GIM INTERNATIONAL

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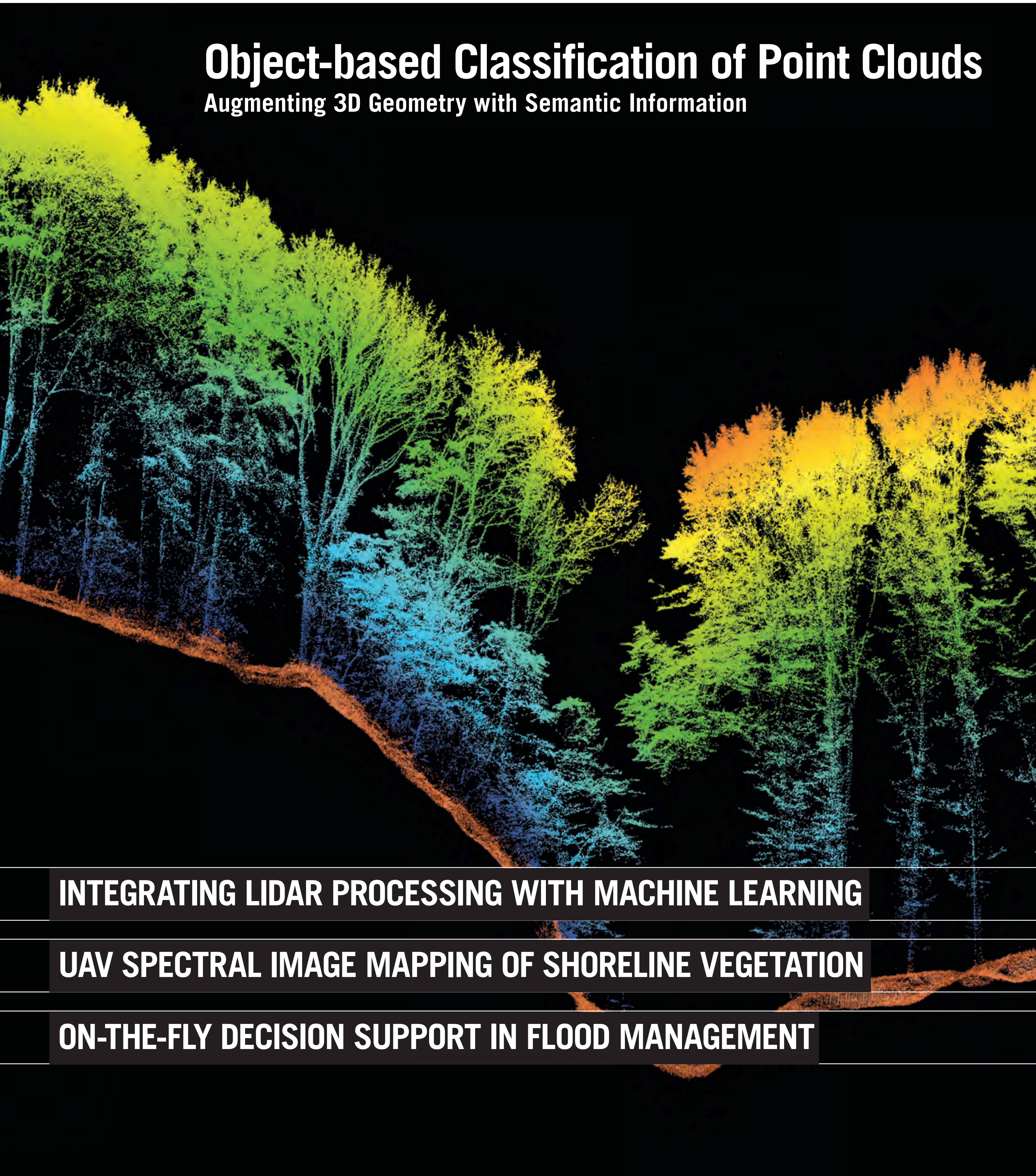

Object-based Classification of Point Clouds

Augmenting 3D Geometry with Semantic Information

INTEGRATING LIDAR PROCESSING WITH MACHINE LEARNING

UAV SPECTRAL IMAGE MAPPING OF SHORELINE VEGETATION

ON-THE-FLY DECISION SUPPORT IN FLOOD MANAGEMENT

GIM INTERNATIONAL

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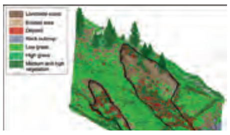
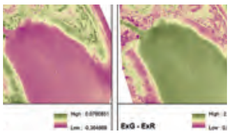
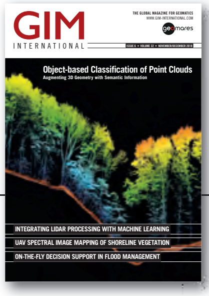




COVER STORY

This issue marks the end of the geospatial year at *GIM International*. We are concluding 2018 with a great variety of topics, ranging from the processing of photogrammetry and the classification of point clouds to 3D visualisations for support flood management and more. Also included in this edition are two articles on the application of UAVs, one on mapping a large copper mine and one focusing on spectral image mapping.



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Inspiration

The geospatial industry is booming and there seems to be no reason why this success won't continue. Business is going well for a lot of geospatial companies, not just thanks to a thriving economy, but also due to the integration of workflows from what used to be separate silos. During Trimble Dimensions, held from 5-7 November in Las Vegas, USA, there were numerous examples – in presentations, panel sessions and on the exhibition floor – of seamless technology that is making life easier for geospatial professionals. Moreover, this technology is putting professionals at the heart of the building process. Around 4,000 Trimble customers flocked to Sin City in the middle of the Nevada desert to witness the latest software that is rapidly changing their working environment and which will enhance their business prospects. Trimble hosts the Dimensions event every two years and it is certainly a good opportunity to get an update on how the industry is evolving. The seamless workflow between surveyors, engineers and contractors is certainly one development that sticks in my mind. That, plus several inspirational speakers including management guru Josh Linkner and motivational activist Sarah Robb-O'Hagan, made me even more excited about new possibilities that lie ahead! It's great to feel so optimistic as we approach the end of another year. I hope you feel it too, and are eager to shape your business effectively to tap into the full potential of the combination of technology, economy and inspiration!

Durk Haarsma, director strategy & business development

Do what you cannot do yet

"I am always doing what I cannot do yet, in order to learn how to do it," is a quote attributed to the famous Dutch Post-Impressionist painter Vincent van Gogh. His work is characterised by thickly laden, dramatic brushstrokes and bold colours. In total he produced around 2,100 artworks, including some 860 oil paintings. Today, Van Gogh is one of the most famous artists in the history of Western art, and several of his paintings rank among the most expensive in the world, but he was not at all commercially successful when he was alive. In fact, it is commonly believed that *The Red Vineyard at Arles* was the only painting sold during Van Gogh's lifetime.

The story of Van Gogh, who struggled to make a living as an artist, is actually quite tragic for a painter who became so famous after his death and left such a huge legacy of splendid artworks. Van Gogh definitely learned his craft by trial and error; his interest in art began when he was a child, when he was encouraged to draw by his mother. This quote is an inspiration for everyone who has a dream and a vision. Van Gogh captured reality in his own unique way, depicting what he saw and visualising the landscape through his paintings. Wheat fields, orchards and other rural scenes such as harvests were among his favourite topics.

The Post-Impressionist art movement was known for the application of vivid colours, the often dense use of paint and for depicting real-life subject matter. Post-Impressionists were more inclined to emphasise geometric forms than their predecessors, the Impressionists. In the mapping and surveying profession, capturing reality often produces point clouds – which can sometimes look surprisingly similar to a Van Gogh painting. Many geomatics companies have got where they are today by taking a similar trial-and-error approach. Start-ups have become household names in the geospatial industry, and some of them are celebrating major milestones this year. During Intergeo, RIEGL, the Austrian manufacturer of high-end laser scanning equipment, celebrated its 40th anniversary. Trimble, the California-based developer of GNSS receivers, total stations, laser scanners and other geospatial solutions, was founded in the same year (1978). Racurs, the Russian photogrammetry specialist, was established 25 years ago.

None of them would have got this far without experimenting to find out what works and what doesn't… i.e. without doing what they cannot do yet.

Wim van Wegen, content manager

5 Questions to... Victor Adrov, Racurs

Racurs has a 25-year track record of success in the Russian and worldwide geomatics markets. The company, which was founded in 1993, has become a household name among photogrammetry specialists, particularly thanks to its innovative digital mapping software for processing aerial, spaceborne and terrestrial imagery: Photomod. Here Dr Victor Adrov, managing director of Racurs, answers five questions on the history, current status and future of the company.

Racurs has been celebrating its 25th anniversary this year – congratulations! So how did photogrammetry software look in the early days of your company?

The first versions of Photomod allowed the processing of only one stereo pair of central projection images, but already had automatic capabilities for tie point measurement and digital elevation modelling (DEM). The system included a stereovectorisation module, realised with the use of anaglyph glasses. The output of photogrammetric processing included DEMs and contour lines, orthophotomaps and 3D vectors. The system had a modular structure and worked on IBM-compatible personal computers in OS Windows 3. Practically speaking, at that time it was one of the world's first photogrammetric systems running on a personal computer. It was used effectively both for processing aerial surveys and in terrestrial and close-range photogrammetry projects.

The first Photomod licence was sold in 1995, and it is still your flagship product to this day. How has it evolved over the years?

Obviously, Photomod has changed a lot over the years. The development of the system was determined by our goal – to create effective high-end photogrammetric technology that allows processing of any remote sensing data and obtaining the output products needed by the customer. As Photomod evolved, it began to process optical data from space and airborne push broom scanners, and a special package appeared for processing data obtained by SAR systems. Of course, a module for automatic triangulation and block adjustment appeared. One of the main competitive criteria when choosing a photogrammetric system is productivity. Therefore, during the development of Photomod, much attention was paid to the development of algorithms for automating basic photogrammetric operations, distributed computing and improving the ergonomics of operator-machine interfaces. Whereas photogrammetric projects used to involve hundreds of images just a decade ago, nowadays big production companies use thousands of satellite images and hundreds of thousands of digital aerial images. When developing new versions of our software, we take into account huge amounts of stored and processed information, focusing on the modern capabilities of computing facilities, cloud and cluster solutions. I think that Photomod is currently one of the most productive digital photogrammetric workstations (DPWs) in the world.

Your R&D department is a very important pillar of your company. How would you describe your research activities?

A distinctive feature of Photomod is that the algorithms and all programming code are developed by our own team. We don't use other companies' software modules for any technological operations. Therefore, it is obvious that we have to focus more on research work. That research works allow us both to develop Photomod and to participate in R&D projects of our partners and users, such as ROSCOSMOS and defence industry initiatives. The main aims of our research are related to improving the efficiency of photogrammetric solutions and obtaining new types of output products needed by customers.

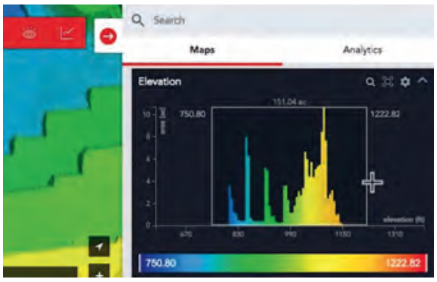
How has the rise of UAVs for mapping and surveying influenced your business?

The development of unmanned aerial vehicles (UAVs or 'drones') and the growing interest in their use in our industry have greatly influenced both the geomatics industry itself and the developers of photogrammetric technologies. First of all, active use of UAVs in aerial surveying led to the appearance of many small companies that required photogrammetric capabilities for data processing. But those companies didn't have the resources to buy expensive high-level software used by professional photogrammetry specialists. That created a market demand for more affordable photogrammetric systems, designed to obtain a limited number of output products in a maximum automatic mode when using non-professional, non-metric cameras. UAV companies did not require advanced stereovectorisation tools or satellite data processing capabilities. Therefore, suppliers of complex professional high-end photogrammetric systems, including us, had to change their working methods to limit and simplify the operations interface, to eliminate redundancy of source information and output production, and to create more affordable specialised automatic solutions for processing UAV data only. In order to compete with producers of specialised software for UAV data processing, we have released and are successfully developing the UAS version of Photomod that is now used by many companies in Russia and around the world.

When it comes to photogrammetry, what are your expectations for the next five years?

I think the following factors will have the biggest influence on the development of photogrammetry: new data sources; new sensors, both aerial (including UAV) and spaceborne; the development of computer technologies and processing algorithms (including AI algorithms); the transition from 2D cartography to 3D representation of spatial data; and the development of internet and cloud solutions. We take all these factors into account when developing our technologies. I think that we can already speak of 'smart photogrammetry'. The ideal photogrammetry system of the future will have a huge set of various types of images as input, automatic data processing in order to obtain a metric 3D model of the territory, and automatic classification for subsequent use in different information systems. All producers of photogrammetric systems, including our company, are working on this. ◂

Delair Acquires Key Airware Assets to Expand Role in UAV Industry

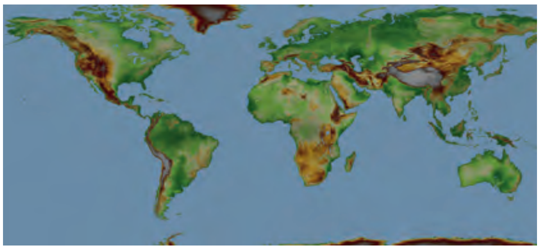


Turning aerial data into business insights.

