake and its wetlands goes beyond its climate signals. Many species are endemic to the plateau, and the endangered Przewalski's gazelle lives only around Qinghai Lake. The ecosystem also plays a critical role as a breeding and stopover site for many migratory waterbirds along the Central Asian and East Asian Flyways.

The full version of both images can be downloaded from https://landsat.visibleearth.nasa.gov/view.php?id=151316.

NASA Earth Observatory images by Allison Nussbaum, using Landsat data from the U.S. Geological Survey. Story by Lindsey Doermann.

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THE IMAGING & GEOSPATIAL INFORMATION SOCIETY

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All written correspondence should be directed to the American Society for Photogrammetry and Remote Sensing, PO Box 14713, Baton Rouge, LA 70898, including general inquiries, memberships, subscriptions, business and editorial matters, 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.

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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*. Annual Individual Membership dues are $175.00 USD and Student Membership dues are $50.00 USD. A tax of 5% for Canada's Goods and Service Tax (GST #135123065) is applied to all members residing in Canada.

Kevin Lim, *Ph.D.*

The Journey from a Ph.D. to a Successful Company

At the start of my doctoral studies, I wasn't sure whether I would remain in academia or transition to a career in the forestry industry. I had a foot in each door, with an applied research project on the use of airborne lidar to map forests funded by both academic and industry sources. Ultimately, my entrepreneurial side prevailed. I spent the final two years of my PhD working in industry and, upon graduation in 2006, decided to take my work to market. A common view among my peers was that there was a great deal of innovation "locked in academia": student research that unfortunately never left campus, despite its potential industry benefits. I had always been curious to find out why this might be so, and I reasoned that by using my own work as a test case, I would get a crash course in facing the challenges of transforming promising research into a profitable business. While I can now safely call it a success story–Lim Geomatics has pioneered numerous forestry technology solutions and is one of Canada's fastest growing companies—the climb has, at times, been steep.

In the start-up phase, I discovered an ironic disconnect between business training and real life. The former centres on creating ideal situations and analyzing them to the last detail: skills ill-suited to navigating the quick, unpredictable flow of life as an entrepreneur. Spending a month painstakingly creating a business plan doesn't keep things from veering off in an unpredictable direction the minute you make your first sale. As a self-taught CEO, I believe entrepreneurship is more a matter of character than education. Mental agility is key to maintaining momentum in the face of uncertainties, and keeping a level head allows you to gain wisdom from failure rather than dwelling on it. You have to blow yourself up, you have to trip a million times; otherwise, you're not going to learn.

Looking back, like many other new grads, I entered the business world wearing rose-coloured glasses, hopeful that prospective clients would be as enthusiastic about my work as I was and would see its value as clearly as I did. Often, fresh science graduates are so focused on their product or solution, the technical magic they've brought to life, that they lose sight of what it really takes to go to market. Unfortunately, hope is not a viable business strategy. Value is determined by the customer, not by how technologically impressive the product is or how strongly its creator believes in it–and being a business means actually selling something. As an example, I once attended a conference and met a scientist who had developed some new technology. Although I wasn't interested in acquiring the entire product, I saw that one small element of it would be beneficial in a range of contexts at my company. I was eager to discuss buying just that piece, but the scientist was unwilling to consider it, instead attempting unsuccessfully to convince me that the true value was in the product as a whole. That all-or-nothing approach, the insistence on keeping one's work intact and "perfect," may serve a researcher well in academia, but it proves self-defeating in business. A piece of the work, if it comes at the right time and solves the right problems, may be of greater value than the whole from the customer's standpoint.

Working in forestry also brings some industry-specific challenges. At Lim Geomatics, we're still trying to commercialize, to some extent, what we've had for 16 years. Even after demonstrating to a prospective client exactly how adopting our technology would streamline their processes or reduce their costs, there's no guarantee of buy-in. No matter how many success stories we have from forestry companies that have chosen to work with us, others still aren't ready to go out on a "lim(b.)" I'm confident that the quality of the technology isn't the problem, and I don't think money is the deciding factor either: many

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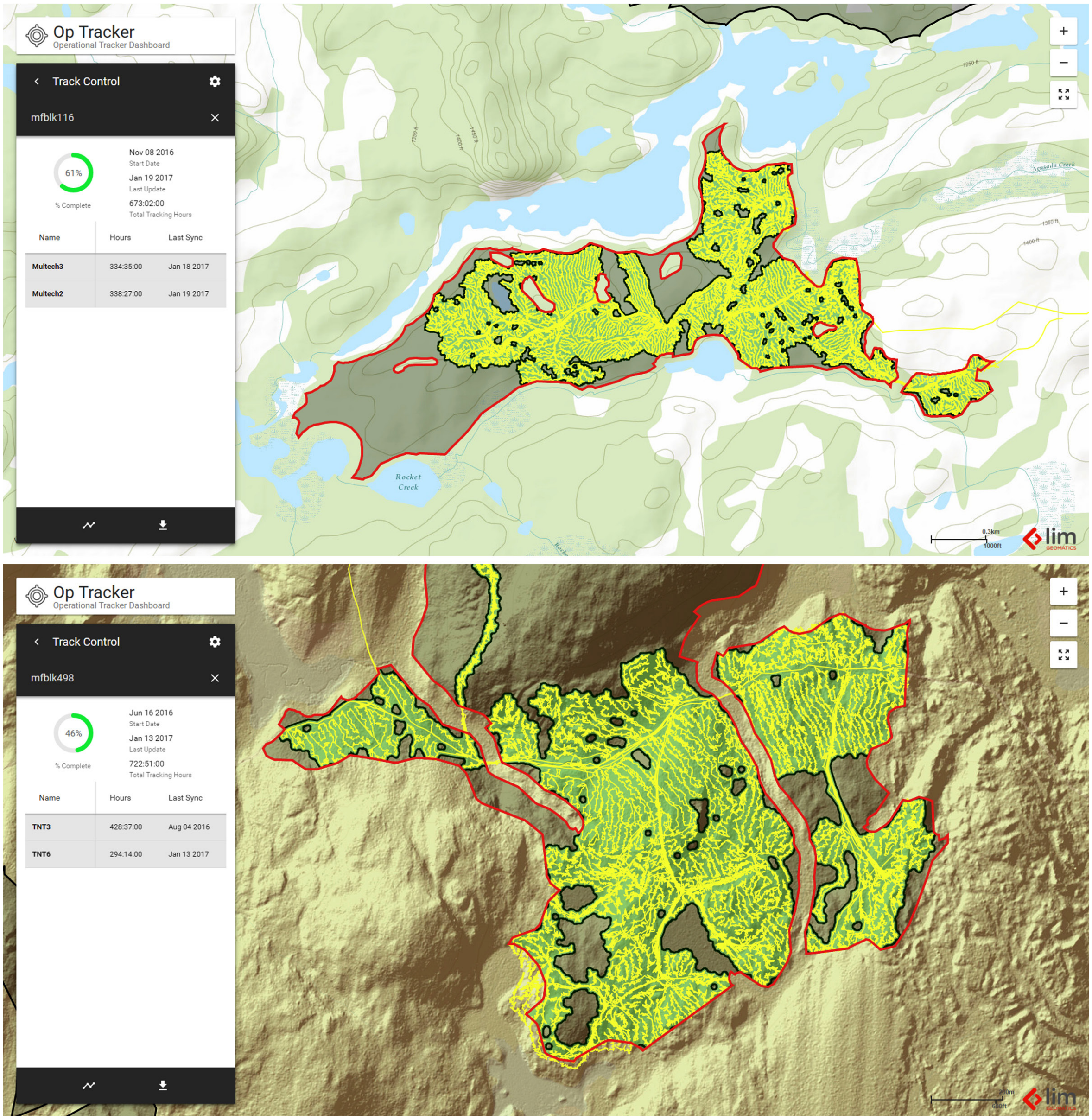

These are screenshots of feller buncher machine tracks (yellow) and the areas harvested (green buffer). The harvested areas are referred to as depletion areas or as-builts. Our mobile technology is installed in the cabs of forestry machines so we can track and report on productivity, specifically productive machine hours (PMH). The lower image shows a hillshade derived from airborne lidar. Both images are delivered through the Op Tracker web application. In this example, lidar remote sensing data, telematics, and GIS are merged together to provide insights into timber harvesting operations.

of the companies that are hesitant to permanently adopt new technology are happy to fund any number of pilots. The main obstacle, as I see it, is resistance to change. For the client, adoption of new technology requires a solid change-management strategy. Although the transition will ultimately result in smoother workflow and decreased costs, it does come with a degree of uncertainty in its early stages, and adaptation to new tools and procedures may temporarily increase the workload of employees who are already stretched thin. Another major factor of change-resistance is that the forestry industry often takes a "traditional" approach to business relationships, preferring to work with familiar companies and revisit past connections over trying something—or someone—new.

How, then, does a new player compete? For one thing, I recommend that novice entrepreneurs consider partnering with more established companies, a strategy I myself unwisely resisted in my company's early days. One person competing against a small business, let alone a large and well-established company, is a David vs. Goliath situation that rarely has the same positive outcome as the story. While collaboration must be undertaken carefully due to the risk of intellectual property being appropriated, it also comes with advantages, such as network connections and greater industry visibility. A second and more important strategy is establishing trust. "People aren't buying you, they're buying the brand" is a saying I have come to understand in the process of building my company—and for me, trust is the foundation of every partnership. Companies that sign with Lim Geomatics trust us to deliver, to do the right thing, based on our brand.

When it comes to building a business, I don't think there is a "right path." Mine has entailed tremendous personal and professional growth, from bootstrapping as a new entrepreneur to

These are screenshots from AFRIDS (Advanced Forest Inventory Decision Support), a solution that allows foresters to interact with forest inventory information products derived from airborne lidar. The upper image shows RGB imagery blended with a canopy height model derived from lidar. A user can draw a block and, within seconds, receive analytics on it: for example, area, volume, height and basal area data. The graph in the lower image is an expanded view of the top pop-up. It presents forest inventory data derived from airborne lidar in addition to diameter distribution data by volume and density.

scaling the operations of a nearly 20-year-old company. Along the way, mentors have been instrumental, providing both opportunities and inspiration. I would highlight the influence of my father, who also built a successful career in computer science; my doctoral supervisor Dr. Paul Treitz, who was always great in enabling my curiosity; Dr. Bob Ryerson, who (after a briefly tense exchange over pizza about similar-sounding company names) entrusted me with door-opening technical work in the Maldives; and now the other CEOs who comprise TEC Canada, notably Pascal St-Jean. I am optimistic that the forestry technology industry is on an upswing. One can cite a current wave of long-standing, more traditional companies that have built up more technical capacity or bought some intellectual property. Innovation remains a key interest of mine: I'm always on the lookout for ideas with commercial potential, and in the future I hope to start a "uni bootcamp" for scientists seeking to market their work. Commercializing academic research is hard—but it shouldn't be!

