2019 IEEE GRSS STRATUS Workshop

Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems

25-27 February 2019

Louise Slaughter Hall
Rochester Institute of Technology
Rochester, New York, USA

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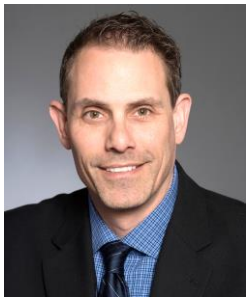
Welcome from Tutorials and General CoChair



On behalf of the organizing committee, we would like to welcome everyone to the 3rd workshop on Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems or simply STRATUS 2019. The three-day workshop is being held in Rochester, New York, on February 25-27, 2019 at the Rochester Institute of Technology (RIT) home to some 19,000 students.

The idea of this workshop started in 2016 as a result of a conversation between myself and my RIT colleague, Dr. John Kerekes. From this, a proposal was submitted to the IEEE Geoscience and Remote Sensing Society (GRSS) for financial support to host a workshop on UAS's. At that time, we had a one-day workshop with a series of talks by individuals from academia and industry. The total number of abstract submissions was 11. The 2016 workshop proved to be very successful and warranted a follow on meeting which was held in October of 2017. The sold-out 2017 workshop included vendor participation and was expanded to two days (one day for tutorials, one day for talks). Again, the workshop was an overwhelming success with 12 unique talks and 2 keynote presentations and sold-out tutorials by Labsphere and Pix4D.

I am proud to say that, three years later, we have grown and have yet again reached full capacity, this time increasing our total number of participants to 110! The 2019 version of the workshop now includes three tutorials given by experts from Labsphere, Pix4D, and Beamio. Additionally, we have received financial support from GRSS, Hyspex, Headwall Photonics, Beamio, Harris Corporation, and EagleHawk Inc. which have enabled us to keep registration cost low while simultaneously offsetting overhead expenditures (i.e., low student registration, student awards, catering, printing, etc.). We are extremely grateful for their support. We are also excited to offer student prizes for best student presentation, paper, and poster. Finally, we have two outstanding keynote speakers this year, Dr. Sally Rockey, Executive Director of the Foundation for Food and Agriculture Research (FFAR) and Dr. Steven Thomson, National Program Leader for USDA, National Institute of Food and Agriculture (NIFA). I hope you enjoy their presentations.

In general, the aim of this workshop is to facilitate interaction between academic researchers, industry researchers and students working in the field of remote sensing utilizing unmanned aerial systems. Since this is an emerging field, the goal of the workshop is not to *define* technical requirements, standards or legal policy, but rather to illustrate the specific connection between remote sensing and unmanned aerial platforms at both the commercial and academic levels. We aim to bring together academics, industry representatives, and domain specialists to share perspectives on this rapidly evolving topic.

I believe this program will promote the dissemination of research results and technical advances in this new emerging field of unmanned aerial systems. I hope you enjoy the tutorials and workshop and look forward to your participation!

Emmett Ientilucci, Ph.D.
Rochester Institute of Technology
STRATUS 2019 Workshop Tutorial and General CoChair

Welcome from the General CoChair

It is with great pleasure, to welcome you all to this exciting 2019 STRATUS conference! We are bringing together providers, processers and users of data, that is collected by drones and other unmanned aerial systems (UAS). Our three-day conference has not only the combination of training, research and outreach components, but it is a platform to share information about innovative collaborations with the latest techniques in this rapidly emerging field.

When I joined the post-2018 STRATUS coalition of multi-disciplinary colleagues last year, it was not instantly clear to me where we were heading. However, excitement took over this hesitation and encouraged me to be more actively involved in hosting another in the series of STRATUS meetings. We discussed a different topic for the upcoming meeting, but we wanted to build on the success of previous ones. After a suggestion to include specific topics, such as environmental monitoring and modeling as well as applications to agriculture, forestry and water sciences, the conference became a special draw for me. As in the past, I wanted to put forth my effort as a co-chair such that this conference can become a place for all participants to experience expanding their horizons and become more passionate about crossing disciplinary boundaries.