Delair, a leading supplier of commercial unmanned aerial vehicle (UAV or 'drone') solutions, has announced an agreement to acquire the key assets of Airware, a developer of innovative software analytics tools for drone-based data. The acquisition gives Delair leading-edge technology assets, including a proven software solution, a highly skilled engineering and customer success team in Paris, and an installed base of customers and dealers worldwide. The acquisition also accelerates Delair's global growth and broadens its end-to-end solution for the commercial UAV market. Financial terms were not disclosed. "The acquisition signals a new period of growth and product line expansion by Delair. With the integration of Airware's complementary technology, we have significantly strengthened our position as the leading provider of drone-based business intelligence globally. This strategic development further enhances our offer which enables the digital transformation of enterprises in the key industries we serve," said Michaël de Lagarde, co-founder and CEO of Delair.

https://bit.ly/2RxKoD5

WorldDEM Now Entirely Edited and Available via Streaming

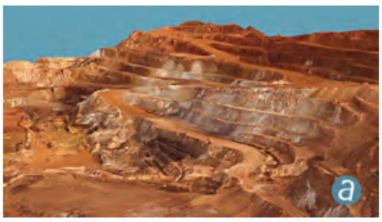


The WorldDEM single-source digital elevation model (DEM).

Airbus Defence and Space has announced that the entire edited WorldDEM database, together with the already available WorldDEM4Ortho dataset, is now available via streaming. This online access to the WorldDEM and WorldDEM4Ortho of the entire Earth's landmass facilitates a wide range of applications such as line-of-sight analysis, hydrological modelling, satellite imagery orthorectification and much more. Following the comprehensive global acquisition campaign and subsequent processing effort, WorldDEM data is now available for the entire world in an edited version. This dataset corresponds to a hydro-enforced digital surface model with water surfaces of lakes and reservoirs set to a single elevation, rivers and canals flattened with monotonic flow, oceans set to zero and coastal infrastructure features removed.

https://bit.ly/2JDw7BW

SimActive Launches Version 8.0 with 3D Modelling



Correlator3D 8.0.

SimActive, one of the leading developers of photogrammetry software, has announced the release of version 8.0 with a new 3D modelling module for Correlator3D. The module allows the generation of 3D textured meshes to create photorealistic models, which can be exported in standard formats including as OBJ files. Adding a 3D modelling function addresses an increasing need in the industry and is the natural progression of the software workflow, according to Louis Simard, CTO of SimActive. The module implements a new capability to bolster the same software at no additional costs for users, ingrained with the principles of simple, fast and precise.

https://bit.ly/2yQAISG

Bentley Acquires Web-based 3D Urban Planning Pioneer Agency9

CityPlanner screenshot.

Bentley Systems has announced the acquisition of Agency9, based in the Swedish capital of Stockholm. Agency9 has already provided nearly half of Sweden's larger municipalities with city-scale 'digital twin' cloud services for city planning and related web-based 3D visualisation. Since 2012, Agency9 has taken advantage of reality meshes created by Bentley's ContextCapture reality modelling software as the digital context for visualising urban infrastructure assets represented in GIS data, terrain surveys and BIM models. Bentley's new iTwin cloud services, which similarly to the Agency 9 acquisition were also introduced at the 2018 Year in Infrastructure conference, add digital alignment and change synchronisation for infrastructure engineering digital twins, and will enable OpenCities Planner (formerly Agency9 CityPlanner) to serve urban planning requirements at fuller levels of detail.

▸ https://bit.ly/2JEOIVF

Teaming up for Better Interoperability between Geospatial and 3D Graphics Communities

Advancing open geospatial standards related to AR and VR.

The Open Geospatial Consortium (OGC) and The Khronos Group, an open consortium of leading hardware and software companies creating advanced acceleration standards, have announced a liaison to jointly advance open geospatial standards related to the fields of augmented reality (AR) and virtual reality (VR), distributed simulation and 3D content services. As part of the liaison, and through collaborative participation in OGC and Khronos initiatives – such as working groups, committee activities, innovation programme initiatives (e.g. test beds, pilots), regional forums and workshops – the two organisations will work jointly to develop use cases and requirements for open geospatial standards concerning 3D, VR and AR APIs and related graphical representations.

▸ https://bit.ly/2D5bfm9

Visiona and Tesera Announce High-resolution Forest Inventories R&D Project

Radar imagery of eucalyptus plantation in Brazil.

Visiona Tecnologia Espacial, a Brazilian company, and Tesera Systems, a Canadian company, have been approved for a joint R&D project to create high-resolution forest inventories for the Brazilian forest sector with remote sensing solutions from Visiona's portfolio, including optical and radar imageries. The project is co-financed by the Brazilian São Paulo Research Foundation (FAPESP) and the Government of Canada through the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP). The usage of the optical and radar imageries is set to contribute to expanding Tesera's expertise in creating high-resolution forest inventories which, up to now, is based on a combination of airborne Lidar and colour infrared imagery for the Canadian market. The predictive performance resulting from combinations of different satellite sensors is one expected outcome of this project. Visiona and Tesera intend to build the means to optimally combine different imagery and generate high-resolution inventory data and analytics according to customer specifications. The participation of several customers in the R&D project is aimed at helping to design a product that effectively meets customer needs.

▸ https://bit.ly/2Or6gOZ

Successful Completion of Urban BVLOS UAV Project in Calgary

senseFly and IN-FLIGHT Data BVLOS UAV project crew.

IN-FLIGHT Data, one of Canada's leading commercial drone operators, has – in collaboration with senseFly, a leading provider of fixed-wing drone solutions – completed North America's first urban beyond-visual-line-of-sight (BVLOS) unmanned aerial system (UAS or 'drone') project in a major city. The project, carried out in the Canadian city of Calgary, Alberta, was commissioned to collect mapping data to support the development of a new graveyard site, the city's first new cemetery since 1940. The mapping of the area, completed using a senseFly eBee Plus fixed-wing drone, saw IN-FLIGHT Data's team conduct a total of 414km BVLOS operations at an average distance of 2.35km from the pilot, and began as part of IN-FLIGHT Data's wider BVLOS UAS operations trial earlier this year. The aim of the trial was to demonstrate the safety and effectiveness of BVLOS UAS flights and the cost and efficiency benefits they can provide to citizens and governments alike.

▸ https://bit.ly/2AMInxm

Geomares Establishes Subsidiary for Technical B2B Marketing Services

Marketing and media company Geomares has announced that it is splitting off its marketing services and transferring them to a newly founded subsidiary: Factrics, marketing by facts. Durk Haarsma, director of strategy & business development at Geomares, explains: "This move represents a conscious choice to make a clear separation between our advertising and marketing services, both internally and externally. The Geomares brands remain an essential link in the interaction between professional buyers and businesses in the geomatics and hydrographic community. With Factrics, we're aiming to become the go-to digital marketing agency in the technical B2B industry, supported by our extensive industry experience in geomatics and hydrography, and in-depth knowledge of digital marketing."

▸ **https://bit.ly/2AMqTkt**

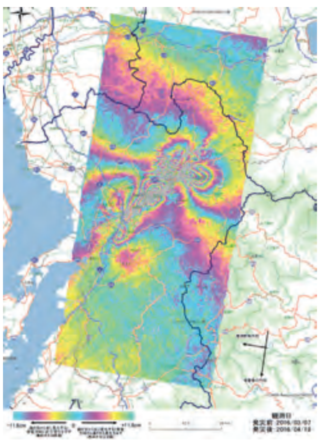
Extensis and LizardTech Continue as One Company

Extensis and LizardTech have announced they are uniting as one global company to help organisations increase the ROI and value of their digital assets, fonts and large imagery. Last year, Extensis and LizardTech collaborated on developing a new portfolio of asset georeferencing capabilities ideal for applications in the geospatial, infrastructure, AEC and BIM segments. With Extensis' market leadership in digital asset and font management combined with LizardTech's expertise in image management and state-of-the-art image compression technology, the united company expects to be in an excellent position to provide an unrivalled suite of solutions and support for digital asset challenges.

▸ **https://bit.ly/2yUBLvp**

Extensis Express Server.

PASCO Introduces InSAR Package Based on the ALOS-2 EO Satellite



Crustal deformation analysis by InSAR.

PASCO, a Japanese provider of satellite-based geospatial information, has signed an agreement to distribute data and images acquired by the ALOS-2 Earth observation (EO) satellite which is owned by the Japan Aerospace Exploration Agency (JAXA). As part of this agreement, PASCO will start selling a new InSAR Package service to support different users' needs for analysis and monitoring over time. In recent years, natural disasters have occurred more frequently around the world, and research projects aimed at disaster prevention have been actively implemented. In particular, research using Earth observation satellites is gaining attention as an effective method because a wide range of information can be obtained on a regular basis. Among them, the Synthetic Aperture Radar (SAR) satellite represented by Japan's Advanced Land Observing Satellite 2: Daichi-2 (ALOS-2) is effective for periodic observation because images are suitable day and night, regardless of atmospheric weather conditions. Interferometric SAR (InSAR) analysis is suitable for monitoring land subsidence and deformation associated with a natural disaster, and the need for this is increasing year by year.

▸ **https://bit.ly/2OnOrle**

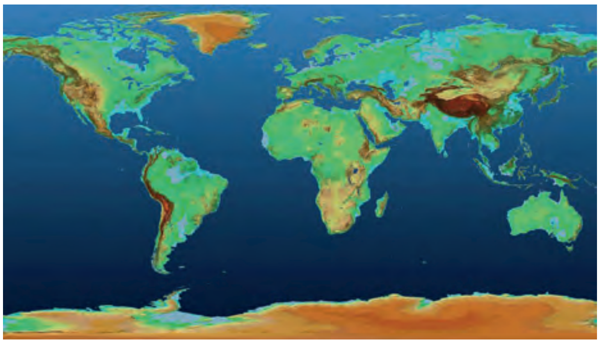
Converting Static Scans into Immersive 360° Imagery

NavVis, a leading provider of indoor spatial intelligence technology, can now automatically convert E57 point cloud files into interactive, realistic 360-degree walkthroughs, following the latest software upgrade to IndoorViewer. NavVis IndoorViewer is a web-based application that displays realistic digital twins using 360-degree panoramic images, point clouds and maps generated by 3D scanning devices. Users can move around digital twins of scanned spaces as if they are on site and use the interactive functionality to add, search for and route to geotagged information and take accurate measurements. The intuitive user interface and functionality has made NavVis IndoorViewer a valuable deliverable for laser scanning professionals who want to extend the use of point clouds beyond BIM models and building plans to a wider range of building stakeholders who would also benefit from 3D scan data. This is particularly relevant for stakeholders working on complex projects or properties, such as manufacturing facilities and construction sites, where IndoorViewer enables remote access to the site and is used as a platform for collaboration and exchanging information.

▸ https://bit.ly/2D5dLsB

360° walkthrough created with IndoorViewer.

Satellites Create 3D Height Map of Earth


DLR's 3D height map of Earth.

DLR Space Administration, the German space agency, has released a 3D height map of Earth. Built from images acquired by two radar satellites (TerraSAR-X and TanDEM-X), it traces the variations in height across all land surfaces – an area totalling more than 148 million square kilometres. DLR is making the map free and open, enabling any scientist to download and use it. The map is based on satellites sending down microwave pulses to the surface of the planet and then timing how long the signals take to bounce back. The shorter the time interval, the higher the ground level. TerraSAR-X and TanDEM-X fly virtually side by side, sometimes coming to within 200m of each other. This is complex to control, but it gives the pair 'stereo vision', by allowing them to operate in interferometric mode in which one spacecraft acts as a transmitter/receiver and the other as a second receiver.

▸ https://bit.ly/2SMdQ9R

Spottitt Presents Cloud-based Geospatial Data Analysis on DNV GL's Veracity Platform


Automated land cover analysis.

Spottitt has launched a cloud-based workspace that puts massive satellite imagery sources and advanced analysis capabilities at the fingertips of energy, environment and infrastructure professionals. The Spottitt service is available now through Veracity, DNV GL's industry data platform and online marketplace. The platform provides users with everything they need to extract valuable information from satellite imagery and related datasets in a secure, self-service cloud workspace, according to Spottitt's CEO Lucy Kennedy. With Spottitt, clients do not need powerful computers, image processing software or formal GIS training to leverage the value of geospatial data. Effective immediately, users may set up a Spottitt account through the Veracity digital marketplace. DNV GL, a global quality assurance and risk management company based in Norway, established the Veracity ecosystem to provide easy access to databases, analytics and applications for its worldwide customer base in energy, maritime and other industries.

▸ https://bit.ly/2PbSe8z

The Parallels between Surveying and Journalism

In October I was in London to attend the Year in Infrastructure Conference, organised annually by Bentley Systems. Chris Barron, chief communication officer at the software solution provider for engineers and construction professionals, kicked off the Media Day with warm words for the journalists who had travelled from all over the world. Barron referred to the fact that the journalism profession is under attack these days. But just as surveyors contribute to buildings and infrastructure all over the world, helping to transform our planet into a more sustainable and liveable place, he said, journalists also play a vital role by informing citizens across the globe about societal challenges as well as the solutions that are available to overcome them.