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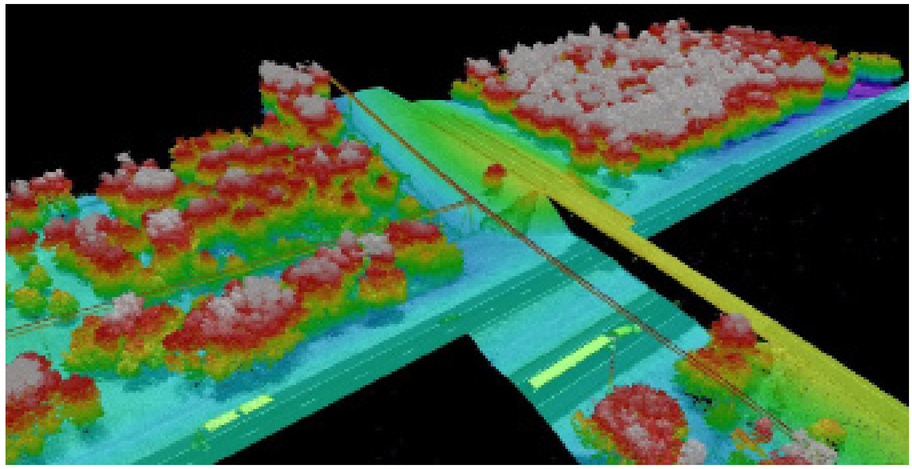
Geospatial Solutions

Pickett provides aerial LiDAR, aerial mapping and imaging, land surveying, hydrographic surveying and engineering services to clients throughout the US and Caribbean. Pickett specializes in offering the simultaneous collection of high resolution Aerial Imagery combined with engineering-grade airborne LiDAR, allowing us to turn around baseline imagery and LiDAR-derived data quickly and efficiently. We deliver CADD and GIS-ready products to meet unique client specifications. Our clients come to us for the most complex projects because of our proven track record of producing deliverables efficiently, safely, cost-effectively and on schedule. With over 60 years of experience, we have established ourselves as leaders and innovators in the surveying and geospatial industry. Contact us today to see how our geospatial services can benefit next your project.



The Optech G2 LiDAR System and Optech Galaxy PRIME LiDAR sensor are some of the many tools we use for a myriad of LiDAR applications with point densities up to 150 points per square meter. When used in conjunction with our iXU-RS 1000 medium-format camera, this system produces a complete picture of site conditions.

The Teledyne Optech G2 LiDAR System and Optech Galaxy T2000 LiDAR sensor are some of the many tools we use for a myriad of LiDAR applications. When used in conjunction with our Phase One iXU-RS 1000 and iXM-RS150F medium-format cameras, these systems produce a complete picture of site conditions.

In the energy sector, we perform aerial surveys of corridors with lengths of 1 mile to 100 miles, with a point density of 50 points per square meter, or more. For the mining sector, we provide aerial surveys ranging in size from 1-acre stockpiles to several thousand acres, using the data to create digital surfaces and compute high-accuracy volumes for accounting purposes. Land development projects range in size from 20 acres to 100 square miles, and occasionally more, finalizing into a detailed topographic survey.

We utilize a RIEGL terrestrial scanner for smaller projects where high-resolution, high-accuracy LiDAR data is required. In combination with the top-mounted DSLR camera, we can create photo-realistic point clouds to survey and document as-built conditions of almost any feature.

Our aerial platform consists of a 2015 Cessna T-206H Turbo Station Air and a 1981 Cessna T-210N Turbo Centurion, both modified with FAA approved camera ports for aerial surveys. Pickett has multiple Unmanned Aerial Systems, and complies with FAA Part 107 regulations, to provide UAS services commercially

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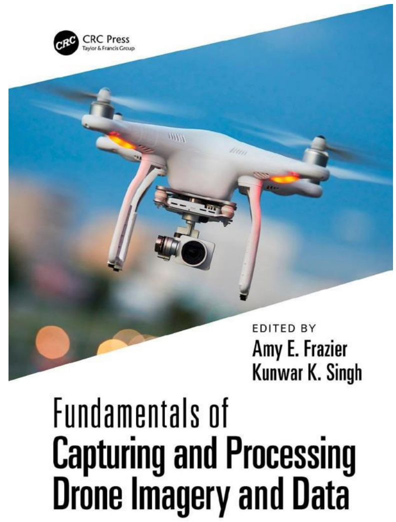

Fundamentals of Capturing and Processing Drone Imagery and Data

Amy E. Frazier and Kunwar K. Singh, Eds.

CRC Press: Boca Raton, FL. 2021. Xxiii and 361 pp., diagrams, maps, photos, images, index. Electronic copy. $130.00(hbk), $91.00(ebk) ISBN: 978-0-367-24572-6 (hbk), 978-1-032-02249-9 (pbk), 978-0-429-28323-9 (ebk).

Reviewed by M.Kathryn Rocheford, PhD, Research Archaeologist, Minnesota Historical Society, Saint Paul, Minnesota.

The editors have compiled a tremendous tome that includes contributions from a multitude of authors have met their reported goal for this book to be accessible to someone with little or no training in collecting and processing drone imagery and data. The editors, Frazier and Singh, have organized the contents of the book in two parts. The Introduction in Part I lays out the contents of the book in tantalizing detail to support picking and choosing the topic(s) of interest. Part I goes on to outline drone terminology and a variety of their real-world applications, as well as an introduction to the concepts of remote sensing and photogrammetry as they pertain specifically to drones. It then presents the specifics for sensor selection, flight planning, drone regulations, and imagery processing using structure from motion (SfM).

The second part of the book provides users with twelve real-world applications written with learning objectives, detailed instructions, and discussion and synthesis questions, making this book a valuable source for students and educators. Data for the hands-on exercises are provided through a web link in the book's introduction. However, the first file to "load" for Chapter 8 is not included in the data set but using the next data set works. The software utilized for the exercises is either free or trial downloads are available, and the links to access them are in the instructions. As the authors noted, every publication that provides links to external websites is prone to broken links and this book is no exception. For example, the Chapter 8 link to the Mission Planner software is not correct, it directs you to the main ArudPilot page and there is no menu panel on the left. However, a quick Google search for Mission Planner ArduPilot will take you to the menu panel. In addition, the ArduPilot site has changed the menu item for First Time Setup. It has been removed and will take some technical savvy to get to the right place. Most instructors know that published computer exercises need to be tested so that minor changes like these can be debugged before giving them to students.

The editors and contributing authors do an excellent job of synthesizing a variety of topics within the context of drone captured imagery and data that are supported with plenty of references for those who want to dig in deeper. Synthesizing the art and science for drone applications was not an easy task, as each topic has a variety of applications other than drones, (e.g., electromagnetic energy, sensor technology, and structure from motion). Instructors and students alike will recognize the basic concepts from other course work and be able to expand their knowledge into the use of drones.

The twelve Hands-On Applications provide enough content for a typical college semester of 15 weeks. Each chapter provides a real-world application from the foundational chapters: Planning Unoccupied Aircraft Systems (UAS) Missions and Aligning and Stitching Drone-Capture Images, to utilization of data from specific sensors, including RGB and multispectral, point cloud from SfM, as well as sensors to measure atmospheric parameters. Recognizing the expense of lidar equipment and the issue with payload mentioned by the authors, this reviewer wanted to see an example that utilized lidar data obtained using a UAS. Finally, there is a variety of discipline specific applications including wildlife management (Chapter 10), vegetation assessment (Chapters 11 & 13), geomorphology (Chapters 14 & 15), cultural resource management (Chapters 16 & 17), and atmospheric monitoring (Chapters 18 & 19), providing something for

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The layman's perspective on technical theory and practical applications of mapping and GIS

MAPPING MATTERS

YOUR QUESTIONS ANSWERED

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

- **Have you ever wondered about what can and can't be achieved with geospatial technologies and processes?**
- **Have you been intimidated by formulas or equations in scientific journal articles and published reports?**
- **Would you like to understand the geospatial industry in layman's terms?**
- **Do you have a challenging technical question that no one you know can answer?**

If you answered "YES" to any of these questions, then you need to read Dr. Qassim Abdullah's column, Mapping Matters.

In it, he answers all geospatial questions—no matter how challenging—and offers accessible solutions.

Send your questions to Mapping_Matters@asprs.org

To browse previous articles of Mapping Matters, visit http://www.asprs.org/Mapping-Matters.html

"Your mapping matters publications have helped us a lot in refining our knowledge on the world of Photogrammetry. I always admire what you are doing to the science of Photogrammetry. Thank You Very much! the world wants more of enthusiast scientists like you."

"I read through your comments and calculations twice. It is very clear understandable. I am Honored there are experienced professionals like you, willing to help fellow members and promote knowledge in the Geo-Spatial Sciences."

YOUR COMPANION TO SUCCESS

GIS Tips & Tricks

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

File Navigation is Easier than You Think

For novices entering into the Esri GIS world from an Apple-iOS™ environment, which is a common occurrence for my beginning GIS students, they have to overcome not only the intricacy's and complexities of the GIS software, but also navigating through a MicroSoft™ Windows filing system, maybe for the first time. For many beginners these are both daunting tasks but even more so for those trying to access GIS data either on their local disks or on a network. Fortunately, the ArcGIS Pro interface provides several tools to construct shortcuts to often-used data paths. The Add Folder Connections tools are available in ArcGIS Pro, and similar tools in ArcGIS Desktop, make short work to finding data in a challenging file system.

Adding a Folder from the Insert Tab in ArcGIS Pro

When starting an ArcGIS Pro project (.aprx) the Map tab opens with a basemap and the ribbon starts on the "Insert" tab as in Figure 1.

In the Project group, clicking on the "Add Folder" icon will start a standard Windows™ file navigator (Figure 2) that you can use to navigate to a folder for quick repeat navigation. The target folder may contain images, GIS data, or other useful files to your project. Simply navigate through the file system to your desired target folder.

When you find the folder that you want to connect to your project, as in this example, I navigated through my Professional\GISData folders to find the \Alaska folder, then I select it (left-click) and clicked OK (Figure 3).

This will place the \Alaska folder in my project's "Folder" file so that when I use the "Add Data" tool on the Map | Layer group, the desired folder will appear (Figure 4, right pane) ready for use; no additional file navigation necessary.