The spirit of our conference organizing team reminded me of an annual gathering of geomorphologists that started the year I was born in nearby SUNY Binghamton: The Binghamton Geomorphology Symposium series. Every year a dedicated team of specialists hosts a small meeting that has specialty topics around a common core interest. It has grown over the years and has been hosted by others around the country becoming known as the “Wimbledon of Geomorphology”.

Source: https://www.instructables.com/id/Raquette-Drone-or-Racket-Racer

Maybe this week’s meeting is the start of such a series. I invite you to also propose potential STRATUS specialty topics that you would like to see hosted in the future, here or elsewhere. In addition, we could decide to create a steering committee of previous and future conference chairs and committee members that could solicit, discuss and accept STRATUS proposals for the coming years ahead, making sure it keeps the purpose and spirit of the past meetings. This way, we stay in touch, share the latest research, technology and learn with every STRATUS meeting something new.

To all of you, I wish a great, productive, and exciting conference. Let’s serve it up!

Chris S. Renschler, Ph.D.,
University at Buffalo (SUNY)
2019 STRATUS General CoChair

Welcome from the Technical Program Chair

Unmanned Aerial Systems or Vehicles (UAS's or UAV's) have gained increasing attention within the remote sensing community in many areas including environment, natural resource, agriculture, and water to name a few. There is ever increasing development and advancement in hardware, algorithm/data processing, and applications of UASs necessitating more frequent scientific gatherings and conferences to exchange the latest advances in UAS remote sensing.

After two years of successful workshops (2016 and 2017), this year's STRATUS workshop has brought together more than 100 students, researchers and practitioners from academia, federal and state governments, and industry from Germany, Colombia, Nigeria, Norway, Canada, and the USA here in beautiful Rochester, NY! There are a total of 30 presentations, posters and full papers in this year's workshop. The topics are diverse covering many areas and are presented in eight sessions including hardware (two sessions), environmental monitoring, image processing and algorithm development, agricultural applications, forest applications, water related applications, and special invited talks. I also should mention that we have a student competition for awards in presentation, poster, and full paper!

I hope you experience a successful and productive workshop at STRATUS 2019 and extend your network of collaboration and partnerships even further. For those traveling, I wish a safe travel back home and let's keep in touch!

Cheers,

Bahram Salehi, Ph.D.
SUNY College of Environmental Science and Forestry
2019 STRATUS Technical Program Chair

Program Committee

Emmett Ientilucci, Ph.D., Tutorial and General CoChair
Rochester Institute of Technology

Chris Renschler, Ph.D., General CoChair
University at Buffalo

Bahram Salehi, Ph.D., Technical Program Chair
SUNY College of Environmental Science and Forestry