What both professions have in common is data. Surveying and journalism are both about gathering information and utilising techniques to distribute it. Surveyors capture, analyse, modify and visualise data. Eventually, the geospatial information is delivered to a broad spectrum of users, ranging from urban planners to governmental organisations – e.g. cadastres and local authorities – and from mining companies to sectors such as construction and infrastructure. The digital transformation has democratised geospatial information; location-based apps on smartphones are just one everyday example. Data captured by surveyors finds its way to the masses. If you replace the word 'surveyors' with' journalists', the previous sentence still makes complete sense!

There are more similarities. The influence of technology and digitalisation has revolutionised both the media and the geospatial landscape. Smartphones and the internet have created a shift in how news is distributed and consumed over the past decade. The same goes for the way in which geospatial information is used and, more particularly, in the infrastructure for bringing geospatial data to the masses – not only for business and governmental purposes, but also for everyday use by citizens.

Geospatial data can be used to create digital twins: 3D reality models that form a digital representation of the built environment. Real-time, continuously updated digital twins can be made available for various stakeholders such as clients, consultants and contractors, but also – and perhaps most beneficially in promoting open and democratic societies – to citizens! This is where geodata – acquired by professional surveyors and mappers – becomes visible as an important contributor to creating a better world. A digital twin can be a very helpful tool in creating solid support for urban planning projects, for example. Governments can develop new plans for cities together with their citizens. This way, geodata forms an important building block for our society. Journalism is a building block too. It informs us what is going on and paints – or at least colours in – a picture of the world for us. In a way, journalism also creates reality models. People consume the same news, but may interpret it differently. The same holds true for geospatial data, which can be interpreted in different ways as well.

Digitalisation has definitely contributed to reducing the limitations on how data can be acquired, and hence to increasing the possibilities for presenting it. To conclude this observation in a fair and balanced way, I have to emphasise that this works for both surveying and journalism. The new methods of gaining, modifying and distributing information have changed the world forever. And if we are careful and follow the right path, future generations will be able to conclude that the digital revolution made our planet a better place. I am sure that geospatial data holds the key to finding solutions for many of today's societal issues, whether by reducing the impact of climate change, fighting poverty or removing borders that block equality. Let me put it like this: both surveyors and journalists can be key contributors to achieving the Sustainable Development Goals.

▲ *Wim van Wegen at the editorial office of* GIM International.

GIM INTERNATIONAL INTERVIEWS DR PHILIPPE SIMARD

Family Business at the Forefront of **Processing Photogrammetry**

SimActive is a leading developer of photogrammetry software. The Canadian company, which was founded by two brothers – Louis and Philippe Simard – in 2003, celebrates its 15th anniversary this year, which gave us a good reason to touch base with geomatics entrepreneur Philippe Simard. In this interview, he talks about the recent developments in digital photogrammetry, the company's flagship product Correlator3D, automated classification of point clouds, the influence of drones in the democratisation of photogrammetry and mapping, and much more. Read on for the latest insights into the processing of geospatial data.

Like Bentley and various other companies in the geomatics industry, SimActive is a family business. You have an academic background and hold a PhD in computer vision. What were your main reasons for establishing a company back in 2003, and what do you regard as the main advantages of operating as a family business?
My brother and I were raised in a family of entrepreneurs and always dreamed of starting our own business together. We both had a background in computer vision and saw an opportunity to apply our knowledge to photogrammetry. The Canadian Department of National Defence was involved in mapping Afghanistan using digital cameras, which were new in the industry back then as traditional film was still the norm. They were looking for software that would be fast, precise and – most importantly – easy to use compared to traditional photogrammetric tools, because teams were being replaced every six months. We won the contract to develop such a new technology and the Canadian Army ended up being the first user of Correlator3D. Now, 15 years on, my brother and I feel the biggest advantage of working together is that we can be blunt with each other if necessary.

▲ *Philippe Simard (left) and his brother Louis founded SimActive in 2003.*

Many companies in the field of digital photogrammetry offer the same type of processing software, i.e. from aerotriangulation (AT) up to the creation of digital terrain models (DTMs), 3D digital landscape models and 3D city models. What sets your solutions and services apart?
With the rise of drones (*unmanned aerial vehicles or UAVs, Ed.*), there have been several new entrants in the industry. Our software offers a higher-end solution for photogrammetric requirements. Because it was originally developed for large-format aerial systems, it embeds rigorous algorithms to consistently generate results with higher accuracies throughout projects. Also, it offers advanced automation capabilities with scripting facilities and a command-line interface. Large datasets (e.g. 20,000 images at 250MP each) can be processed in one batch on a single standard PC, with timings varying linearly with the number of images. Rival tools competing on that aspect show exponential timings, forcing users to divide large projects into several smaller parts or to invest in cost-prohibitive hardware setups.

One of the distinguishing features of Correlator3D is its high processing speed. Is this because of the smart implementation of semi-global matching (SGM) to enable the creation of very dense photogrammetric point clouds, or are there other provisions?
For some reason, SGM algorithms seem to draw the most attention from users when talking about the generation of point clouds.

In practice, while they are an important aspect, they represent only a small fraction of implementing an autocorrelation module. Correlator3D algorithms were designed to be easily parallelised on hundreds of processors. This has made it possible to port them on graphics processing units (GPUs), as opposed to using CPUs. We introduced the first GPU-powered AT and DSM (*digital surface model, Ed.*) generation engines in the industry, enabling severalfold increases in processing speed.

Can you tell us more about the major design principles of Correlator3D?
Our software was inspired from one basic principle: simple is powerful. When we started developing the product 15 years ago, the available photogrammetric software required days – if not weeks – of personal training. Thus, our goal has always been to design solutions that would be simple, but that would still provide all the means to control the quality of the results. As such, the software builds on a modular approach where the user performs one operation at a time and controls the quality of the results at each step. For example, aerial triangulation is done first and the quality of the overall data is assessed and improved as necessary using built-in tools. Then, a DSM is generated, a DTM is extracted and elevation data can be edited interactively. Lastly, orthophotos are created along with a mosaic, seam lines can be visualised and modified as well, and overall colours can be adjusted.


▲ *Philippe Simard.*

What were the main hurdles to overcome in the design, operationalisation and commercialisation of Correlator3D?
One big advantage of the software is that it can support any type of imagery gathered by aircraft, satellites and drones. Such datasets differ greatly both in size (from 5MP for a drone image up to 2,000MP for a satellite photo), in nature (colour, panchromatic, infrared, multi-spectral) and the way they are collected (pushbroom cameras, multi-sensor setups, consumer-grade cameras, and so on). It represents a big technical challenge to come up with unified algorithms as well as a single processing interface. Users also have different requirements and expectations. As a company, we were able to not only overcome these technological challenges, but also to successfully market our product worldwide for such a great variety of applications.

Automated classification of point clouds, created from both laser scanning and photogrammetry, is a very active research area. Are you working on extending your software in this direction?
We have always been a pioneer in the classification of point clouds, especially on the extraction of DTMs from DSMs. While Lidar data provides first and last return information which greatly facilitates the extraction of a bare earth model, photogrammetrically derived DSMs only contain geometric information. Correlator3D includes a module for automatic DTM extraction, and also features manual tools to further help the classification. We are continuously improving these functions based on comments from users, and the feedback has always been that our offering in that regard is unique in the market.

Which applications and users did you have in mind when designing your software in the initiation phase?
As I mentioned earlier, the requirements for the software came from the Canadian Army, so military users definitely provided the initial inspiration. Such clients are very demanding in all aspects, but especially in processing speed and quality of results. We also had early adopters in the surveying and mapping industry. First and foremost, such users need absolute accuracy, as the map products they deliver are utilised for applications such as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engineering. In all these cases, the sensors used were medium/large-format camera systems up to 250MP.

How would you describe the present user base of SimActive software?
We have thousands of users in over 100 countries across the world. They include government agencies like the US Army Corps of Engineers, the European Satellite Centre, Ordnance Survey and the National Geospatial Agency (NGA). We also serve large companies in various fields such as Chevron, Boeing Insitu, AeroVironment and BHP. Our traditional client base comprises firms that conduct flights using aircraft with in-built sensors, such as Sanborn, KKC, Atlantic Group, Wantman Group and Optimal Geo. With the rise of drones in the last few years, we have also seen exponential growth in the number of small firms using our software.

Open source seems to be the new paradigm for many software developers all around the world, and especially those operating in an academic research environment. How is open source affecting your business?
There has indeed been a rise in open-source solutions, especially GIS software for viewing geospatial data. However, they are not popular in photogrammetry because of the complexity of our field, and there has been no impact on our sales. Users are not only looking for software tools, but also for advanced technical support. For example, we advise users on how to collect data to optimise results. We also help in establishing efficient workflows and integrating our software into their processes. And if they encounter issues in projects, we analyse their situation and make recommendations.

Since the introduction of the first digital photogrammetric camera in 2000, photogrammetry has made some fascinating advancements. Which societal and technological developments will further boost photogrammetry in the next five years?
Drones have had a significant impact on technology in the last few years and are continuing to do so. They have contributed to the democratisation of photogrammetry and mapping, making it easier for neophytes to get started. This revolution will keep happening, with photogrammetry becoming more and more accessible. Surveying projects using imagery used to take weeks, if not months. With the advancement of technologies, turnarounds are becoming much faster, enabling drone data to be collected in the morning, processed in the afternoon and delivered by the end of the day.

▲ *Philippe Simard addressing the audience on photogrammetry software.*

TURNAROUNDS ARE BECOMING MUCH FASTER, ENABLING DRONE DATA TO BE COLLECTED IN THE MORNING, PROCESSED IN THE AFTERNOON AND DELIVERED BY THE END OF THE DAY

Which knowledge and skills do you expect from young technological professionals who want to build a career within your company?
Our team is growing rapidly and we are always looking for talented people. On the R&D side, we tend to hire engineers with a background in computer vision or artificial intelligence. This gives us a different point of view than photogrammetry, and being able to see things differently translates into innovation. On the sales side, being in a highly technical field, we recruit smart people who are not only able to handle business aspects, but can also understand the technology side and guide clients in the purchase process.

Do you have a final message for the geospatial community?
Collecting image data using drones, satellites or aircraft will keep getting easier in the years to come. But the real challenge will continue to be the quick and efficient processing of huge amounts of data. This has always been our focus at SimActive and we feel the role we play in the industry can only keep growing.

ABOUT PHILIPPE SIMARD
Dr Philippe Simard has been the president of SimActive since its creation in 2003. Under his leadership, the company rapidly positioned itself at the forefront of the industry. Through his efforts, SimActive has experienced exponential global growth, and the software is now used by thousands in over 100 countries. His prestigious achievements include adoption of Correlator3D by governments, military organisations and leading mapping firms around the world. He holds a doctorate in electrical engineering from McGill University, where he completed his research in computer vision. Within two years of forming SimActive, he won the prestigious Young Innovator Award from the Networks of Centres of Excellence, which honours top Canadian researchers whose work benefits society.

AUGMENTING 3D GEOMETRY WITH SEMANTIC INFORMATION

Object-based Classification of Point Clouds

Today, the analysis of 3D point clouds acquired with topographic Lidar or photogrammetric systems has become an operational task for mapping and monitoring of infrastructure and environmental processes. Numerous applications require the identification and delineation of landscape objects and their properties. So far, many software solutions have been focused on the analysis of constructed and man-made objects, which are characterised by a regular and well-defined geometry (e.g. buildings, roads and other infrastructure). In comparison, the detection and analysis of natural landscape objects is challenging, since object boundaries might be fuzzy and the object characteristics within one class can be very diverse.

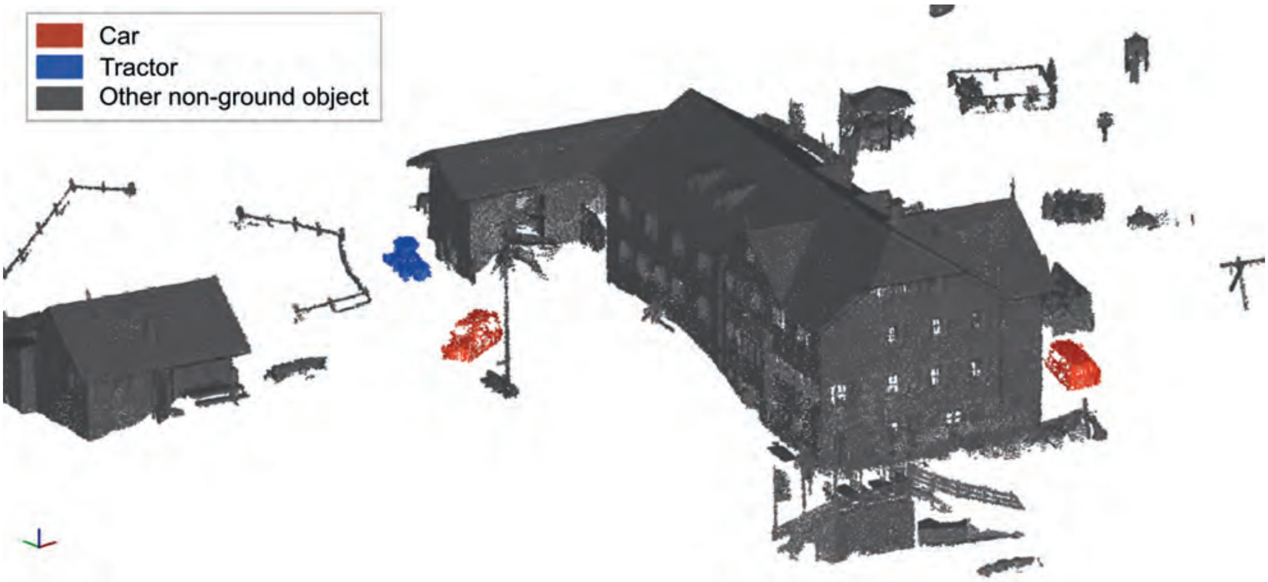
In contrast to image or voxel data, point clouds usually have irregularly distributed point patterns and thus lack a regular basic unit. Therefore, local relations between neighbouring points have to be established as a first step. Many different variants of object-based workflows exist. The key steps of a typical object-based workflow for point cloud classification are (i) the segmentation of the point cloud, (ii) the calculation of segment features, and (iii) the classification of segments based on their feature values to label the objects of interest.