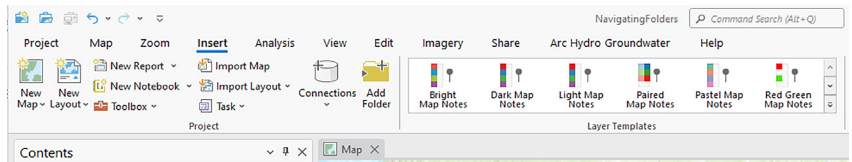

Figure 1. The ArcGIS Pro starting ribbon showing the Insert Tab and the Add Folder tool.

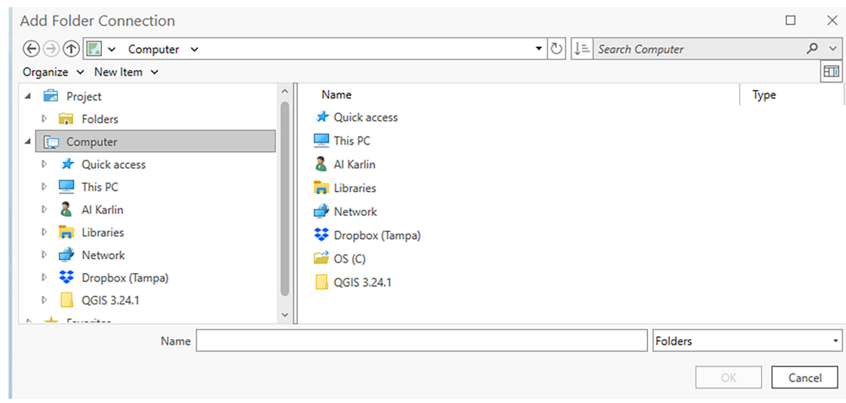

Figure 2. The Add Folder Connection file navigation dialog box activated from the Add Folder tool.

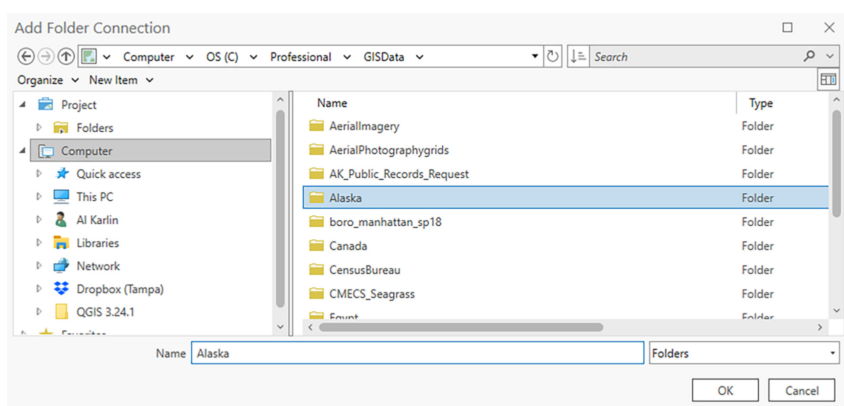

Figure 3. Navigating to and selecting a windows file folder to add to the project Folder.

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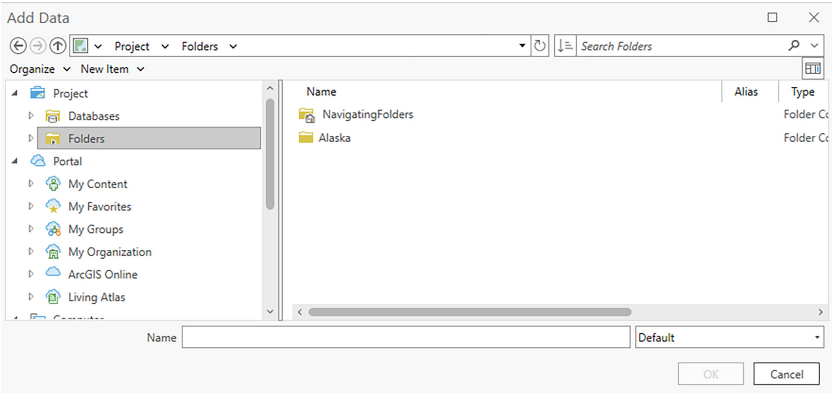

Figure 4. The ArcGIS Pro project Folder, as accessed from the Add Data tool, showing the folder previously attached to the project from Figure 3.

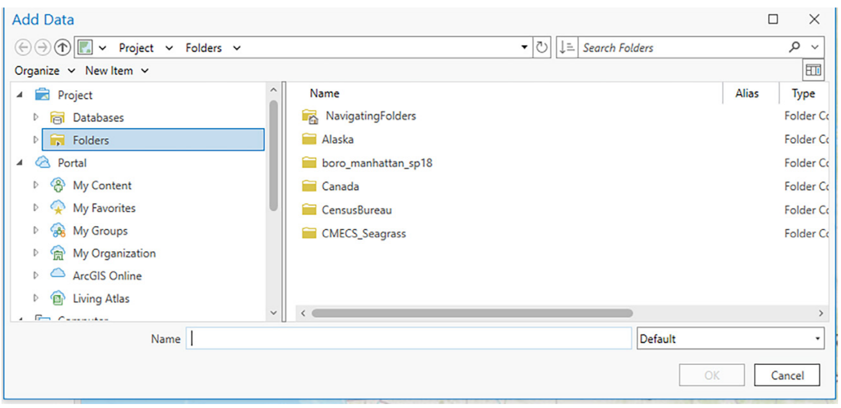

Figure 5. The ArcGIS Pro project Folder, as accessed from the Add Data tool, showing the multiple folders attached to the project by using the Shift + Select tip.

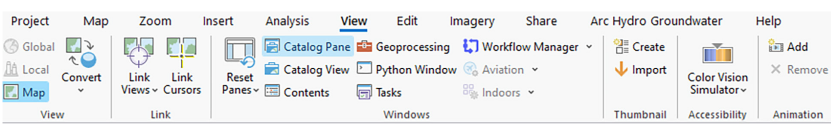

Figure 6. The ArcGIS Pro ribbon showing the View Tab and the Catalog Pane in the Windows group.

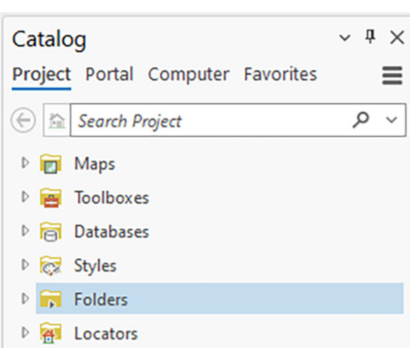

Figure 7. Opening the Catalog pane shows the project's Folders icon with an expand arrow to the left of the folder.

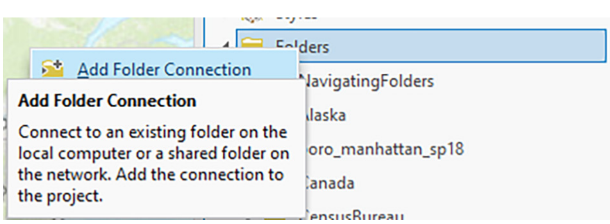

Figure 8. Adding a Folder Connection using the Catalog pane.

TIP #1 — You can add multiple paths (Figure 5) to your project's "Folder" by holding the SHIFT key while you Select (left-click) on folders to add. In this case, I added the \boro_manhattan_sp18, \Canada, \CensusBureau and \CMECS_Seagrass folders using the Shift+Select combination.

Adding Folders from the Catalog Pane to ArcGIS Pro

If you are like me, you are accustomed to having a Catalog pane (what used to be ArcCatalog) handy to manage your files. I strongly encourage my students to follow this practice.

TIP #2 — From the View tab (Figure 6) on the ribbon, in the Windows group, open a Catalog Pane and dock the Catalog pane (or float it) as you like. (I generally dock it on the right-hand side of the canvas.)

When you open the Catalog pane, you see the "Folders" (Figure 7). Right-clicking on the "Folders" starts the "Add Folder Connection" (Figure 8) which will open a Windows File navigator as in Figure 2. Of course, you can use the Shift + Select combination to choose multiple folders.

TIP #3 — Right-clicking on any individual folder icon, gives you additional options for managing that connected folder (Figure 9).

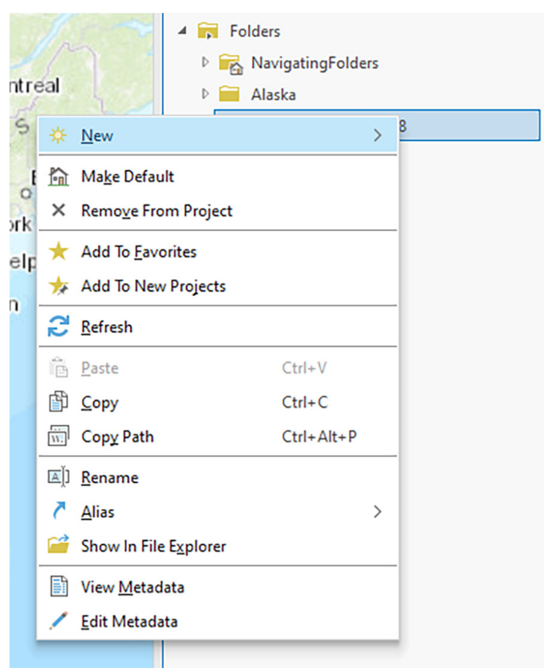

Figure 9. Right-clicking on a folder from the Catalog pane reveals additional file management options.

Adding a Folder in ArcGIS Desktop

For those using ArcGIS Desktop, Connect to Folder from the ArcMap interface is a bit different. The Connect to Folder tool is available only from the "Add Data" button. After the "Add Data" button is pressed, the Windows file navigator displays several optional icons along the top of the file browser, including the "Connect to Folder" icon. When this icon is selected (Figure 10), the Connect to Folder (Figure 11) will allow you to navigate and connect to a folder.

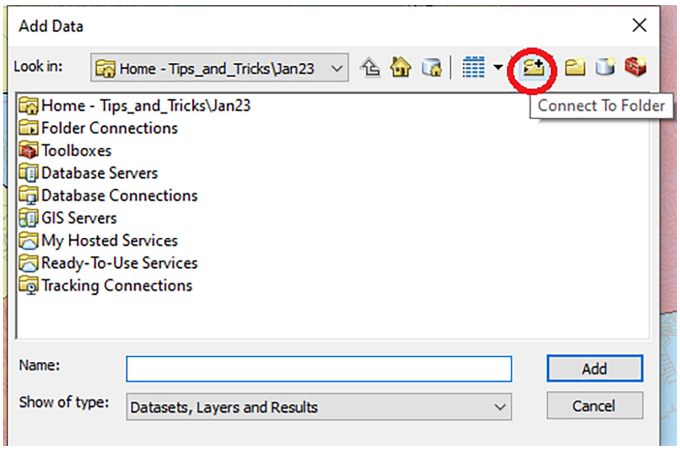

Figure 10. In ArcMap Desktop, the Connect to Folder icon is located on the Add Data dialog box.