POINT CLOUD SEGMENTATION

In the segmentation step, the point cloud is partitioned into subsets of neighbouring points called 'segments'. In addition to neighbourhood definitions, further characteristics, such as spectral values and geometric features, are used for guiding this process. The result is a set of internally homogeneous segments, i.e. groups of points representing the basic units for classification. In many cases, segmentation procedures aim to produce relatively small segments, representing only object parts (sub-objects) in the first step rather than the final objects of interest directly. Once these segments are classified, adjacent segments of the same class can be merged to spatially contiguous objects. Such a step-wise procedure based on initial oversegmentation has proven to be beneficial as it reduces the risk of combining multiple real-world objects in one segment (undersegmentation).

POINT FEATURES VERSUS SEGMENT FEATURES

Depending on the target classes, the classification relies on features that



▲ *Figure 1: Subset of a classified point cloud from a Lidar UAV.*

characterise the different classes well enough for distinct separation, i.e. the classes must have a unique signature in the feature space, with sufficient differences between classes. Features on a point basis can, on the one hand, originate directly from sensor measurements, such as colour from imagery or corrected Lidar intensity. On the other, geometric point features can be extracted from the neighbourhood of the point. The neighbour search can be constrained either by a fixed number of neighbour points or by a defined search radius (for a cylinder or sphere). For the given neighbourhood point set, such features can describe the local point density, height distribution or deviations from a locally fitted plane, for instance. Moreover, eigenvalue-based features, derived from the point sets' 3D covariance matrix, are often used, such as the omnivariance as a descriptor for the shape of the points' distribution in 3D space.

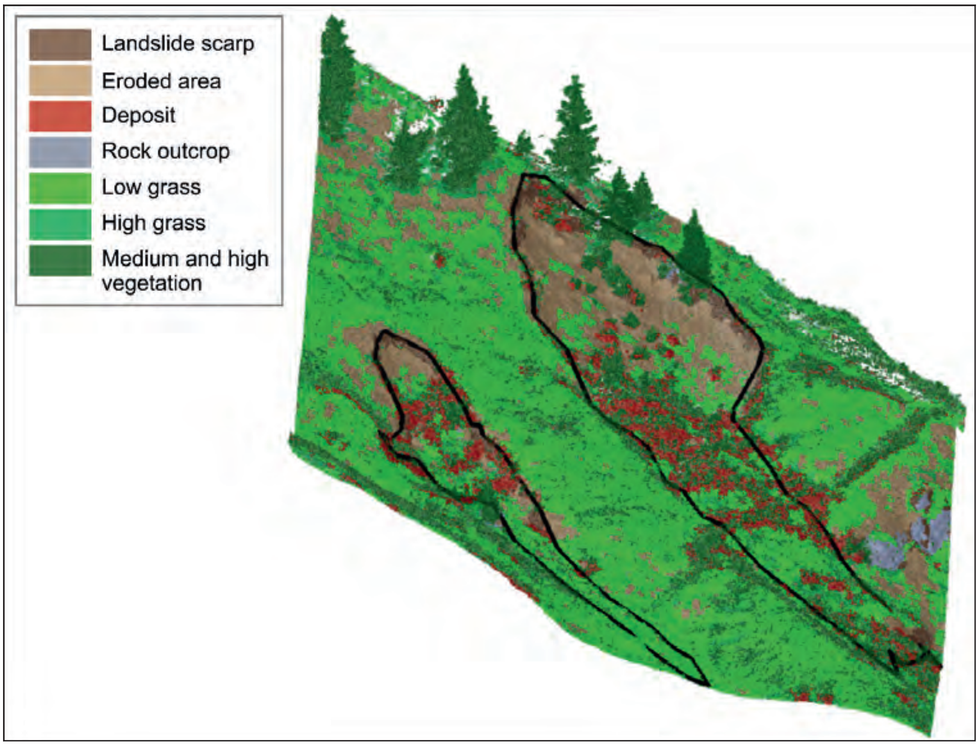
In contrast to per-point classification, object-based classification exploits features that relate to segments (sub-objects). Such segment features can be the average or the standard deviation of all point-specific feature values in a segment. These segment features are often more representative for class characteristics than single point features, which can be very variable within a class and even within one object. Additional features, like segment shape and size, may also be useful to separate classes.

CLASSIFICATION OF SEGMENTS

In the classification step, the (sub-)objects (i.e. segments) are assigned class labels based on their characteristic feature values. Figure 1 shows a simple example for object-based classification of vehicles in a point cloud acquired by a Lidar unmanned aerial vehicle (UAV). Here, all non-ground segments have been classified based on only two features: their mean Lidar reflectance and their mean omnivariance. First, individual people and small objects are filtered out by an object size threshold, then the segments are grouped into classes by k-means clustering with these features. Finally, semantic labels ('car', 'tractor', 'other non-ground objects') are assigned a posteriori to these classes.

While such simple unsupervised classification approaches might work for a small and very basic classification problem, various supervised classification algorithms are available for more challenging tasks.

▲ *Figure 2: Test site with two shallow landslides.*



▲ *Figure 3: Random forest classification of a point cloud and reconstructed landslide shapes (black).*

In supervised approaches, a statistical classifier is 'trained' with a limited number of representative sample segments with known class labels. This 'training subset' has often been labelled manually or using existing ancillary datasets. Finally, this classifier is applied to label all segments, depending on their feature values. In this respect, the segmentation can reduce the number of data entries to be classified by several magnitudes (e.g. from several million points to a few thousand segments). This improves the scalability of computationally expensive machine-learning algorithms for the classification of large point clouds, for instance.

Probably the most important advantage, however, is the ability to model context in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terms of a spatial relationship (topology) between objects. By taking into account objects of different scale levels, hierarchical relationships between objects and sub-objects can be established. Such topological relationships can, for instance, be used to correct misclassifications by applying topological rules. Figures 2-4 show an example from landslide monitoring in a complex natural scene, using repeated terrestrial laser scans (TLS). Here, a machine-learning algorithm detects landslide-affected areas in 3D point cloud segments separated from stable slope areas and vegetation, based on geometrical features. After the classifier had been trained on a subset of segments from one scan epoch, it was used to classify the entire time series, which currently consists of 13 scan epochs. The 'medium and high vegetation' class was accurately classified in this step. However, the geometrical similarity between 'eroded area' and 'low grass' as well as between 'high grass' and 'deposit' makes their correct classification difficult. Thus, a simple topology relates the pre-classified segments to coarsely detected landslide outlines from each epoch, i.e. objects at a higher hierarchical level (super-objects). Reclassification by rules considering spatial context (e.g. 'no eroded area outside the landslide outline') improved the classification accuracy for certain classes by up to 14%. This example shows how object-based point cloud analysis for natural landscape objects can be used for applications in 3D deformation monitoring, automated interpretation of deforming objects and the identification of underlying geomorphological processes.

RECLASSIFICATION BY SPATIAL CONTEXT RULES IMPROVED CLASSIFICATION ACCURACY BY UP TO 14%

ADVANTAGES AND CHALLENGES

It can be concluded that object-based classification of point clouds, i.e. using segments as the base unit for classification, is a promising alternative to classification of individual points. While generalising over noise and outliers in feature space, the geometric detail and accuracy of the original 3D point cloud is preserved for use in further analyses, such as deformation calculations. In addition, object-based approaches have the advantage of providing more informative features and contextual relationships for classification and object interpretation.

One of the most crucial steps in the approach is achieving a valid segmentation. This should keep points from different target objects separated, but at the same time create segments that are sufficiently large to provide meaningful additional features, such as segment size or shape and spatial context. The analysis of natural objects is especially challenging, since object definitions are sometimes ambiguous and gradual transitions exist at object boundaries. This approach provides an innovative way to tackle these challenges and to improve monitoring of objects in a natural environmental context.

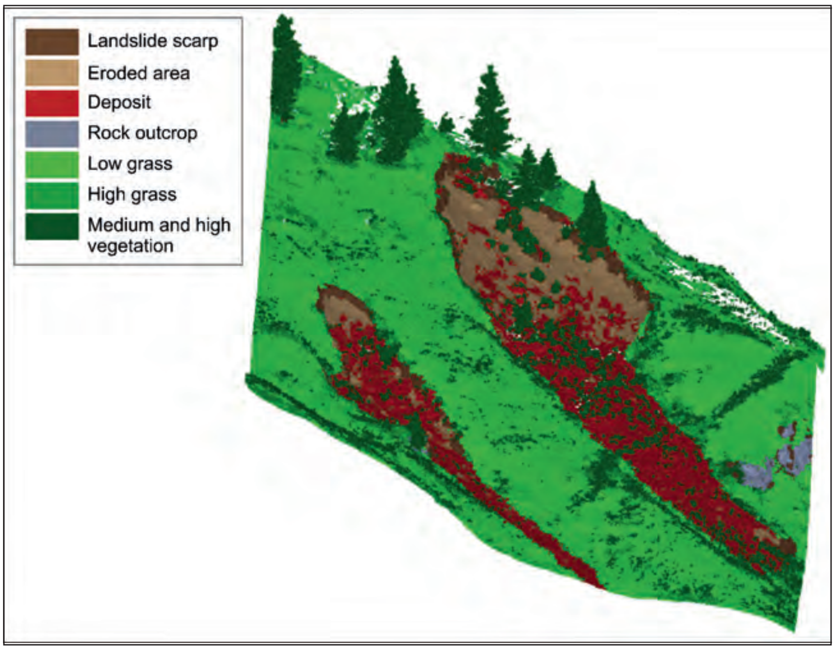

Figure 4: Final classification result.

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ABOUT THE AUTHORS

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Dr Martin Rutzinger is head of the Remote Sensing and Geomatics Research Group at the Institute for Interdisciplinary Mountain Research of the Austrian Academy of Sciences in Innsbruck. He is specialised in 3D point cloud processing and information extraction for environmental monitoring linked to research in geomorphology, vegetation mapping and natural hazard management.

COMBINING METHODS FOR FAST SIMULATION AND 3D VISUALISATION

On-the-fly Decision Support in **Flood Management**

In flood and storm water management, simulation is widely used for flood risk assessment, for designing mitigation measures and for sustainable urban planning. In this context, live sessions are an effective tool for collaboration between domain experts and decision-makers to discuss and develop new ideas. This article presents an integrated flood simulation and visualisation system that is able to provide answers to the questions of experts and stakeholders on the fly. It supports fast incorporation of new parameters through visual interfaces, immediate provision of simulation results, derivation and analysis of key indicators, and 3D visualisations that even non-experts can understand.

In the standard workflow of flood and storm water management, flood simulation is separated from the analysis and visualisation of the results. Moreover, these steps usually happen offline, prior to the presentation of the results to decision-makers and stakeholders. If new ideas or questions emerge during the presentation (e.g. about possible protection measures), the entire time-consuming process has to be repeated, which might take days.

The interactive decision support system called Visdom drastically shortens this process by combining simulation, analysis and visualisation in a single tool. Working with alternative scenarios is a core concept in this system. Users can vary simulation parameters over different scenarios and compare the simulated outcomes right away to analyse the consequences of individual parameter variations. The simulation parameters include properties of flooding events such as the intensity and duration of rainfall, the magnitude of river floods or the failure of existing protection measures. They also include characteristics of hypothetical protection measures such as mobile barriers (short-term measures) or retention areas (long-term measures).

Figure 1: Buildings are colour-coded according to the estimated flood damage in a heavy rainfall scenario.

Thanks to the integrated design, Visdom provides immediate answers to questions about flood incidents and mitigation measures that might emerge during live sessions with domain experts, stakeholders and decision-makers. Ideally, these answers prompt new ideas to refine simulation parameters, e.g. by adding a new barrier. In Visdom, initial results are available after just a few seconds. The interactivity of the system has been demonstrated in live sessions, such as at the Cologne Flood Protection Center in Germany. Decision-makers in Cologne currently use the system remotely, which is made possible by the client-server architecture.

FAST SIMULATION

To cover a wide range of possible flood disasters, various types of flooding scenarios are considered, such as river flooding, heavy rainfall or sewer overflows. Water propagation is calculated by solving the 2D shallow-water equations. The simulation uses an improved numerical scheme avoiding unrealistically high velocities at dry/wet boundaries.
The implementation is optimised for the parallel processing architecture of modern graphics processing units (GPUs), making computation many times faster than real time. For sewer or subway networks, a 1D pressurised-flow simulation is used. This can be coupled with the surface flow simulation at sewer inlets, for example.

ON-THE-FLY ANALYSIS AND 3D VISUALISATION

Depending on the extent of the simulation domain, the dataset can be very large and contain the results of numerous scenarios. For prompt visual feedback, analysis tasks are executed in parallel. One such task is the estimation of building damage from inundation (visualised in colour in Figure 1). For damage estimation, multiple scenarios can be considered simultaneously, e.g. to determine the average or worst-case outcomes. In this context, it also makes sense to visualise the uncertainty of the predicted outcomes. In Figure 2, simulated water levels are visualised together with their probabilities along the façade of a user-selected building. For this, once the user has selected the building, the system extracts flooding probabilities for that building from all simulated scenarios on the fly. In Figure 2, the terrain is colour-coded according to the maximum water depth.

For effective public communication, visualisations of simulation results should be intuitive. Besides the abstract terrain colouring, a realistic water surface representation is used (Figure 1). Most people have an intuitive understanding of how water looks, so a natural depiction of water increases the interpretability of the visualisations. For the efficient rendering of water in real time, established rendering techniques from the entertainment industry have been adopted and combined with specially tailored algorithms. Various effects provide subtle hints, such as animated waves and foam to indicate flow directions and velocities.

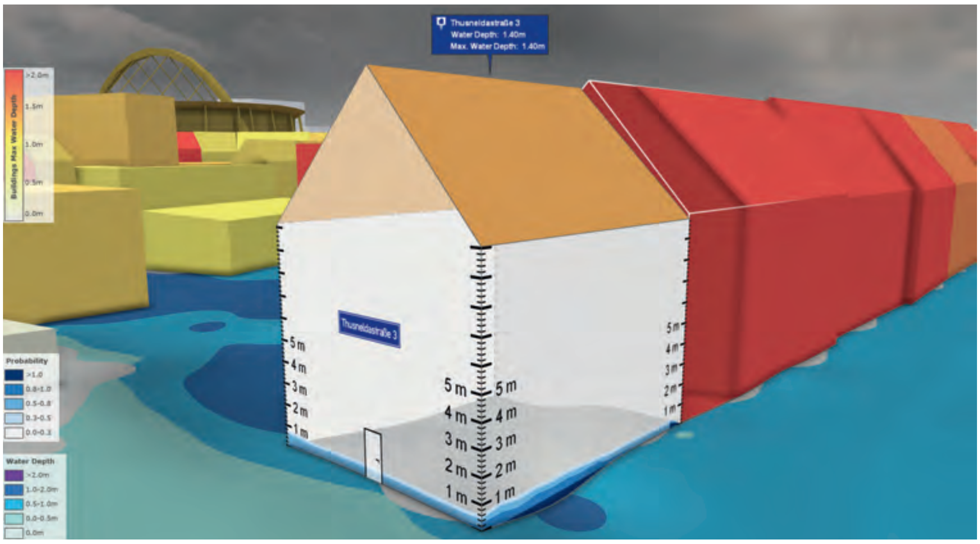

Figure 2: Flooding probabilities visualised along the façade of a building of interest.

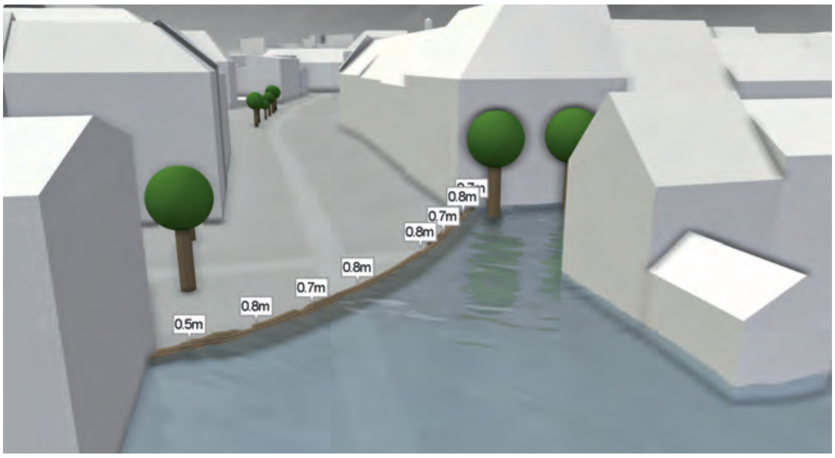

Figure 3: Testing the efficacy of a sandbag barrier by sketching it directly in the 3D visualisation.

Figure 4: Storm water scenario in an Austrian town. Water depth in sewer pipes is colour-coded.

SIMPLE SETUP OF NEW SCENARIOS

To test new ideas on the fly during live sessions, it should be easy to create and modify scenarios. Visdom offers sketch-based interaction so that users can intuitively perform common tasks by directly interacting with the 3D visualisation. No expert knowledge is required to change simulation parameters. For example, user interface elements for the display and manipulation of values are embedded in the 3D view. Simulation domain boundaries can be dragged in the 3D view and protection measures are sketched directly on the terrain (Figure 3). These interactions make it possible to modify an existing scenario within seconds to examine the consequences.


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DESIGN OF URBAN PROTECTION MEASURES

Cologne is currently protected by more than 11km of protection walls along the River Rhine. The Flood Protection Center is responsible for the city's preparedness for and response to flood-related incidents such as overtopping of protection walls, breaches or heavy rainfall. Designing flood protection measures in complex urban environments is a challenging task. Here, Visdom assists decision-makers with interactive scenario-based modelling. After specifying the flood incident (e.g. by inputting a water level in the river or by picking a breach location), users are able to quickly test and compare the effectiveness of different mitigation measures. For example, using the mouse, a mobile water barrier for the protection of important infrastructure can be sketched on the terrain. When simulating the scenario, the system automatically adjusts the barrier height locally to the water depth (Figure 3). Material requirements are computed as well as the delivery routes and times for the pre-defined depot locations. By modelling and comparing a multitude of different scenarios on the fly, flood managers are able to prepare a pool of response plans for the relevant incidents.

HEAVY RAIN MODELLING

In recent years, storm water management has become a hot topic for communities of all sizes, from small villages to large cities. In case of heavy rainfall, not all water seeps away; much of it runs off and collects in surface depressions, causing damage to infrastructure, property and, sometimes, people. The pressurised flow in sewer pipes can cause unexpected overflows in multiple locations. Potential pipe clogging caused by debris further complicates the situation. In short, storm water events are complex phenomena involving water exchange between the surface and the sewer network. In Visdom, the models for the surface flow and the underground flow in sewer pipes are tightly interlinked and treated coherently. The water consumed by sewer inlets is removed from the surface and vice versa, thus preserving the total amount of water. The system allows the user to model storm water scenarios of varying intensity, e.g. for risk assessment, for the creation of mitigation plans or for designing a sewer network. Using simple interactions, it is possible to simulate pipe clogging or to sketch additional sewer inlets. Visdom is currently used to assess risks caused by storm water events in several communities in Austria and Germany (Figure 4).

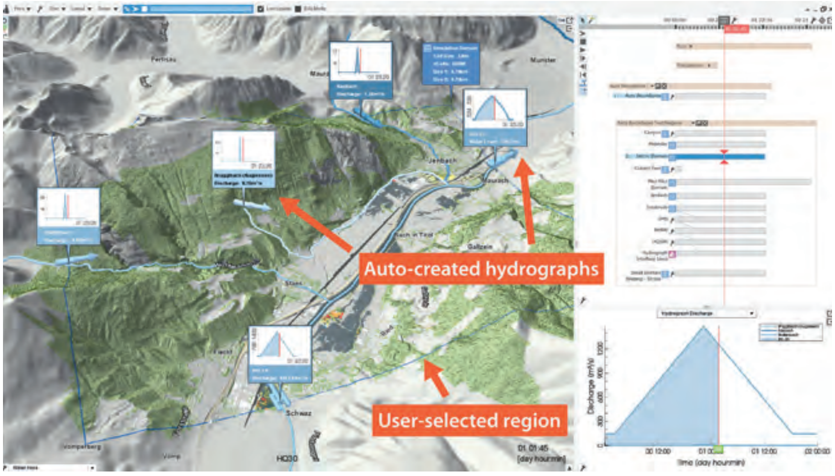

Figure 5: The system automatically derives simulation parameters for this user-selected region in Austria.

DETAILED FLOOD RISK ANALYSIS ON A NATIONAL SCALE

Simulation-based flood risk assessment on a national scale poses challenges with respect to the heterogeneity and the sheer size of the data. The HORA 3 project, commissioned by the Austrian Ministry of Sustainability and Tourism together with the Austrian Insurance Association, focuses on flood modelling for all rivers and streams in Austria. In this project, Visdom is the main software platform, combining methods from rainfall-runoff modelling, hydrodynamic simulation, geospatial analytics and visualisation. The user can pick a region of interest anywhere in the country and specify the annual flood probability (e.g. once in ten years, once in 100 years). Behind the scenes, the system automatically derives all necessary boundary conditions and other parameters for the simulator (Figure 5). Therefore, flood simulation can be triggered instantly, without a complex and error-prone setup process. The goal of the project is to create detailed flood risk maps for different flood probabilities and make them publicly available through the project website. Using these maps, citizens will be able to estimate the vulnerability of their premises to possible future flood hazards.

MORE INFORMATION

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Daniel Cornel is a researcher at VRVis Forschungs-GmbH. He holds an MSc in visual computing from the Vienna University of Technology and is currently pursuing his PhD. He is specialised in real-time rendering with a focus on engine development.

IDENTIFICATION BASED ON VISIBLE SPECTRAL BANDS

UAV Spectral Image Mapping of Shoreline Vegetation

Rapid identification of a clear water surface, shoreline and vegetation can serve as a means of monitoring of the water level and as an important indicator of changes. In cases when a high level of detail or on-demand data collection is required, unmanned aerial vehicles (UAVs or 'drones') can provide a good service. It is important to think about the costs of the UAV and the connected sensors as well. Multispectral and thermal cameras are still very expensive in comparison to visible cameras. This article shows how a commercially available middle-class drone (DJI Phantom 3 with built-in camera), which collects data only in the visible spectral bands and is affordable even for individuals, can be easily used to calculate colour spectral indices to identify shoreline, vegetation and water.

An area lying to the north of the city of Pardubice in the Czech Republic is very rich in ponds. The area of interest is flat, lying approximately 220 metres above sea level. It comprises clear water surfaces, seasonally flooded greenery, vegetation including treetops, dry reeds (including dry grass) and dry trees (see Figure 1).

FLIGHT PLANNING AND DATA COLLECTION

The dataset was captured on 20 April 2018, i.e. in spring. The flight was planned in advance in DJI GO and then sent to the drone. The drone automatically flew according to the plan. It took approximately 15 minutes to cover the area of 0.0285km^2 so no break in the flight was necessary. The total length of the flight was 1,545m, and it was planned in

Figure 1: Area of interest – shoreline of the Skrin pond.

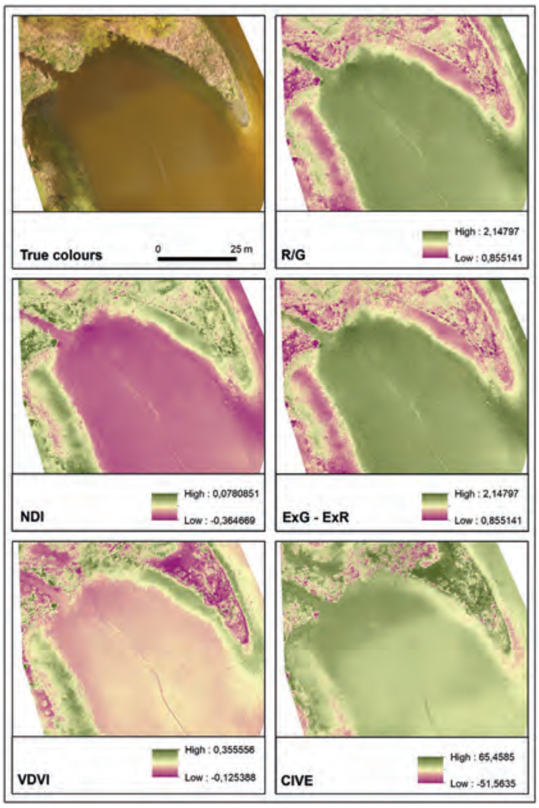

Figure 2: Area of interest and calculated vegetation indices.

seven main lines consisting of 64 waypoints in total. Front and side overlap were both 60%. Average speed was 2.2m/s, altitude was 39.6m and resolution was 1.7cm per pixel.

DATA PROCESSING TO CALCULATE VEGETATION INDICES

Two software tools were used: Pix4Dmapper 4.2.27 trial and ArcGIS for Desktop 10.5.1. Pix4Dmapper was used for a mosaic building and calculating all indices. ArcGIS was used for visualisation of the resulting indices. WGS 84 – UTM zone 33N was used as a coordinate system.

The final mosaic was created from 33 images, covering 0.012km^2. Certain types of land cover require a higher overlap, so images showing only treetops were not aligned because of the lack of common points. Nevertheless, the final mosaic covered the whole shoreline so it was perfectly usable for the next step.

The survey team calculated various colour-based vegetation indices, which are based only on red, green and blue bands: CIVE, ExG, ExR, GRVI, NDI, TGI, VARI and VDVI. Several colour band combinations and combinations of particular indices were calculated as well to include different approaches described in the literature. ArcGIS was used for visualisation of the results because it provides more visualisation methods and better tools for map creation. The 'Pink to YellowGreen Diverging, Bright' colour ramp was used for all indices, which helped to visually distinguish between particular land cover types. The other settings were: stretched visualisation, percent clip stretch (both min. and max. 0.5). Green colour represents the highest values, dark pink represents the lowest values, and yellow represents medium values in all cases to simplify comparison of the results. An inverted scale would be more natural in some cases, e.g. for displaying vegetation with the green colour.