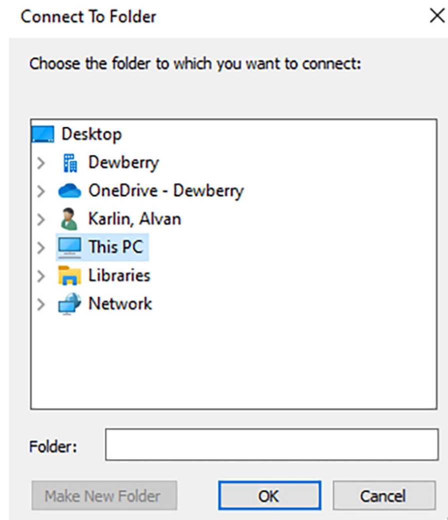

Figure 11. The Connect to Folder dialog box and navigator in ArcMap Desktop

Unfortunately, if you need to connect to multiple folders, you will need to navigate to each separately; the Shift + Select combination does not work.

Finally, from ArcCatalog or a Catalog Window in ArcMap, you can also right-click on the "Folder Connections" to Connect to Folder (Figure 12) in much the same way as in ArcGIS Pro (Figure 8).

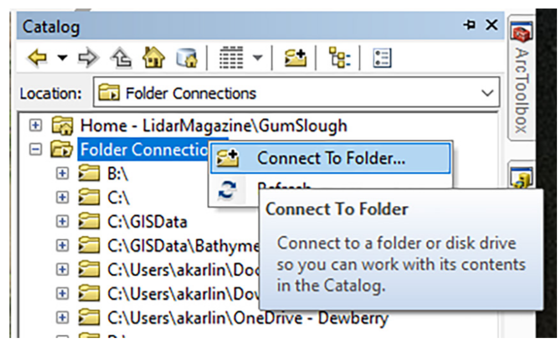

Figure 12. The Connect to Folder tool in ArcCatalog or a Catalog Window in ArcMap Desktop.

While learning to navigate through a Windows™ file system may initially be a challenge to iOS™ (and other) users, connection to folders in the ArcGIS environment certainly helps overcome some of those difficulties.

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

Al Karlin, Ph.D., CMS-L, GISP *is a senior geospatial scientist with Dewberry's Geospatial and Technology Services group in Tampa, FL. Al works with all aspects of lidar, remote sensing, photogrammetry, and GIS-related projects. Al also teaches Map-making for the Social Sciences at the University of Tampa.*

BOOK**REVIEW** *continued from page 405*

cultural and natural science disciplines. While there are additional sensors (e.g., lidar, thermal infrared) and discipline specific applications that are not included in this tome (e.g., fire and emergency response, civil engineering, and forensic investigations), the array of sensor technologies across disciplines is impressive. In addition, the foundations provided in this book would support incorporation of additional sensors and would be portable to other disciplines. This book is one of the best foundational books providing enough theoretical background that is accessible to a novice and exemplary hands-on applications for users to gain experience with real-world data. I highly recommend this book for independent learners, as well as educators for incorporation as a text/lab book.

ASPRS PARTICIPATING IN GEO WEEK — FEBRUARY 2024!

Geo Week is the premier event for increased integration between the built environment, advanced airborne/terrestrial technologies, and commercial 3D technologies, bringing together former stand-alone events AEC Next Technology Expo & Conference, International Lidar Mapping Forum, and SPAR 3D Expo & Conference, and powerful partnership events including ASPRS Annual Conference.

Geo Week was created as a response to the changing needs of built world and geospatial professionals, and to acknowledge the convergence of technology taking place currently. New technological innovations, the need for remote workflows, and hardware breakthroughs are redefining expectations across teams, organizations, and entire industries. Geo Week is at the center of it all.

The ASPRS program at Geo Week 2024 will include technical sessions, continuing education workshops, committee meetings, and a student-focused Academic Hub.

NEW ASPRS MEMBERS

ASPRS would like to welcome the following new members!

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A Lightweight Conditional Convolutional Neural Network for Hyperspectral Image Classification

Linfeng Wu, Huajun Wang, and Huiqing Wang

Abstract

Deep learning (DL), especially convolutional neural networks (CNNS), has been proven to be an excellent feature extractor and widely applied to hyperspectral image (HSI) classification. However, DL is a computationally demanding algorithm with many parameters and a high computational burden, which seriously restricts the deployment of DL-based HSI classification algorithms on mobile and embedded systems. In this paper, we propose an extremely lightweight conditional three-dimensional (3D) HSI with a double-branch structure to solve these problems. Specifically, we introduce a lightweight conditional 3D convolution to replace the conventional 3D convolution to reduce the computational and memory cost of the network and achieve flexible HSI feature extraction. Then, based on lightweight conditional 3D convolution, we build two parallel paths to independently exploit and optimize the diverse spatial and spectral features. Furthermore, to precisely locate the key information, which is conducive to classification, a lightweight attention mechanism is carefully designed to refine extracted spatial and spectral features, and improve the classification accuracy with less computation and memory costs. Experiments on three public HSI data sets show that the proposed model can effectively reduce the cost of computation and memory, achieve high execution speed, and better classification performance compared with several recent DL-based models.

Introduction

With the development of hyperspectral sensors, the spatial resolution and the number of spectral bands in the hyperspectral image (HSI) have greatly increased. Compared with multispectral and natural Red-Green-Blue images, the abundant spatial and spectral information provided by HSI can be used to more accurately identify ground objects containing different materials. Therefore, hyperspectral image classification, which classifies each image pixel into specific labels, has attracted great attention in many real applications around the world, such as vegetation ecology (Liang *et al.* 2015), atmospheric science (Liu *et al.* 2022), geology and mineral resources (Jain and Sharma 2019; Peyghambari and Zhang 2021), marine research (Serranti *et al.* 2018) and precision agriculture (He *et al.* 2018). However, high-dimensional HSIs have few training samples and large spatial variability of spectral features, which brings great difficulties to hyperspectral classification.

In the past decades, many traditional machine learning algorithms have been proposed to classify HSI, such as support vector machine (SVM) (Tarabalka *et al.* 2010), random forest (Abdel-Rahman *et al.* 2013) and k-nearest neighbor (Ma *et al.* 2010). These methods usually only consider spectral information, and feature extraction is not sufficient. Therefore, other traditional machine learning algorithms also consider spatial information, such as extended morphological profiles (Quesada-Barriuso *et al.* 2014), composite kernels (Zhou *et al.* 2015), and sparse representation (Wang *et al.* 2015), and the results are more satisfactory. However, traditional machine learning algorithms use hand-crafted features, which are relied heavily on expert knowledge. In addition, the hand-crafted features are not enough to discriminate subtle variation, which restricts the classification performance.

In recent years, inspired by the successful application of deep learning in image classification (Krizhevsky *et al.* 2012), object detection (Girshick *et al.* 2014), and natural language processing (NLP) (Bordes *et al.* 2012), deep learning (DL) has also been applied to HSI classification and achieved good performance. Compared with machine learning algorithms, deep learning can effectively extract hierarchical and nonlinear features via a series of hierarchical layers. For example, lower layers can extract shallow and simple features, and the deeper layers can represent more abstract features. In addition, different networks focus on extracting different feature types, which makes deep learning more suitable for dealing with various situations. In the remote sense community, DL-based methods demonstrate extremely promising results. For example, a stackable auto-encoder network introduced the concept of deep learning into hyperspectral data classification for the first time (Chen *et al.* 2014). To avoid loss of detailed information caused by dimension reduction methods such as principal component analysis and negative matrix factorization, the restricted Boltzmann machine and deep belief networks (Li *et al.* 2014) are introduced in to realize the feature extraction and classification. With the development of DL, many advanced networks have been effectively used to solve HSI classification tasks (Ahmad *et al.* 2022) with different degrees of success. For example, a spectral-spatial residual network (SSRN) (Zhong *et al.* 2018) is proposed to jointly extract spectral and spatial features. An integration of multiple convolutional neural networks (CNN) (Sikakollu and Dash 2021) is proposed to generate more reliable and robust prediction results. To highlight the most critical spectral and spatial information, a double-branch dual-attention mechanism three-dimensional (3D)-CNN (Li *et al.* 2020) is proposed, and satisfactory results are obtained in a small number of training samples. However, in terms of the visual invariance of CNN's fixed-size convolution kernel, the visual transformation of the input image will lead to the instability of the network performance. To overcome this problem, some methods introduced the concept of NLP to explain the process of image classification from a new perspective. Motivated by the self-attention mechanism (Vaswani *et al.* 2017) and recurrent neural network (Paoletti *et al.* 2020), vision transformers (VIT) (Hong *et al.* 2021) reconsideration of the input image as a sequence of tokens to capture long-range dependence, have also become popular. In addition, generative adversarial network (Zhan *et al.* 2018; Zhong *et al.* 2020) create artificial instances from data sets, while retaining features similar to the original set, which alleviates the problems of class imbalance and the limited number of labeled samples.

However, most existing work tends to improve classification accuracy at the cost of complex models and many training samples. For computationally intensive deep learning algorithms, the complexity

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Call for *PE&RS* Special Issue Submissions

Ushering a New Era of Hyperspectral Remote Sensing to Advance Remote Sensing Science in the Twenty-first Century

Great advances are taking place in remote sensing with the advent of new generation of hyperspectral sensors. These include data from, already in orbit sensors such as: 1. Germany's Deutsches Zentrum fur Luftund Raumfahrt (DLR's) Earth Sensing Imaging Spectrometer (DESIS) sensor onboard the International Space Station (ISS), 2. Italian Space Agency's (ASI's) PRISMA (Hyperspectral Precursor of the Application Mission), and 3. Germany's DLR's Environmental Mapping and Analysis Program (EnMAP). Further, Planet Labs PBC recently announced the launch of two hyperspectral sensors called Tanager in 2023. NASA is planning for the hyperspectral sensor Surface Biology and Geology (SBG) to be launched in the coming years. Further, we already have over 70,000 hyperspectral images of the world acquired from NASA's Earth Observing-1 (EO-1) Hyperion that are freely available to anyone from the U.S. Geological Survey's data archives. These suites of sensors acquire data in 200 plus hyperspectral narrowbands (HNBs) in 2.55 to 12 nm bandwidth, either in 400-1000 or 400-2500 nm spectral range with SBG also acquiring data in the thermal range. In addition, Landsat-NEXT is planning a constellation of 3 satellites each carrying 26 bands in the 400-12,000 nm wavelength range. HNBs provide data as "spectral signatures" in stark contrast to "a few data points along the spectrum" provided by multispectral broadbands (MBBs) such as the Landsat satellite series.