RESULTS AND INTERPRETATION

Based on the visual interpretation and literature, the following colour indices were chosen as the most suitable ones: CIVE, ExG – ExR, NDI, Red/Green ratio and VDVI (see Figure 2 for results and Figure 3 for calculating algorithms).

The clear water surface is highlighted by R/G, ExG – ExR (dark green in both cases) and NDI (dark pink). The water surface can be easily distinguished from the seasonally flooded greenery. The borderline between the clear water surface and seasonally flooded greenery is indiciated by the yellow line. Green vegetation is highlighted by all indices. VDVI and CIVE clearly highlight treetops, displaying green and dry vegetation in dark colours so that these two types of land cover can be easily distinguished. Seasonally flooded greenery is well visible with R/G, NDI, ExG – ExR and VDVI because it is bordered by a yellow line. The best result is provided by VDVI (green colour). Dry reeds and dry trees are well highlighted by VDVI (dark pink) and CIVE (dark green).

CIVE	Colour Index of Vegetation Extraction	0.441*Red – 0.81*Green + 0.385*Blue + 18.78745
ExG	Excess Green	2*g – r – b
ExR	Excess Red	1.3*r – g
NDI	Normalised Difference Index	(Green – Red)/(Green + Red)
VDVI	Visible-band Difference Vegetation Index	(2*Green – Red – Blue)/(2*Green + Red + Blue)

▲ *Figure 3: Calculation formulas used to calculate vegetation indices.*

COMMENTS ON THE INDICES

VDVI is very useful for differentiating green vegetation from dry vegetation. R/G (and its opposite G/R) makes it easy to distinguish between vegetation and the clear water surface. The ExG – ExR difference makes it possible to distinguish all vegetation from the clear water surface. NDI makes it possible to distinguish all vegetation from the clear water surface. CIVE clearly highlights green vegetation, which can be easily distinguished from dry vegetation (both trees and reeds). The clear water surface cannot be easily distinguished because it is visualised in a similar way as dry vegetation.

CONCLUSION

Shoreline, vegetation and the clear water surface can be easily monitored by a middle-class UAV equipped with a camera recording only in the visible spectral bands. It provides data with a very high spatial resolution on demand and at acceptable costs. It can significantly help with monitoring of less accessible areas such as overgrown or waterlogged terrain, as in this case. Particular land cover types can be easily distinguished by a visual interpretation as the first step. Vegetation indices based on visible spectral bands appropriately complement the visual interpretation. They can quickly highlight vegetation, seasonally flooded vegetation and the clear water surface to enable identification of the shoreline as well. Each index emphasises different types of land cover so it is beneficial to combine multiple indices. ◂

ACKNOWLEDGEMENT

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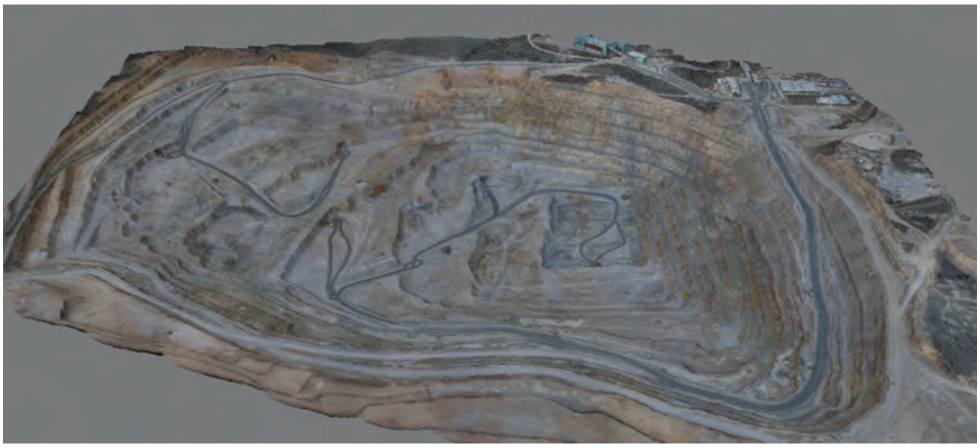
CAPTURING GEOSPATIAL DATA UNDER CHALLENGING CIRCUMSTANCES

3D UAS Mapping of a Copper Mine

In May 2018, the Erdenet Mine in the north of Mongolia was mapped in just three days. The open pit mine measures 5km by 2km and has an elevation difference of 200 metres. The dusty and complex circumstances called for the use of an unmanned aerial system (UAS). Despite the strong wind and extremely variable weather conditions, a single UAS quickly captured the geospatial output necessary for the management of one of Asia's – and the world's – largest copper mines.

The big data gathered and processed by the Czech firm UpVision provided a perfect overview of the vast location and recorded the exact status of the mine explorations, enabling three-dimensional modelling of the complex site. This was the first time a UAS had been used, but the results were so satisfactory that the method will be used regularly from now on. This will also allow the management to build an overview in 4D; by combining the initial results with future flights, they can easily compare data series over time

The UAS before take-off.



▲ *3D model of the mine.*

to predict and record work progress and build a digital 4D archive.

PREPARATIONS

The detailed mapping of the mine took two weeks of serious preparation. First, 21 ground control points (GCPs) had to be created and measured in the local UTM coordinate system using GPS RTK. Points had be marked with reflective sprays to ensure visibility during the days of the actual mapping. They had to be rechecked after controlled blasting in the mine and remarked when needed. Next time, more permanent markings will be used in several places. Additionally, it was necessary to carry out exploration of the mine surroundings to find the most suitable landing location for the unmanned aircraft: ideally a length of at least 20-30 metres of grassland. Two such locations were found about three kilometres apart. Seven flights were done from the first landing location and two flights from the second (on a relatively steep grassy slope at the edge of the mine).

One major challenge was to create a flight plan since there are significant height differences in the area around the Erdenet Mine. Therefore, the flight plan for mapping the entire face of the mine was executed at two different image resolutions/flight altitudes. Another big challenge was posed by the weather and climate conditions in the north of Mongolia. The first half of May 2018 was selected as the mapping period since May has minimal rainfall. Even so, the weather was very variable; on some days it was clear and over 20 degrees, but on others there were snowstorms and snow covered the ground control points. Luckily, the snow melted in the afternoon and did not damage the points. In addition to temperature fluctuations, the biggest problem for the UAS was that the mine is located at an altitude of about 1,400 metres above sea level and a persistently strong wind prevails, reaching up to 20m/s during the day. The wind also creates a lot of dust in the air around the mine. But thanks to the long days in May, with good lighting conditions, the flight schedule could be adapted to flying several missions in the early morning (6:00-8:30h) and in the evening (18:00-20:00h). The mission took nine mapping flights during a total of three days, usually with two flights in the morning and two in the evening depending on the weather conditions. The duration of each flight did not exceed 30 minutes because of the increasing strength of the wind.

DATA CAPTURING AND PROCESSING

More than 10km² of the mine and its surroundings were mapped from the MaVinci Sirius unmanned aircraft. UpVision has been using this UAS for more than five years for missions in difficult terrain, not least because of its manual flight mode and the possibility to repair the UAS immediately on the location. The camera used was a Panasonic GX1. The overlaps between images and rows were 80/70%. The image resolutions from the two flight heights were between 4cm and 10cm per pixel.

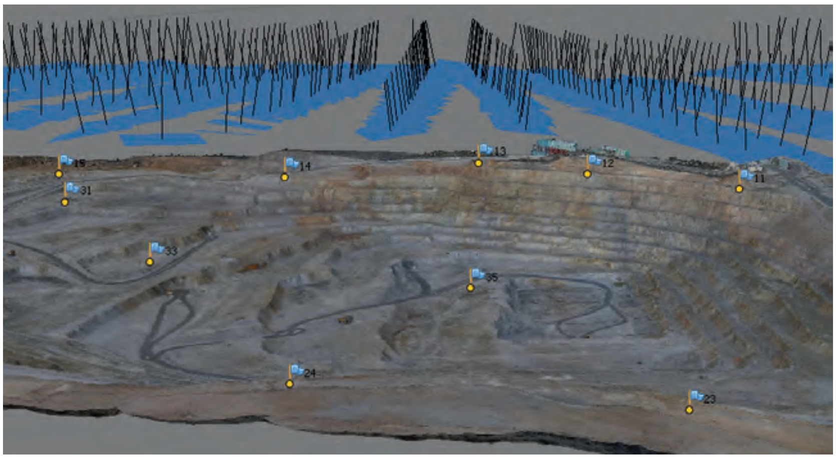
Raw data matching was performed directly on location after each completed flight, which took just five minutes using the MaVinci Desktop planning software. The minimum necessary overlaps for the orthophoto and the digital surface model could easily be verified through visual control of the aerial images. Almost 7,000 aerial photographs including the external orientation were processed and computed in several blocks in Agisoft Photoscan Pro software.

THE ERDENET MINE AND CZECH GEOLOGISTS

Geographically speaking, Mongolia is bordered by China to the south and Russia to the north. Why is UpVision from the Czech Republic mapping a copper mine in Mongolia? That is not as strange as it seems. The copper deposits were found in the 1960s by Czechoslovakian geological expeditions. Mine mapping has always been an important output of these geological expeditions, which the Czech Republic continues to operate to this day. The mine was established in 1978 with the help of the former Soviet Union, of which Czechoslovakia was then part and with which Mongolia maintained close links. Today, it is one of the biggest ore mining and ore processing facilities in Asia. The complex processes 26 million tons of ore per year, of which around 530,000 tons of copper concentrates and around 4,500 tons of molybdenum concentrates are extracted annually. The mine accounts for a substantial part of Mongolia's GDP and tax revenue.

▲ *Aerial panorama from the UAS.*

The main output of the aerial mapping was the detailed digital surface model in the form of a textured point cloud, formed by 400 million points in the local UTM coordinate system. Geologists primarily use the digital mine surface model in software with which they can analyse the slopes and walls for potential stability problems. Other outputs were orthophotos in various image resolutions for detailed mine coverage. For this, some extra flights were performed using a very small UAS (DJI Mavic Air) for highly detailed vertical documentation of the mine walls. All the data will be used to build a 3D mine model to create cross-sectional and longitudinal profiles of the mine as a basis for the planning of further mining operations. ◀



▲ *With aerial image previews and ground control points.*

MORE INFORMATION

https://youtube/niAVcuC_Tjk
www.upvision.cz

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INSIGHTS FROM INTERGEO 2018

A Glimpse of the **Geospatial Future**

There is an abundance of data today, but how can it be processed, visualised and analysed to deliver real business benefits? We are in the midst of a digital transformation, and words such as Internet of Things, artificial intelligence and smart cities have become part of our everyday vocabulary, but which opportunities will digitalisation really create for society? And is the unmanned aerial vehicle (UAV or 'drone') truly democratising the geospatial industry? These are just some of the questions that may have crossed the minds of visitors to Intergeo 2018 in Frankfurt. And if they spoke to the right exhibitors and attended the right conference sessions, they hopefully found the answers they were looking for. Here, we share some of the insights we gained into the geospatial future during the world's largest event for geoinformation and geodesy.

Intergeo, held in Germany every autumn, has become the leading meeting place for organisations in the global geospatial market. This year's edition in Frankfurt, the financial capital of Europe and an international transport hub, once again attracted thousands of mapping and surveying professionals from across Europe and beyond. Hundreds of companies on the exhibition floor at the Messe Frankfurt venue were showcasing their latest innovations – often in the form of solutions rather than tangible products.

PROGRESS IN TOTALS STATIONS AND LASER SCANNERS

Despite the growing focus on solutions, Intergeo still featured plenty of familiar hardware such as total stations, laser scanners, digital cameras, GNSS receivers, mobile mapping systems and unmanned aerial systems. These are all indispensible tools for capturing data, but one key change over the past five years has been the sheer volume of that data, which now comes in terabytes or even petabytes. Total stations have become increasingly sophisticated, often requiring very skilled handling. Progress in laser scanners includes increased acquisition range, accuracy and speed combined with reduced size and weight. Intergeo also provided surveyors with reliable, innovative GNSS survey solutions – multi-constellation use, multi-frequency tracking – that meet their specific requirements, such as flexibility, low power consumption and field-upgradeable software. Particular eye-catchers among the exhibits were the digital aerial cameras designed to expand the efficiency of aerial imaging operations, with a strong focus on new sensor developments, e.g. dual-frame sensors for RGB and NIR imaging.

MOBILE MAPPING MOVES ON

In mobile mapping, advances in multi-sensor integration are paving the way for high-end mapping applications. At the conference session titled 'What's Next in Surveying and Mapping', chaired by *GIM International*, Mladen Stojic, president of Hexagon Geospatial, explained that he foresees a

▲ *It was standing room only at the* GIM International *session during the Intergeo conference.*

▲ *Intergeo 2018 attracted around 19,000 enthusiastic visitors from over 100 countries.*

shift in the focus from outdoor mapping to indoor and below-ground mapping. "In the USA, people spend 87% of their time indoors so there is a huge need for indoor mapping," he commented. He added: "Our world doesn't stop above ground, there's a lot of change below ground too," referring to the ever-expanding utility networks that need monitoring, visualising and analysing. At the same conference session, Erica Nocerino from Fondazione Bruno Kessler (FBK), described the potential use of smartphones for mobile 3D data capture. As portable low-cost mapping systems, smartphones can be used for indoor mapping and navigation in public buildings such as shopping malls and hospitals. Her research has included a real-life use case at an archaeological site in Paphos, Cyprus, in which multiple surveyors used the collaborative, app-based 'Replicate' workflow on a cloud-based server to generate and edit point clouds, resulting in 3D models that "inject real assets into a VR world".