The goal of this special issue is to seek scientific papers that perform research utilizing data from these new generation hyperspectral narrowband (HNB) sensors for a wide array of science applications and compare them with the performance of the multispectral broadband (MBB) sensors such as Landsat, Sentinels, MODIS, IRS, SPOT, and a host of others.

Papers on the following topics are of particular interest:

1. Methods and techniques of understanding, processing, and computing hyperspectral data with specific emphasis on machine learning, deep learning, artificial intelligence (ML/DL/AI), and cloud computing.
2. Issues of hyperspectral data volumes, data redundancy, and overcoming Hughes' phenomenon.
3. Building hyperspectral libraries for purposes of creating reference training, testing, and validation data.
4. Utilizing time-series multispectral data and hyperspectral data over many years to build data cubes and apply advanced computational methods of ML/DL/AI methods and approaches on the cloud.
5. Discussions of hyperspectral data analysis techniques like full spectral analysis versus optimal band analysis.
6. Developing hyperspectral vegetation indices (HVIs) for targeted applications to model and map plant biophysical (e.g., Yield, biomass, leaf area index), biochemical (e.g., Nitrogen, anthocyanins, carotenoids), plant health/stress, and plant structural quantities.
7. Classification of complex vegetation and crop types/species using HNBs and HVIs and comparing them with the performance of multispectral broadband data.

All submissions will be peer-reviewed in line with *PE&RS* policy. Because of page limits, not all submissions recommended for acceptance by the review panel may be included in the special issue. Under this circumstance, the guest editors will select the most relevant papers for inclusion in the special issue. Authors must prepare manuscripts according to the *PE&RS* Instructions to Authors, published in each issue of *PE&RS* and also available on the ASPRS website, https://www.asprs.org/asprs-publications/pers/manuscript-submission.

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Important Dates

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Final Papers Due — May 1, 2024

Tentative Publication Date — 2024

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Call for *PE&RS* Special Issue Submissions

Special Issue on the Scholarship and Impacts of Professor Nina S. N. Lam

Expected Date for Publication: 2024

Special Issue Editors

Michael Leitner (mleitne@lsu.edu)
Jane Read (jaread@syr.edu)

This special issue recognizes Professor Nina S. N. Lam's ~45 years of contribution to Geographic Information and Environmental Sciences. From her first publications on spatial/areal interpolation methods in the early 1980s, she evolved into an internationally recognized scholar known for her leadership in diverse research areas, from scale, resolution, and fractals to environmental health, disaster resilience, and sustainability. Professor Lam, who currently holds the E. L. Abraham Distinguished Professor of Louisiana Environmental Studies title, has been the recipient of many honors and awards, including the inaugural Carolyn Merry Mentoring Award from the UCGIS (2016), being named a Fellow of both the AAG (2020) and the UCGIS (2016), as well as being named a LSU Rainmaker, recognizing one of the top 100 research and creative faculty (2008), and the LSU Distinguished Faculty Award (2006). Her legacy in research, teaching, and service continues through her many students, who are actively contributing to Geographic Information Science (GISc) in academia, government, and the private sector, including the second co-guest editor of this special issue.

This special issue celebrates the outstanding scholarly work of Professor Lam. We invite original contributions from her students, collaborators, and anyone impacted and influenced by her work. Topics covered should be broadly situated within remote sensing, disaster/environmental sciences, sustainability, environmental health, and GISc, including but not limited to subjects related to her research and impact. Please contact special issue editors for questions and suggestions.

Interested authors should send a manuscript title and short abstract (about 250 words, including the authors' names and affiliations) to the special issue editors (mleitne@lsu.edu; jaread@syr.edu) by July 15, 2023 (see complete publication timeline below).

Manuscript length should be around 5,000-6,000 words. All submissions will be subject to standard *PE&RS* peer review processes. See Instructions for authors (https://www.asprs.org/asprs-publications/pers/pers-instructions-for-authors-submitting-a-manuscript-for-peer-review). All submissions should be made online at the Photogrammetric Engineering and Remote Sensing Manuscript Central site (https://www.editorialmanager.com/asprs-pers/). Authors must select "Special Issue" when they reach the "Article Type" step in the submission process and identify the "Scholarship and Impacts of Professor Nina S. N. Lam Special Issue" in their cover letter. New users should first create an account. Once logged on to the site, submissions should be made via the Author Dashboard. Online user guides and access to a help desk are available on this website.

Timeline for publication of *PE&RS* Special Issue

Manuscript Proposal Deadline (Title and Abstract)	July 15, 2023
Submission Deadline	January 31, 2024
Information about Acceptance	On a rolling basis
Submission of Revised Manuscript Deadline	June 30, 2024
Publication in *PE&RS*	2024

Multi-Level Perceptual Network for Urban Building Extraction from High-Resolution Remote Sensing Images

Yueming Sun, Jinlong Chen, Xiao Huang, and Hongsheng Zhang

Abstract

Building extraction from high-resolution remote sensing images benefits various practical applications. However, automation of this process is challenging due to the variety of building surface coverings, complex spatial layouts, different types of structures, and tree occlusion. In this study, we propose a multilayer perception network for building extraction from high-resolution remote sensing images. By constructing parallel networks at different levels, the proposed network retains spatial information of varying feature resolutions and uses the parsing module to perceive the prominent features of buildings, thus enhancing the model's parsing ability to target scale changes and complex urban scenes. Further, a structure-guided loss function is constructed to optimize building extraction edges. Experiments on multi-source remote sensing data sets show that our proposed multi-level perception network presents a superior performance in building extraction tasks.

Introduction

Urban buildings are an essential element in urban environments and serve as an important indicator of the state and scope of urban development. A city building map depicts the distribution, shape, and size of city structures (Zhou *et al.* 2021), which plays a significant role in a variety of city projects (Wang *et al.* 2022). With the continuous development of remote sensing science and technology, the resolution of remote sensing images has been continuously improved (Shao *et al.* 2021). As high-resolution remote sensing images contain rich ground object information such as color, spectrum, texture, shape, and context (Guo *et al.* 2021), they have become an important data source for urban building extraction. The extraction of urban buildings from high-resolution satellite images benefits a variety of fields and tasks, including detecting urban changes, analyzing land use, inspecting and remediating housing safety problems, drawing and updating maps, urban digital three-dimensional modeling, urban planning and construction, to list a few (Alshehhi *et al.* 2017; Zhu *et al.* 2021).

In recent years, with the rapid advancement of deep learning, automated building extraction from high-resolution remote sensing images has become a common practice (Cheng and Han 2016; Luo *et al.* 2021; Shen *et al.* 2022). Convolutional neural networks (CNN)-based deep learning models are widely used in natural image categorization, object identification, and semantic segmentation (Ma *et al.* 2019). The superior performance of CNNs has been demonstrated in automated building extraction from high-resolution remote sensing images (Guo *et al.* 2021; Liu *et al.* 2018). However, CNN retains many notable issues, such as limited perceptual area, erroneous edge segmentation, and spatial information loss (Zhu *et al.* 2021). Following its proposal in 2017 (Shelhamer *et al.* 2017), the fully convolutional network (FCN) has achieved great success in semantic segmentation (Sun *et al.* 2022; Zhuang *et al.* 2019). Marcos *et al.* (2018) propose Rotation Equivariant Vector Field Network (RotEgNet) to encode rotation equivariance in the network itself. Rotation equivariance reduces the model size and runtime memory requirements while keeping most of the orientation information.

It is important to apply deep learning well to building extraction from high-resolution remote sensing images. Shao *et al.* (2020) proposed the Building Residual Refinement Network (BRRNet), which consists of two parts: a prediction module and a residual refinement module. The prediction module is based on an encoder-decoder structure that introduces unordered convolutions with different expansion rates to extract more global features. The residual refinement module refines the residuals between the results of the prediction module and the actual results in one step, thus improving the accuracy of building extraction.

DR-Net uses deeplabv3+ encoder/decoder backbone, combined with densely connected convolutional neural network and residual network structure to greatly reduce the number of parameters in the building extraction model (Chen *et al.* 2018; Yang *et al.* 2020). Combine a grid-based attention gate and a trackless spatial pyramidal pooling module on top of the encoder-decoder architecture to capture and restore building features progressively and efficiently to distinguish buildings from their complex surroundings (Deng *et al.* 2021).

PolygonCNN first performs coarse segmentation to extract the initial building outline (Chen *et al.* 2020), then uses a modified PointNet to learn the shape prior and predicts the deformation of polygon vertices to generate fine-grained building vector results. Xu *et al.* (2022) proposed a gated spatial memory module (GSM) and a centroid-aware head (CH). The GSM transmits semantic information from top down to enhance important features and complement missing information. The CH is used to regress the geometric center of each building to facilitate complete recognition of irregularly shaped buildings. To enhance the boundary extraction of buildings, holistic nested edge detection is used to first extract edge features at the encoder, and then in the boundary enhancement module, the extracted edges and segmentation masks are combined to share mutual information (Jung *et al.* 2022).

CFENet uses the spatial fusion module, the focus enhancement module, and the feature decoder module to perform level-by-level refinement extraction of buildings (Chen *et al.* 2022). A coarse-to-fine boundary refinement network is proposed to extract buildings from remote sensing images accurately (Guo *et al.* 2022). The result of refinement is used as a pseudo-label in the self-supervised process, which increases the robustness of the model against noisy labels or obstacles. Kokila and Jayachandran (2023) proposed a convolutional

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Classifying Building Roof Damage Using High Resolution Imagery for Disaster Recovery

Elaina Gonsoroski, Yoonjung Ahn, Emily W. Harville, Nathaniel Countess, Maureen Y. Lichtveld, Ke Pan, Leslie Beitsch, Samendra P. Sherchan, and Christopher K. Uejio

Abstract

Post-hurricane damage assessments are often costly and time-consuming. Remotely sensed data provides a complementary method of data collection that can be completed comparatively quickly and at relatively low cost. This study focuses on 15 Florida counties impacted by Hurricane Michael (2018), which had category 5 strength winds at landfall. The present study evaluates the ability of aerial imagery collected to cost-effectively measure blue tarps on buildings for disaster impact and recovery. A support vector machine model classified blue tarp, and parcels received a damage indicator based on the model's prediction. The model had an overall accuracy of 85.3% with a sensitivity of 74% and a specificity of 96.7%. The model results indicated approximately 7% of all parcels (27 926 residential and 4431 commercial parcels) in the study area as having blue tarp present. The study results may benefit jurisdictions that lacked financial resources to conduct on-the-ground damage assessments.

Introduction

In the United States, hurricanes cause substantial economic damage and are responsible for nearly 7000 deaths since 1980 (NOAA 2023). In response to hurricanes and other disasters, the Federal Emergency Management Agency (FEMA) provides aid to qualified communities. FEMA's Public Assistance (PA) Program provides grants to governments and nonprofits after disasters to aid community recovery (FEMA 2023). The Individual Assistance (IA) Program is meant to supplement individuals' insurance, providing funds for basic needs and recovery costs (FEMA 2022). IA has been found to be one of the most vital programs for recovery in the immediate aftermath of a disaster (Lamba-Nieves and Santiago-Bartolomei 2022). In addition, FEMA and the Army Corps of Engineers may offer the Blue Roof Operation after a disaster. The goal of this collaboration is to install blue tarpaulin (tarp) at no-cost on roofs of eligible homes to temporarily prevent further damage of homes until permanent repairs can be completed (FEMA 2017). While they are meant to be short-term solutions, blue tarps have been observed for years after an event (Rowan and Kwiatkowski 2020).

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Although tarps will not be used for severely damaged buildings, the presence of blue tarps still gives insight into how much damage communities experienced and how they are recovering (Miller *et al.* 2013; Miura *et al.* 2020; Naito *et al.* 2020; Rathfon *et al.* 2012).

The present study has two main objectives. First, we seek to quantify the number of parcels with blue tarp present in counties designated by FEMA for individual and public assistance (Area A) versus just public assistance (Area B) after Hurricane Michael (October 2018). Unlike previous work, the current study seeks to classify damage over a large geographical area, including severely and relatively minimally affected counties. We investigated whether accurate results could be obtained across diverse environments. Blue tarps are an indicator of post-hurricane destruction that are also relatively spectrally distinguishable from other infrastructure (Rathfon *et al.* 2012; Miura *et al.* 2020). Second, while multiple short- and medium-term recovery programs are based on county-level damage assessments, few studies have actually quantified the number of buildings impacted by severe conditions within all disaster affected counties (Gurley and Masters 2011; Walker 2011; Tomiczek *et al.* 2014). We determined whether there are small pockets of damage to households outside of counties eligible for IA. The results of the study provide a finer scale to evaluate damage and quantify how many households may be missed when relying on county-level damage assessments.

High-resolution remotely sensed data is capable of identifying blue tarps over the entire affected area. Ground-based damage surveys are accurate and reliable but frequently focus on a specific municipality with a limited sample size (Gurley and Masters 2011). Furthermore, many communities lack the resources needed to even conduct such surveys (FEMA 2016). Alternatively, remotely sensed data collection can aid in disaster response (e.g., routing relief supplies) and recovery efforts. Such data can assess damage over a wide area relatively quickly and cost-effectively when compared to ground-based surveys (Jiang and Friedland 2016). For this study, we used high spatial resolution (<0.5 ft2) optical imagery to detect blue tarps as indicators of small areas of damage after Hurricane Michael. While high-resolution imagery provides superior ability to detect small areas of damage, it has drawbacks in terms of the data size and expertise needed to use the data (e.g., access and skill to use high-performance computing clusters) (Sun *et al.* 2020).

High-performance computing has contributed to a growing body of work using machine learning and deep learning methods to classify imagery and study disaster impacts. One such method includes the support vector machine (SVM) classifier. SVMs have been applied to assess disaster damage and recovery with comparable results to deep learning methods such as convolutional neural networks (CNNs) (Hasan *et al.* 2019). Using SVM, researchers have accurately identified collapsed buildings after disasters demonstrating the method's suitability in urban and rural contexts (Moya *et al.* 2018; Sheykhmousa *et al.* 2019). CNNs have produced highly accurate results, as well detecting different levels of damage (none, minor, major, and destroyed) with improvement over an SVM in Bay County, Florida and portions of its neighboring counties after Hurricane Michael (Berezina and Liu 2022). However, this study

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chose an SVM over deep learning methods since it is relatively accurate with smaller training data and shallow data structures (Wang *et al.* 2021). We relied on publicly available optical imagery with only three bands to detect blue tarps after Hurricane Michael.

The results of the classification were used to determine whether blue tarps were located in counties ineligible for IA. In response to environmental disasters such as hurricanes, governors of affected states can request a Major Disaster Declaration based on a variety of factors, including damage severity and state funds available. If accepted, federal programs including IA, PA, and/or Hazard Mitigation Assistance may be available based on the request and preliminary damage assessments (FEMA 2022). Recent evidence has shown that certain vulnerable populations are more likely to be denied aid even if located in an eligible area (García 2022; Lamba-Nieves and Santiago-Bartolomei 2022). After Hurricane Maria struck Puerto Rico in 2017, large numbers of homeowners were denied aid for reasons such as being unable to prove homeownership and scheduling inspections (García 2022). In addition, areas with higher populations of foreign-born individuals were found to have lower damage estimates and therefore less aid (Grube *et al.* 2018). However, when looking at social vulnerability factors and damage at the county level, damage severity is still the largest predictor of IA aid (Emrich *et al.* 2022). This is expected and gives credibility to the way the program is operating, but county-level assessments still leave opportunity for households to be missed.

Methods

Study Area and Event

Hurricane Michael made landfall in Bay County, Florida on October 10, 2018. The storm contributed to 45 fatalities and over $25 billion in damages (NOAA 2023). Power outages spanned six US states and included 1.7 million customers (Woodward and Marcy 2018). The hurricane was the strongest on record to hit the Florida panhandle and, as a result, federal disasters were declared for counties across the area. This study covered 15 of those counties located in the Florida panhandle: Bay, Calhoun, Franklin, Gadsden, Gulf, Hamilton, Holmes, Jackson, Jefferson, Liberty, Madison, Taylor, Wakulla, Walton, and Washington. These counties generally had higher rates of poverty (12.2–29.9%) and populations without health insurance coverage (8.9–18.3%) than national rates (11.8% and 8.8%, respectively). In addition, these counties had lower rates of employment than the national average as well as lower average educational attainment (US Census Bureau 2018). For the purpose of quantifying damage at a building level, we relied on parcel data. Parcels are legally owned areas of land with a defined location, boundary, and a specific type of usage or development designation. In total, the data included 461 106 parcels located within the study area. Of this total, 101 596 of the parcels were commercial, with the remaining 359 510 parcels (78%) classified as residential. FEMA designated these 15 counties eligible for assistance following Hurricane Michael. The most severely impacted counties qualified for IA and PA from FEMA. These included Bay, Calhoun, Franklin, Gadsden, Gulf, Holmes, Jackson, Liberty, Taylor, Wakulla, and Washington counties. The remaining four counties qualified for PA alone (Figure 1) (FEMA 2018).

Data Sources

The post-Hurricane Michael imagery used in this study were sourced from aerial photographs taken through the Florida Department of Revenue and stored in the Florida Department of Environmental Protection's Land Boundary Information System (LABINS) (LABINS 2019). The images were captured between December 2018 and February 2019, and have 0.5-foot spatial resolution with red, green, and blue spectral bands. Each image tile covers one square mile and in total the data required 5 terabytes of storage.

Parcel Data

Parcel data were sourced from the University of Florida's GeoPlan Center and contain the Florida Department of Revenue's tax roll information from 2018 (FGDL 2019). In addition to information about the property (e.g., year the structure was built, value, use), these data contain spatial polygon information. When matched by location in a Geographic Information Systems software, these data can be used to determine how many households had blue tarps present within the study area. These parcel data are publicly available.

Image Classification

The study area includes a variety of landcover types. However, the class of interest only included blue tarps to indicate whether a structure was damaged or not. Therefore, the final classification result was obtained through two steps: first, a multi-class classification and second, a binary classification distinguishing blue tarps from all other classes. The multi-class schema contained seven training classes: *Blue Tarp, Pool Water, Impervious Surface, Vegetation, Bare Soil, Roof,* and *Large Waterbody*. These training classes are created by taking samples of pixels belonging to these different classes from different areas in the image. Researchers then created a signature file in ESRI ArcMap software using these training samples. We manually entered the mean values from the signature file to train the "Train Support Vector Machine (SVM) Classifier" in Python 3 using the scikit-learn package (Pedregosa *et al.* 2011). SVM classifiers distinguish classes by creating a linear hyperplane to separate the data. While SVM was originally used for binary classifications, the Support Vector Classification tool in scikit-learn implements a "one-versus-one" approach for multi-class problems. This approach reduces the problem to a collection of binary problems

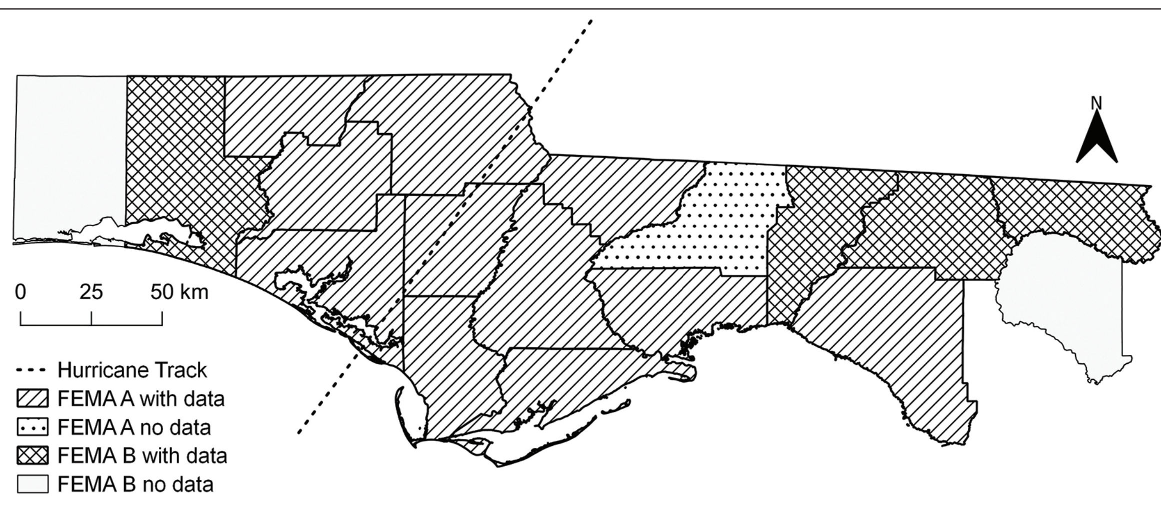

Figure 1. Map of the Florida panhandle showing counties that were affected by Hurricane Michael. Federal Emergency Management Agency (FEMA) A indicates a county was eligible for both individual and public assistance. FEMA B counties were only eligible for public assistance.