IT'S A DATA-DRIVEN WORLD

Unsurprisingly many of the innovations on display were linked to digitalisation, the driving force that is currently revolutionising our industry. In our data-driven world of surveying and mapping, the challenge is to extract the right information from the gigantic ocean of geodata as efficiently as possible. The data processing workflow has become much more user-friendly over the last few years, but at Intergeo it became clear that the variety of data types remains one of the key challenges. Mladen Stojic echoed this in his presentation on 'Bridging the Divide – Smart Digital Reality', saying that one of the main problems is how to combine dynamic data with static data. "A smart solution consolidates changing data and reacts to change as change occurs," he stated. He outlined several ways in which Hexagon is bridging the divide between static and dynamic data, including for conducting a census, for community policing and for public transport authorities.

FROM DATA TO DECISION-MAKING

Big geospatial data is an important asset, but processing and visualisation tools are essential pillars for analysis and decision-making based on that data. On the exhibition floor, companies such as nFrames and Racurs showcased photogrammetry solutions that transform massive imaging projects into dense point clouds, digital surface models (DSMs), seamless true orthophotos or textured meshes. On the point cloud side, there has been a wave of high-end software solutions to store, process, analyse and visualise the vast datasets of a staggering amount of three-dimensional points. Companies such as RIEGL, Trimble and Pythagoras all displayed their newest products and increasingly user-friendly methods for turning data into valuable geospatial end products. Meanwhile, at the *GIM International* conference session, Gerd Hesina, CEO of VRVis, addressed the 'visualisation challenge' and presented several examples of how a combination of spatial and non-spatial data can be visualised in interactive, high-accuracy georeferenced large-area 3D models. Use cases include tunnel monitoring, traffic planning, flood management in heavy rainfall scenarios (see also page 22 of this edition) and even the use of visualisation algorithms for geologic interpretations on the next Rover mission to Mars.

DEMOCRATISATION OF THE GEOSPATIAL INDUSTRY

Unmanned aerial vehicles have been described as a 'democratic tool' that have triggered a major change in the approach to geoinformation as they have become cheaper, more flexible and deployable, and easier to use, coupled with increasing processing automation, cheaper hardware and a rise in open-source solutions. In his presentation on 'UAV Photogrammetry, Where Do We Stand?' during the conference session, Francesco Nex from the University of Twente predicted a shift towards standardisation rather than customisation, since drone replaceability is key in mission-critical situations such as first response and fire-fighting. In terms of automation, real-time processing remains an issue, he said, since onboard processing is linked to high energy consumption while the use of a remote PC is associated with high latency. This poses problems for collision avoidance, for example. Further challenges still to be overcome include bandwidth issues in an increasingly 'connected' world, plus more effective use of automation (including deep learning) and further harmonisation of the regulatory situation.

GEOMATICS AND THE SMART CITY CONCEPT

One of the central themes of Intergeo was the smart city concept, which relies on an endless stream of data acquired by sensors all over the city. During the traditional Intergeo press conference on the Wednesday, Hansjörg Kutterer, director general of the German National Mapping Agency (BKG), stated that skilled surveyors play an essential role in providing context for the geodata that forms the skeleton of a smart city and designing truly effective solutions. By bridging the gap between the geospatial community, cities and politicians, Intergeo's 'Smart City Solutions' platform aimed to highlight the huge opportunities that the smart city phenomenon offers for surveyors. Lorenzo Martelletti, director of strategy and products at Pix4D, echoed this in his presentation on 'The Impact of AI and Machine Learning on Geospatial Data' at the *GIM International* conference session, reminding the audience that "there will be around 45 billion cameras by 2022," which is very interesting for the development of geospatial-related applications. Artificial intelligence (AI) and deep learning will be catalysts for further advancement, with machine learning already being used to train processing software and enable automatic classification of point clouds or to remove irrelevant parts – such as the sky – from imagery. Looking ahead to the future, Lorenzo Martelletti suggested taking a more holistic approach: rather than using drones as 'flying cameras' and then using software to reconstruct from the data they capture, projects should be designed around a flight plan and the right sensors to solve a specific business problem. One thing is for sure: there will be no shortage of innovations at future editions of Intergeo!

▲ *Drones have triggered a major change in the approach to geoinformation.*

AN INNOVATIVE APPROACH INTEGRATING LIDAR PROCESSING WITH MACHINE LEARNING

Monitoring **3D Urban Growth**

Automated measurement of the third dimension of urban growth is a crucial requirement for future urban planning and monitoring. Airborne Lidar is increasingly being used to produce regular time-based data over metropolitan areas. However, the current solutions ignore the specific needs of urban planners, are complicated to run and fail to address the problem of monitoring 3D urban growth over time at building scale. To address the current challenges, two possible solutions have been developed into an integrated procedure.

Urban planners want to automatically estimate all three dimensions and model the changes to buildings, the building footprints and absolute height information over time to monitor growth and predict change patterns accurately. To monitor changes to buildings over time using airborne Lidar data, there are two possible solutions for processing the data, as listed below. This article investigates which of these two possible solutions is the preferred solution, and which is able to best determine the magnitude of change in the heights of the buildings.

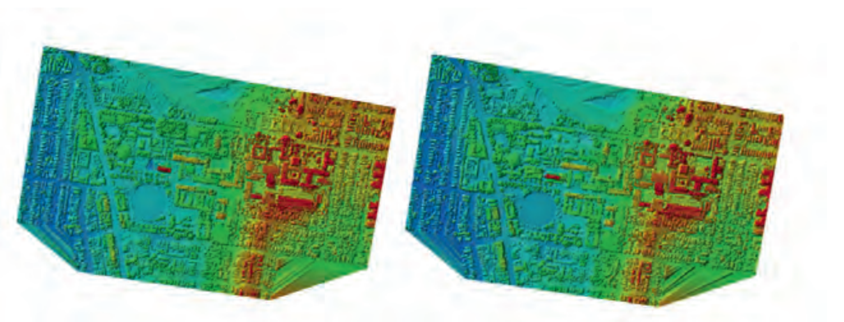
- Solution 1: Classification of buildings using temporal Lidar datasets and the determination of the magnitude of changes by comparing the extracted building heights. For this solution, two approaches were tested: a pixel-based approach using a machine learning algorithm known as Support Vector Machines (SVM), and a point-based approach using a tool from ERDAS IMAGINE which is a software solution for processing data acquired by remote sensing and photogrammetry technologies.
- Solution 2: Application of a change detection algorithm to temporal Lidar datasets and the determination of whether or not changes have occurred in a building class. For this solution, two pixel-based algorithms were applied, namely SVM and image differencing.

DATA PROCESSING

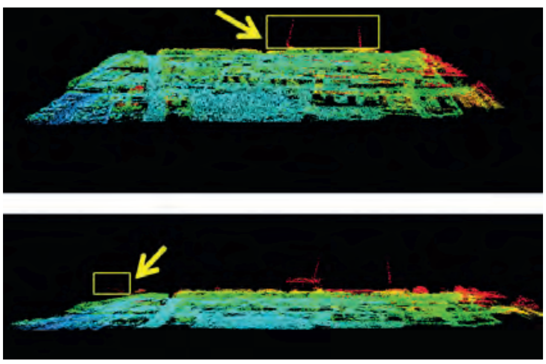
To investigate the solutions, bi-temporal airborne Lidar datasets are required as a minimum. In this research, the datasets used were collected in 2005 and 2008 above the University of New South Wales (UNSW) campus in Sydney, Australia. Lidar data is usually represented by points; however, it can also be converted to pixels containing XYZ information of the points within the pixels. The resultant raster data is called a digital surface model (DSM). The UNSW Lidar dataset DSM covers plain, sloping and complex urban scenes with various sizes of urban objects (Figure 1).

Before applying any algorithm, some pre-processing is required. Removing outliers from the datasets is a key preparatory task for both building classification (Solution 1) and change detection (Solution 2). In this case outliers can be generated by the measurement process (measurement noise) or constitute height points that do not contribute to the change detection process of urban buildings. Outliers observed in the 2008 dataset include construction machinery such as tower cranes (Figure 2).

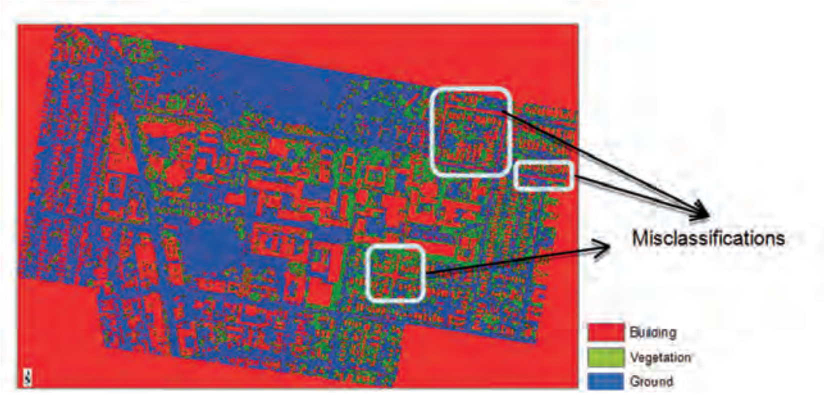
For Solution 1 (building classification), SVM was applied to both the 2005 and 2008 datasets. In addition, the point-based



▲ *Figure 1: Airborne Lidar over the UNSW campus in 2005.*



▲ *Figure 2: Tower cranes are noise to be removed from this 2008 Lidar dataset in the data preparation step.*



▲ *Figure 3: Building classification of 2005 Lidar data using SVM.*

Parameter	Threshold
Min. slope	30°
Plane offset	1m
Min. height	0m
Min. area	100m^2
Max. area	10,000m^2
Roughness	0.3m

▲ *Table 1: Parameters used in ERDAS.*

classification tool in the ERDAS software was used. For Solution 2 (change detection), image differencing and SVM were used on the time-series pixels.

RESULTS

The research showed that Solution 1 using building classification of time-series Lidar data for monitoring 3D urban growth is time consuming, cumbersome, complex for non-experts and less accurate than using a change detection algorithm. As demonstrated in Figure 3, the building classification using SVM for 2005 data shows significant misclassifications between roads and buildings in sloping terrain, which is the result of classifying the boundaries of buildings as trees. This is in line with previous experimentation by the authors in the same area. This problem can probably be remedied by adding aerial image data and stacking the resulting RGB layers as additional layers for the SVM method. Since temporal aerial images were not available, further work on improving the SVM result using additional images was not possible.

Next, the classification tool in ERDAS was tested for its suitability for the point-based approach for Solution 1 (building classification). The algorithm in ERDAS requires a number of parameters that have to be set interactively until the best result is obtained for the area under study (Table 1). With the chosen parameter thresholds, there was no problem of misclassification between roads and buildings in sloping terrain. However, visual comparison of classified buildings still showed some discrepancies among the results of unchanged building points (Figures 4 and 5). Another inconsistency can be seen in the level of omission errors in classified buildings of the two datasets, which is higher in the 2005 dataset than in the 2008 dataset. This inconsistency is an important issue for the determination of volumetric elements and pixel-based spatiotemporal building volume change calculations for an urban area over time.

Solution 2 (change detection) using image differencing is less complicated than the procedure described above. However, this method entails problems such as a high level of noise which causes a significant ‘salt and pepper effect’. For the SVM method applied for Solution 2, there is a lack of extraction of the magnitude of the height change. Other types of errors occur in building boundaries, and missing data causes errors that affect the results of DSM differencing.

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▲ *Figure 4: Building points extracted from 2005 Lidar data and classified by object-based methods in ERDAS.*

▲ *Figure 5: Building points extracted from 2008 Lidar data and classified by object-based methods in ERDAS.*

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INTEGRATING THE TWO METHODS

Considering the advantage of SVM giving a smaller salt and pepper effect and the benefit of the image differencing method for providing the magnitude of height change, integrating the two would address both issues, as demonstrated in Figure 6. For this solution, additional post-processing is recommended to determine to which specific class the detected changes belong: building, vegetation, road, etc. Depending on the aim of the research, it might be necessary to remove all unwanted items. For example, if 3D changes of buildings are important for sustainability studies, all other classes should be removed from the integrated result.

CONCLUSION

With the post-processed, integrated result, urban planners would be able to determine the changes in the magnitude of building heights rather than making an overall less accurate estimation achieved by using either of the conventional techniques separately. Accurate vertical changes enable policymakers to estimate 'mass to voids' and 'buildings to green space' ratios, which would consequently increase the application of airborne Lidar for the built environment.

▲ *Figure 6: The results from the new solution combining a machine learning algorithm with DSM differencing.*

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Sara Shirowzhan completed her PhD in geomatic engineering at UNSW, Australia. She develops metrics, GIS-based apps and algorithms to solve digital problems of 3D representation and analysis of the indoor and outdoor built environment.