(Foody *et al.* 2006). SVM models are commonly applied to classification problems and perform relatively well compared to other deep learning methods even with limited training samples (Jozdani *et al.* 2019).

Batch processing tools were required to not only classify the aerial photographs (raster tiles), but also to convert the output into vector data for intersection with parcel information. A scripted batch code handled data classification and processing. The Rasterio package (GitHub 2019) read in the imagery as three-dimensional Numpy arrays (Harris *et al.* 2020). Each image was flattened to a two-dimensional array and run through the SVM classifier. The results were recoded to a binary classification (tarp or not tarp) and then converted to polygons using the Fiona package (GitHub 2019) to compare to the parcel information. We separately assessed the accuracy of the 1) multispectral classification and 2) multispectral classification with a spatial filter which excluded tarp polygons less than 200 square feet to reduce noise in the classification. Sensitivity testing filtering smaller polygons (50 and 100 square feet) did not reduce the noise while removing areas larger than 200 feet resulted in more false negatives and reduced the overall accuracy.

The accuracy assessments were based on a separate validation sample of 300 randomly positioned points (150 points per class). The points were placed within parcels with a minimum of 328 feet (100 meters) between points. Each point was manually checked for correct classification by looking for the presence or absence of visible blue tarps within a parcel in the aerial imagery. Researchers then calculated the overall and target class accuracies for the multispectral classification and multispectral classification with a spatial filter.

Results

The results of the classification accuracy assessment are reported in a confusion matrix (Table 1). The accuracy assessment was conducted for both the spatially filtered and unfiltered results. Before the application of the spatial filter, the overall accuracy was 78%. The final filtered results indicated an overall accuracy of 85.3% with a kappa coefficient of approximately 0.71, indicating an improvement over the result that was not filtered. The user's accuracies of the blue tarp class and non-tarp class in the filtered result were 95.7% and 78.8%, and producer's accuracies were 74% and 96.7%, respectively. Pools and roofs, which were highly reflective, were more commonly confused with blue tarp than impervious surfaces, vegetation, or darker roofs. The spatial filter by polygon area improved the specificity of the tarp classification from 82% to 96.7%.

The presence of any blue tarps indicated whether a parcel had been damaged by the hurricane and received a damage designation in the classification (Figure 2). Within the study area, blue tarps were located in approximately 7% of all parcels (27 926 residential and 4431 commercial). Examining just residential parcels by county, results showed Calhoun County had the largest proportion of all parcels with blue tarps at approximately 22.6%, followed by Bay County at 20.5% and Jackson and Gulf Counties at 16.9% and 13.9%, respectively (Table 2). In general, the counties in Area B including Hamilton, Jefferson, Madison, and Walton had relatively lower percentages of parcels (0.3–2.9%) with tarps, which is in agreement with the FEMA aid classification. These counties were all located farther from the hurricane track (Figure 3).

Discussion

Main Findings

The results of this study demonstrated that we could determine individual building damage across a large disaster-affected area at relatively low cost and time. Other studies using various methods, including CNNs and combinations of remote sensing and survey data, have resulted in higher accuracies. However, these studies generally focused on a smaller area or on just one or more urban centers (Berezina and Liu 2022; Gurley and Masters 2011; Miura *et al.* 2020; Naito *et al.* 2020). However, the present study covered a much wider geographical area with more variability in environment (urban versus rural, coastal versus inland) and included photographs taken on different days, which may result in differences in reflectance of blue tarps. Despite these challenges, the SVM model used still resulted in an acceptable accuracy (85.3%) when identifying buildings that had blue tarps present on their roofs. Common confusion with the blue tarp class included high reflectance surfaces (e.g., metal roofs) and pools. Further refinement of the model could improve the accuracy and the introduction of other machine learning and/or object oriented classification methods may allow for detection of damage beyond tarps (Miura *et al.* 2020).

Filtering polygons by removing those with an area under 200 square feet did successfully reduce the noise in the model output. Researchers compared the accuracy between the spatially filtered and unfiltered results using the same methodology. The spatial filter improved the overall accuracy by approximately 7% and had a large impact on improving the model specificity. Previous studies have used object size to reduce classification errors (Jiménez-Jiménez *et al.* 2020; Palmer *et al.* 2018). Similar to the current study, these studies reduced

Table 1. Two class accuracy assessment of 300 independent and randomly distributed points. The spatially filtered results (bottom) show improvement in the overall accuracy and specificity over the unfiltered results (top).

		Unfiltered		
Class	**Tarp**	**Other**	**Total**	**User's Accuracy:**
Tarp	111	27	138	80.4%
Other	39	123	162	75.9%
Total	150	150	300	
Producer's Accuracy:	74%	82%		Overall Accuracy: 78%
		Spatially Filtered		
Class	**Tarp**	**Other**	**Total**	**User's Accuracy:**
Tarp	111	5	116	95.7%
Other	39	145	184	78.8%
Total	150	150	300	
Producer's Accuracy:	74%	96.7%		Overall Accuracy: 85.3%

Table 2. The proportion of residential parcels in each county where the model detected blue tarps as a percentage of all residential parcels within that county.

County	Parcels with Tarps (%)
Area A	
Bay	20.5
Calhoun	22.6
Franklin	3.5
Gadsden	7.0
Gulf	13.9
Holmes	4.8
Jackson	16.9
Liberty	9.3
Taylor	1.2
Wakulla	1.1
Washington	7.3
Area B	
Hamilton	0.7
Jefferson	0.9
Madison	0.8
Walton	3.5

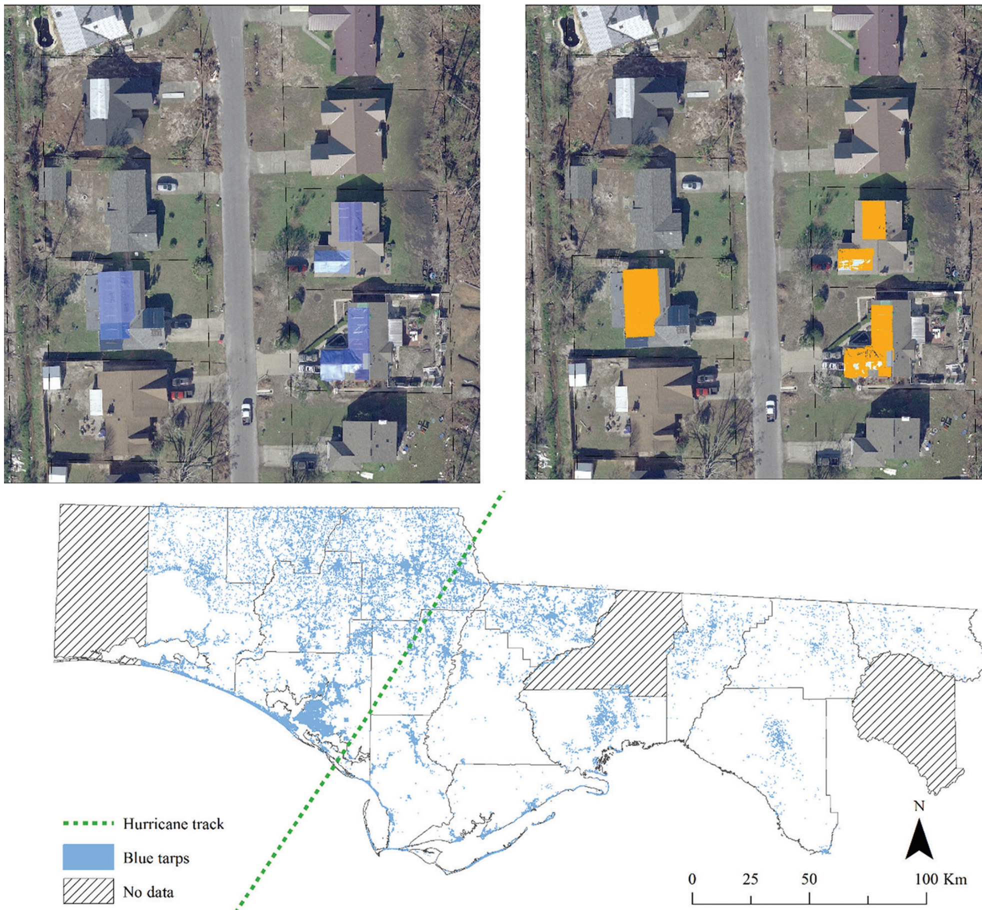

Figure 2. The unaltered aerial photograph is shown (top left) followed by the results of the classification overlayed in orange (top right). The model classified tarps in all counties which had imagery available and were disaster designated by Federal Emergency Management Agency (FEMA) (bottom).

Figure 3. The map shows the percentage of residential parcels with tarps by county with high proportions located in counties nearer to the hurricane track.

noise by eliminating areas too small to be the roof in a primary structure. The improvement indicates the filter was appropriate for reducing the number of false positives in the final model results.

In addition, our results did indicate that some damaged homes were located in counties not eligible for individual assistance from FEMA. While the proportion was small (0.3–2.9%), the results still suggest there are households with damaged structures located in areas ineligible for assistance. To further investigate the pre-hurricane blue tarp prevalence, we counted the number of blue tarps present in Bay (FEMA A) and Jefferson (FEMA B) counties using data from the National Agriculture Imagery Program (NAIP). The NAIP images were collected in 2017 for Florida, approximately one year before the hurricane. The results showed low percentages of tarp in Bay (0.07%) and Jefferson (0.02%) counties, which are significantly less than after the hurricane (Bay 20.5% and Jefferson 0.9%). These findings show that while there may be blue tarps present before the storm, it is likely most were installed post-storm. In addition, the results provide evidence that there are areas in FEMA B that sustained damage. Media reports suggest that FEMA may be more likely to deny aid requests in rural areas struck by local disasters. Yet, aid is approved in statewide disasters, even if the damage they cause is less severe (Harris and Eaton 2022). This study provides an objective way for FEMA to target IA to sub-county areas that suffered infrastructure damage. If there is no state aid available, homeowners have few ways to seek financial aid.

Furthermore, there is evidence that communities that were economically disadvantaged and/or hosted a higher proportion of people of color were more likely to have aid requests rejected, which further compounds existing inequalities (Grube *et al.* 2018; Domingue and Emrich 2019). Previous studies have found evidence of pre-storm inequalities in that racial/ethnic minorities and populations with lower socioeconomic status are more exposed to inland flooding (Collins *et al.* 2019). Furthermore, these same populations are often living in areas with more poorly maintained infrastructure, older housing that may be built to less stringent building code requirements, and face lengthier recovery times (Peacock 2014; Wyczalkowski *et al.* 2019). Future work monitoring damage at the household level may provide further insight into inequities in storm damage and recovery and the impacts living in more severely damaged areas may have on health (Pan *et al.* 2021).

Blue tarps are distributed to qualified homeowners to provide temporary covering, protecting structures from further damage while repairs are being made. While the tarps are only meant to last a few months, studies have found the coverings are present from two to three months to over two years after a disaster (Rathfon *et al.* 2012; Rowan and Kwiatkowski 2020). There are various reasons why individuals are unable to repair their homes within the timeframe blue tarps are designed to last and for the most part, the most vulnerable face the greatest challenges. For example, although federal aid is available, it may be denied for failure to prove home ownership or issues during the home inspection process. In addition, even if approved for funds, in some cases the monetary amount can be insufficient to repair the home (García 2022). Failure to repair or have the home covered in the interim can result in further damage to the home (Allen 2007).

The study results have implications for health and indoor environments and methods can be applied for investigating these environments after disasters. Unsafe housing has a number of negative implications, including towards human health such as exposure to mold, mental health impacts, and chemical exposure. Studies conducted after Hurricane Katrina have examined the effects of dampness in the home on human health. Researchers found respiratory symptoms were associated with exposure to water damaged homes during clean-up activities in New Orleans following Katrina (Chulada *et al.* 2012; Cummings *et al.* 2008; Grimsley *et al.* 2012; Mitchell *et al.* 2012). In addition, flooding from hurricanes and debris removal can expose residents to harmful chemicals. After Hurricane Katrina residents were concerned about chemical exposures in air, soil, and water (Picou 2009). Lastly, studies have consistently found worsened mental health associated with disasters (Goldmann and Galea 2014). Although these health effects are linked to direct exposures such as injury, the long-term impacts of the disaster, such as loss of property, can lead to high levels of stress. Prolonged stress is associated with some of the most common mental health conditions after disasters, including posttraumatic stress disorder and major depressive disorder (Foa *et al.* 2006; Nillni *et al.* 2013; North and Baron 2021). Therefore, alleviating the stress associated with damaged housing has implications for improving mental health.

Limitations

This study has some limitations. First, we did not account for blue tarps in the entire study area that may have been present before Hurricane Michael struck Florida. However, we did provide estimates in two counties using NAIP imagery taken before the hurricane. Second, the images used to classify blue tarps were taken between two and four months after the hurricane made landfall. Some homes may have been repaired within this timeframe. In addition, for blue tarps to be installed by the Army Corps of Engineers, the roof must have less than 50% structural damage (FEMA 2017). Therefore, any residences too heavily damaged to install blue tarps are not considered through this classification. Third, blue tarps not located on roofs (e.g., blue tarps used to cover sheds or vehicles) would also be identified by the model. These tarps were largely excluded by the spatial filter that removed any areas under 200 square feet. Additionally, by limiting the analysis to occupied residential parcels, we excluded parcel land use codes without homes such as common areas and vacant residential properties. While we excluded these properties in an effort to limit inclusion of non-residences, it is difficult to distinguish multi-building damage within a parcel; for instance, if the non-primary structure on the property was damaged. Object-based classifiers may improve the accuracy of detecting blue tarp and other forms of roof damage.

Lastly, the study results did not include the severity of the damage. With building footprint data, it may be possible to provide the proportion of the damage for each structure. However, by relying on blue tarp presence alone, it is not possible to assess the severity of damage. Instead, blue tarp presence provides a practical assessment of damage to help frontline responders direct resources efficiently and effectively. Introducing a CNN and additional data (e.g., building footprints) may improve the accuracy as well as provide additional information about the damage sustained (Berezina and Liu 2022). CNN could also make use of spatial information and account for information in nearby pixels (Hasan *et al.* 2019). In addition, using image segmentation methods may help to improve the accuracy of the classification particularly when using such high-resolution data. Deep learning methods that can make use of the rich spatial information in the data may improve the accuracy of the model and eliminate some of the class confusion (e.g., confusion between blue tarps and pools) (Qi *et al.* 2020).

Conclusion

This study presents evidence that high resolution imagery provides a feasible method to detect post-disaster damage and recovery. Remotely sensed imagery has the advantage of being able to cover a wide area relatively quickly at relatively low cost compared to ground surveys. However, computing abilities and storage may limit the applicability of high-resolution data. Spatially filtering the model output improved the overall model accuracy and specificity. While this study focused on identifying blue tarps in counties affected by Hurricane Michael, future studies could expand this methodology to include more frequent data collection and deep learning methods to detect roof damage more generally and track recovery over time. Detection of damage in areas outside of those eligible for individual assistance also has the potential to provide further evidence of inequitable aid distribution. Safe housing is a basic need for disaster survivors and denying or providing inadequate aid has long-term implications for community resilience and recovery (He *et al.* 2021; Lichtveld *et al.* 2020; Shultz and Galea 2017). Remote sensing provides a means to assess damage quickly and monitor recovery in the months after a disaster to understand where disaster effects persist.

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Estimation of the Forest Stand Biomass and Greenhouse Gas Emissions Using Lidar Surveys

Rida Sultanova and Radik Mustafin

Abstract

At the research points, the relationship between the Normalized Difference Vegetation and Normalized Green Red Difference indices is characterized by a determination coefficient equal to 0.52. The estimation of the emission of carbon dioxide and nitrogen oxide in the forest air at an altitude of 40 m above the level of the soil cover during the growing season showed differences in their values during the daytime and at night. The results helped determine promising methods of inventory of the carbon landfill forest area for aboveground woody biomass assessment based on data obtained from several sources and land forest estimation research. The research involved: 1) integration of an unmanned aerial vehicle -based digital camera and lidar sensors in order to optimize the efficiency and cost of data collection; 2) taking advantage of high-resolution aerial photographs and sparse lidar point clouds using an information fusion approach and the ability to compensate for their shortcomings.

Introduction

The strategic approach to the use of forests is estimated by its productivity and an increase in the sustainability of forest ecosystems (IUFRO 2020). The problems of urbanized territories, including pollution of the atmosphere, soil, water bodies, increased greenhouse effect, and others, cannot be solved without the participation of forest ecosystems. When forest resources are limited and forest development is intensive, the improvement of forest management methods assumes a greater scientific and economic importance. Climate change, the degradation of the environment with the growth of the world's urban population, and a resource-intensive lifestyle challenges the forest industry to find the most effective methods of forest monitoring. Anthropogenic transformation of natural ecosystems significantly reduces carbon sequestration, leading to the predominance of emission processes over the absorption of greenhouse gases. Natural ecosystems of the Republic of Bashkortostan changed by people occupy the main areas including forests and agricultural lands. Therefore, the main task of managing previously disturbed natural ecosystems involves carbon sequestration during progressive successions.

Aboveground woody biomass (AGB) is one of the major elements of the global carbon cycle (Chan *et al.* 2021; Shoot *et al.* 2021), providing the organic carbon deposition (sequestration and storage). According to the research of Pugh *et al.* (2019), the maximum amount of carbon is concentrated in the aboveground woody biomass of the stand, while the maximal proportion of carbon deposited in the dead soil cover (woody detritus) is 4%. AGB monitoring and mapping allow estimating the carbon budget in forests, which contributes to solving scientific and practical problems in the strategy of forest adaptation to climate change and forest management regulation by developing intensive forest assessment methods (Hein *et al.* 2018; Abzhanova *et al.* 2018; Togisbayeva *et al.* 2022). Highly accurate assessment of aboveground woody biomass requires detailed land forest estimation, which is still a basic method. However, field research requires a lot of time and effort (Machar *et al.* 2016; Mukhametov *et al.* 2018; Sakharova *et al.* 2022).

Methods based on obtaining image data using remote sensing (multispectral or radar methods) demonstrate significant potential for rapid and up-to-date determination of plant biomass. They are affordable methods for determining vegetation cover indicators in remote areas (Wiggins *et al.* 2019). In the last two decades, studies based on a combination of field measurements and Landsat remote sensing data have become widespread, including studies on long-term dynamics of forest area and biomass density (Deo *et al.* 2017; Matasci *et al.* 2018). Landsat is especially popular in estimating forest biomass and sample sites since the images have an average spatial (30 m × 30 m) and temporal (16 days) resolution and wide coverage (Li *et al.* 2020). This spatial resolution of Landsat is similar to the size of sample plots in the national forest inventories of many countries, which reduces spatial errors when comparing pixels and sample plots (Nguyen *et al.* 2020).

Aerial laser scanning or laser altimetry is a method of active remote sensing that determines the topography of the Earth's surface by measuring the duration of the passage of the emitted laser pulse. The method involves the use of a photodiode that registers the echo reflected by a laser emitting short, infrared pulses to the Earth's surface. The photodiode allows for obtaining high-accuracy, three-dimensional data from large areas of forest plots, which are important for the management of forest resources. The spectral information provided by optical images can be used to identify tree species necessary for an accurate biomass assessment.

However, satellite images usually have a rough spatial resolution. In addition, because of exposure to aerosols and water vapor, remote sensing images require calibration and correction. An unmanned aerial system with multiple sensors may be relevant for collecting ultra-high spatial resolution data. As an alternative to optical remote sensors, light identification detection and ranging (lidar) can provide accurate structural information on forests for biomass assessment (Tijerín-Triviño *et al.* 2022). Wiggins *et al.* (2019) note that lidar survey is a cost-effective alternative to monitoring, which can provide high-resolution characterization of variations in forest structure depending on the type of terrain. The study on the forests of the Sierra de San Pedro Martir National Park (Baja California, Mexico) estimated the error of the processed lidar surveys data on trees of various height classes. The study also involved assessment of the total number of trees and the evaluation of the structure and spatial distribution in comparison with the results of forest estimation measurements. The consistency between lidar and field estimates of the forest structure, density, and spatial distribution was maximized by removing trees less than 12 m high.

Guo *et al.* (2017) used lidar to obtain data on woodlands of natural subregions of boreal and foothill forests of Alberta (Canada). Based on the data obtained, they note that lidar can accurately measure the three-dimensional structure of vegetation and can be widely used in the wild for habitat mapping, species distribution modeling, and for guiding biodiversity monitoring and species conservation assessment at the regional level (Gamoń *et al.* 2022). In addition, according to Ruiz *et al.* (2018),

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EMPLOYMENT PROMOTION

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

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