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Celebration of FIG's 140th Anniversary and Handover

FIG was founded in Paris on 18 July 1878 by delegates from seven national associations – Belgium, France, Germany, Great Britain, Italy, Spain and Switzerland – and was known as the Fédération Internationale des Géomètres. This has since become anglicised to the International Federation of Surveyors. 2018 marks the 140th anniversary of FIG, which was celebrated in conjunction with a handover ceremony from current president of FIG, Chryssy Potsiou (Greece, 2015-2018), to president-elect Rudolf Staiger (Germany, 2019-2022). Today FIG has become a very different, vibrant organisation with membership from more than 120 countries, but still with its original aim: to bring surveyors together in order to help each other and global society.

COOPERATION BETWEEN FIG, UIA AND ECCE

From 7-9 November 2018, the Technical Chamber of Greece (TCG) hosted the TUFE2018 event in cooperation with surveyors (FIG), architects (UIA), European engineers (ECCE) and the European Working Party on Land Administration (UNECE WPLA) with the theme of 'Economy, Society and Climate Change – the Impact of Megatrends in the Built Environment, Construction Industry and Real Estate'. Chryssy Potsiou had done a great job to ensure the success of this event. At the closing ceremony, a cooperation agreement was signed between UIA, FIG and ECCE by the three presidents.

HANDOVER AND CELEBRATION

The 140th anniversary celebration and handover ceremony was held on 9 November in festive surroundings at the Eugenides Foundation in Athens, Greece. Many FIG-related people travelled to Athens for the occasion, from Africa, Asia, the USA and Europe, and three honorary presidents attended. Juha Talvitie (Finland, 1991-1994) gave an interesting presentation on the development of FIG over the last 50 years, and competently chaired the handover ceremony. He described his own FIG experiences which go back to the 1960s and asked the audience to share details of their own FIG history (and it is also possible to do this on the FIG Facebook page…). Bob Foster (USA, 2000-2002) held a brilliant presentation on a higher ethic and 'looking back and looking ahead', and Holger Magel (Germany, 2003-2006) fascinated the audience with his speech on territorial justice – a new paradigm for the development of a country and the importance and relevance of rural areas. Representatives from Africa were Kwame Tenadu (Ghana), representing the Local Organising Committee for the FIG Working Week 2021, who talked about sustaining multilateralism in FIG for our common good, and Mansur Muhammad Kabir (Nigeria) who shared his African perspectives on enhancing the professional collaboration and strategic partnership in FIG. The very first FIG honorary ambassador, Clarissa Augustinus, pointed out the significant role of FIG and its presidents in the development and achievements of UN-Habitat/GLTN.
Chryssy Potsiou expressed her thanks for the four years she was at the helm of FIG, and the president-elect and other speakers praised her for her ability to bring people together.

Louise Friis-Hansen

More information
www.fig.net

Chryssy Potsiou, FIG president, together with honorary presidents Juha Talvitie, Robert Foster and Holger Magel, and president-elect Rudolf Staiger at the handover ceremony.

Report on the 8th Session of the UN-GGIM

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) seeks to promote international cooperation in the field of global geospatial information management, and is the relevant body on geospatial information management. The annual meeting of representatives from Member States' national geospatial information authorities and geospatial information experts is an opportunity to address global challenges regarding the application of geospatial information, including in the development agendas, and global policymaking in the field of geospatial information management. In this context, geodesy plays a major role through the Global Geodetic Reference Frame (GGRF) and the IAG participates as an observer in all meetings and related activities of UN-GGIM. This year, a Road Map for the GGRF for Sustainable Development Implementation Plan presented by the UN-GGIM Subcommittee on Geodesy was discussed at the UN-GGIM session.


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IAG made an Intervention that reads as follows:
The International Association of Geodesy commends the work done by the UN-GGIM Subcommittee on Geodesy, and emphasises that the Roadmap Implementation Plan is an important building block to determining a sustainable Global Geodetic Reference Frame. Together with its geodetic services, IAG encourages modernisation of geodetic infrastructure, as well as development of Core Observatories, especially in developing regions.

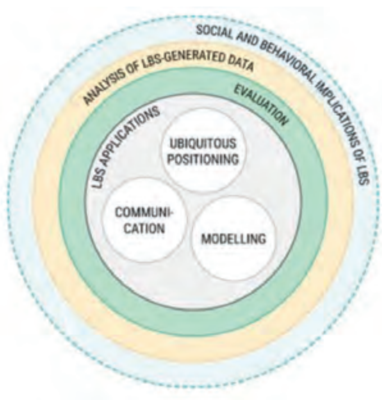
IAG notes that there is a clear need for strengthened intergovernmental mechanisms in support of global geodesy, and notes with appreciation the Subcommittee on Geodesy's efforts to provide this through a Convention or other possible governance mechanisms mentioned in the Position Paper on Governance. IAG encourages the establishment of funding mechanisms for global geodesy, in order to support geodetic infrastructure and education in developing Member States. IAG further notes that such funding will provide a means to strengthen the GGRF overall, as well as help realise the geodetic contributions to the UN Sustainable Development Goals and Sendai Framework for Disaster Risk Reduction.

More information
https://bit.ly/2RUktp9

Participants at the 8th Session of the UN-GGIM, 1-3 August 2018, UN Headquarters, New York City, USA.

Location Research

The ICA column in this publication in September 2016 introduced the Commission on Location Based Services (LBS), which was charged with, amongst other tasks, developing a cross-cutting research agenda addressing the wide-ranging field of LBS. As LBS develops, this becomes increasingly important; the integration of information and communication technology (ICT), especially mobile ICT, in every aspect of our daily lives means that '4A services' (anytime, anywhere, for anyone and anything) are being developed to benefit our human society and environment. Such technologies bring convenience and improve our quality of life, but also lead to surveillance, privacy and ethical issues. It is important to investigate how these influence the way we grow, interact, socialise and learn. The LBS Research Agenda aims to contribute to advancing the use of such technologies and to examining the role of fundamental geospatial information.
Developing the agenda was a collaborative process that included inviting suggestions from the LBS community and running sessions at the 2016 LBS conference and the 2017 International Cartographic Conference. 'Key research challenges' were identified that should be addressed to take LBS to a higher level to better benefit our society and environment.
A total of 20 specific topics make up the resultant research agenda, under seven broad areas of research. 'Ubiquitous positioning' includes indoor and outdoor positioning as well as multi-sensor devices. 'Context modelling and context-awareness' addresses 'smart' environments and ambient spatial intelligence, whilst 'Mobile user interfaces and interaction' covers human computer interaction, including visualisation and augmented reality. 'User studies and evaluation' takes this further to consider user experiences and mobile spatial cognition. 'Analysis of LBS-generated data' acknowledges questions of big data and movement analysis, along with data collection issues including geotagging and VGI. 'Social and behavioural implications of LBS' tackles privacy, legal and ethical matters related to LBS, and 'Innovative applications' looks at smart transport, mobile health care, social networks and autonomous vehicles.
This comprehensive report is published for open access in the *Journal of Location Based Services* (Vol 12, No 2) (https://doi.org/10.1080/17489725.2018.1508763) under the lead authorship of Commission chair, Haosheng Huang (University of Zurich). The journal, along with the annual LBS Conference, provides an excellent insight into the work of the Commission and the wider importance of LBS studies in general. The next LBS conference (the 15th in the series) will return to its historic roots at TU Wien in November 2019 (https://lbsconference.org/).
The Commission is dedicated to research efforts to 'positively' shape the future of the mobile information society.



The LBS Research Agenda.

Looking Ahead: ISPRS Congress 2020

The XXIV ISPRS Congress (http://www.isprs2020-nice.com), which is the congress for the geospatial community held every four years, will take place in 2020 in the gorgeous city of Nice, on the Mediterranean Sea, from 14-20 June. Nice is the cosmopolitan and multicultural capital of the French Riviera and is an outstanding location between the sea and the Alps, close to the Italian border, where culture and heritage meet the cutting-edge technology of Sophia Antipolis, the French Silicon Valley. The Acropolis congress centre is in the heart of the city, just a four-minute walk from the old town of Nice, a ten-minute walk from the beaches, and 17 minutes by tramway from the airport.

The ISPRS 2020 Congress will cover a full week. A rich programme will enable participants to keep up with the state of the art in terms of the current trends in science, technology and business, to meet and network with a very large number of experts, and to cross-fertilise with colleagues coming from neighbouring fields. This congress will gather together leading specialists and technologists, engineers, researchers and students in the field of photogrammetry, remote sensing and spatial information sciences coming from universities, research foundations, mapping and spatial agencies, public organisations, private companies and end users.

Throughout the week, there will be six science-oriented parallel tracks devoted to the presentations of new high-quality contributions in the scope of the five technical commissions of ISPRS (sensor systems, photogrammetry, remote sensing, spatial information science, and education and outreach). One other scientific track will address special thematic subjects. Besides these scientific tracks, there will be two other tracks. A fora track will address the interaction between science, public organisations, industry and decision-makers on hot topics for the geospatial community (global mapping & resource monitoring, smart cities, autonomous navigation, digital globes & geoplatforms, open science & open source & open data). An industry track will also be introduced for the first time, dedicated to industry presentations of new technologies and products. Networking events will be organised too, including 'speed dating' aimed at enabling students and professionals to meet up with companies.

The ISPRS 2020 Congress will also hold a strong three-day exhibition featuring both private and public companies. This exhibition will give attendees the unique opportunity to get an update on the advancements in new geospatial technologies and solutions (satellite systems, Lidar systems, hyperspectral imaging systems, mobile mapping systems, UAVs, virtual and augmented reality devices, serious games, 3D printing, big geodata processing, GIS technologies, geodata warehouses, geovisualisation, geoservices, VGI technologies, Spatial Data Infrastructures, etc.) and their applications (digital globes and portals, web services for geoplatforms, very-high-resolution mapping, UAV data acquisition and mapping, road mapping, road construction, underground and indoor mapping, cultural heritage, geodecision-making, urban planning, smart and sustainable cities, 3D city models, 3D road and street models, virtual and augmented reality geovisualisation, autonomous navigation and driving, street mobility diagnosis for the disabled, etc.).

The ISPRS 2020 Congress will be hosted by SFPT (the French society of photogrammetry and remote sensing), and will be organised with the support of the major French public institutions dealing with photogrammetry, remote sensing and spatial information sciences. Director of the ISPRS Congress is Nicolas Paparoditis, member of the ISPRS Council and director of research and education at IGN-France.

More information
contact@isprs2020-nice.science

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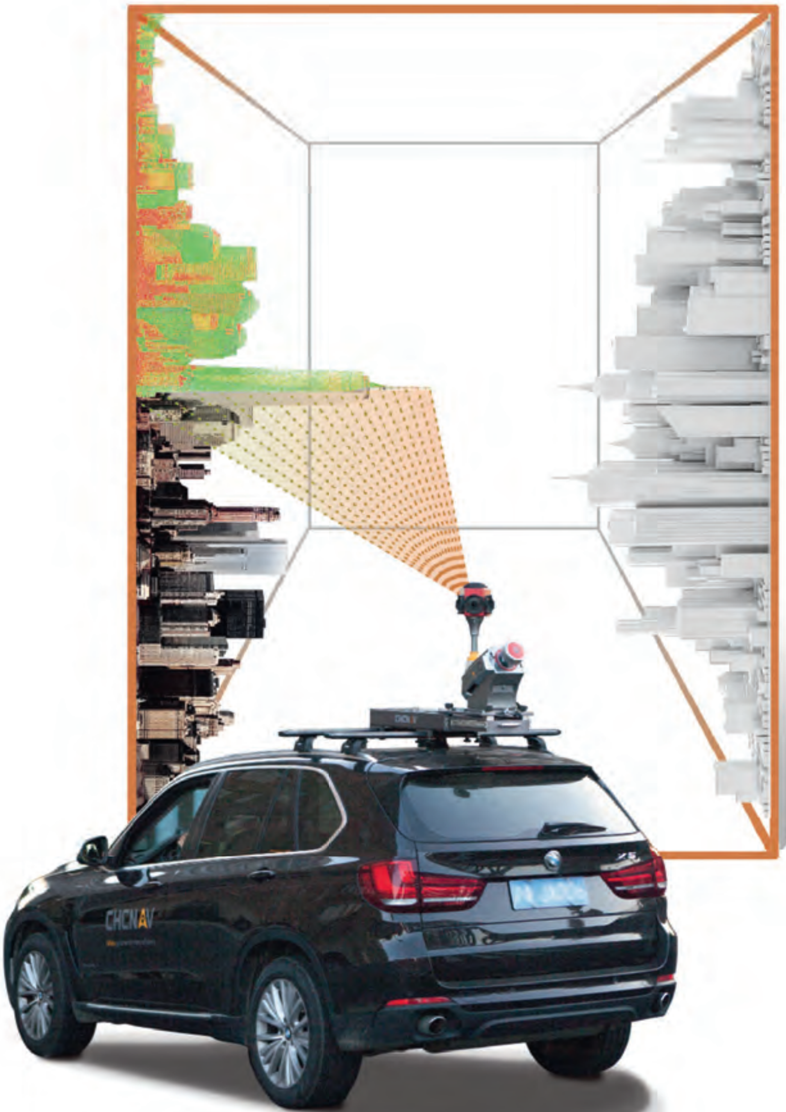

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