Peter Spacher, Ph.D., Sponsor and Exhibits Chair
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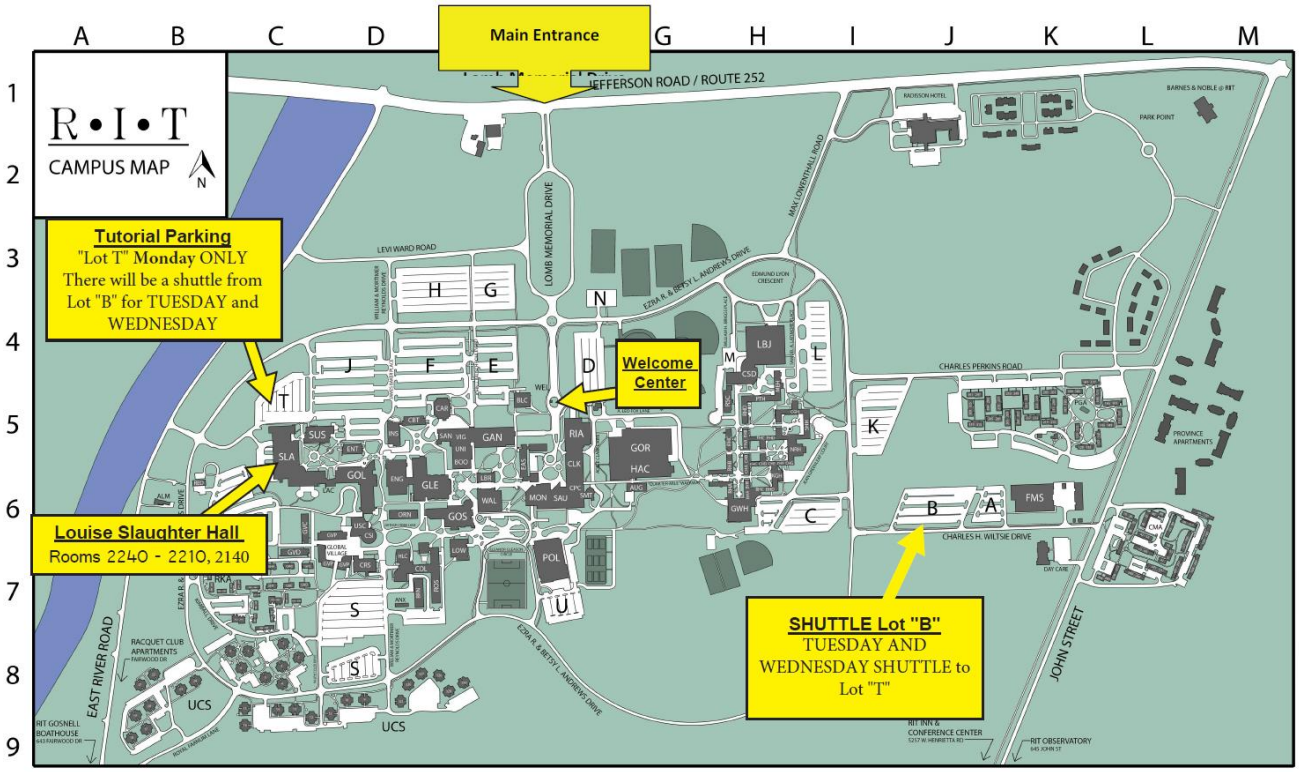
Don McKeown, Financial Chair
Rochester Institute of Technology

Colleen McMahon, Local Arrangements Chair
Rochester Institute of Technology

Melanie Warren, Local Arrangements
Rochester Institute of Technology

RIT Campus Map with Parking Lots

(See next page for parking instructions)



Shuttle Bus Transportation and Parking

MONDAY: For tutorials, you can park in Lot "T". Parking passes will be emailed to particpants.

TUESDAY/ WEDNESDAY:

1. There will be a shuttle from Lot "B" to Lot "T". Parking passes are on the website: http://ewh.ieee.org/r1/rochester/grss/STRATUS2019

2. Run times for both days will be:
   a. 7:30 AM to 9:30 AM
   b. 3:30 PM to 5:30 PM
   c. Bus will run approximately every 14 minutes.
   d. Transportatoin outside of these time is detailed on next page, "RIT Shuttle Bus"

3. Our STRATUS BUS will be a "white bus with green lettering".
   a. The Cedar Bus Company
   b. There will be a "STRATUS" sign in the window
   c. Stay in vehicle until bus arrives
   d. Bus driver will have some extra passes

RIT Shuttle Bus Tranportation

(For pick up and drop off between 9:30 AM and 3:30 PM)

TUESDAY/ WEDNESDAY:

1. This is the RIT Bus System.

2. There will be a shuttle between Lots “B” and “J”
    a. Lot “J” is next to Lot “T” (see map above)

3. Run times are as follows:

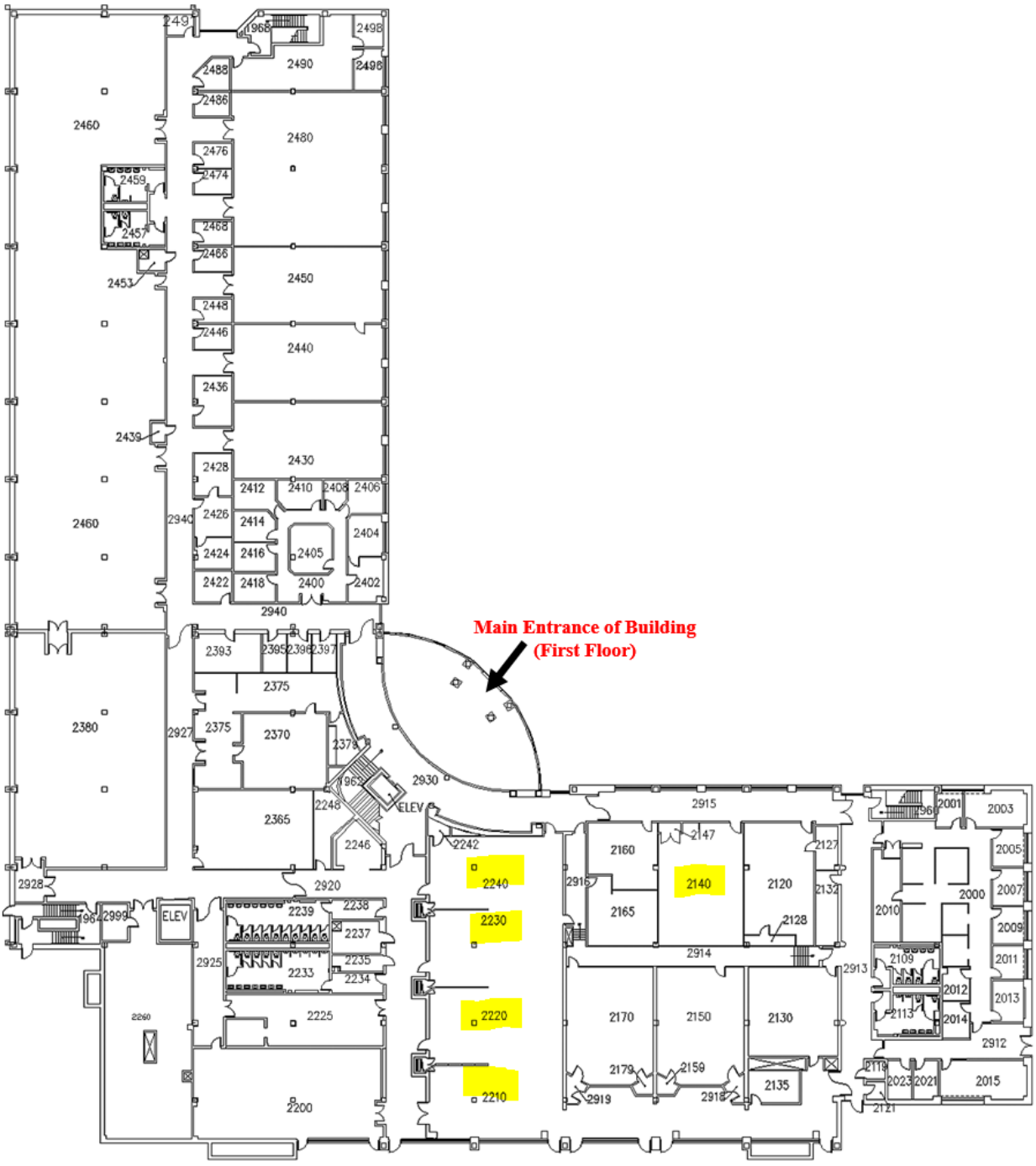
B Lot Pickup	J Lot Dropoff
9:40 AM	9:53 AM
10:20 AM	10:33 AM
11:00 AM	11:13 AM
11:40 AM	11:53 AM
12:20 PM	12:33 PM
1:00 PM	1:13 PM
1:40 PM	1:53 PM
2:25 PM	2:38 PM
3:05 PM	3:18 PM

J Lot Pickup	B Lot Dropoff
9:53 AM	10:20 AM
10:33 AM	11:00 AM
11:13 AM	11:40 AM
11:53 AM	12:20 PM
12:33 PM	1:00 PM
1:13 PM	1:40 PM
1:53 PM	2:25 PM
2:38 PM	3:05 PM
3:18 PM	3:45 PM

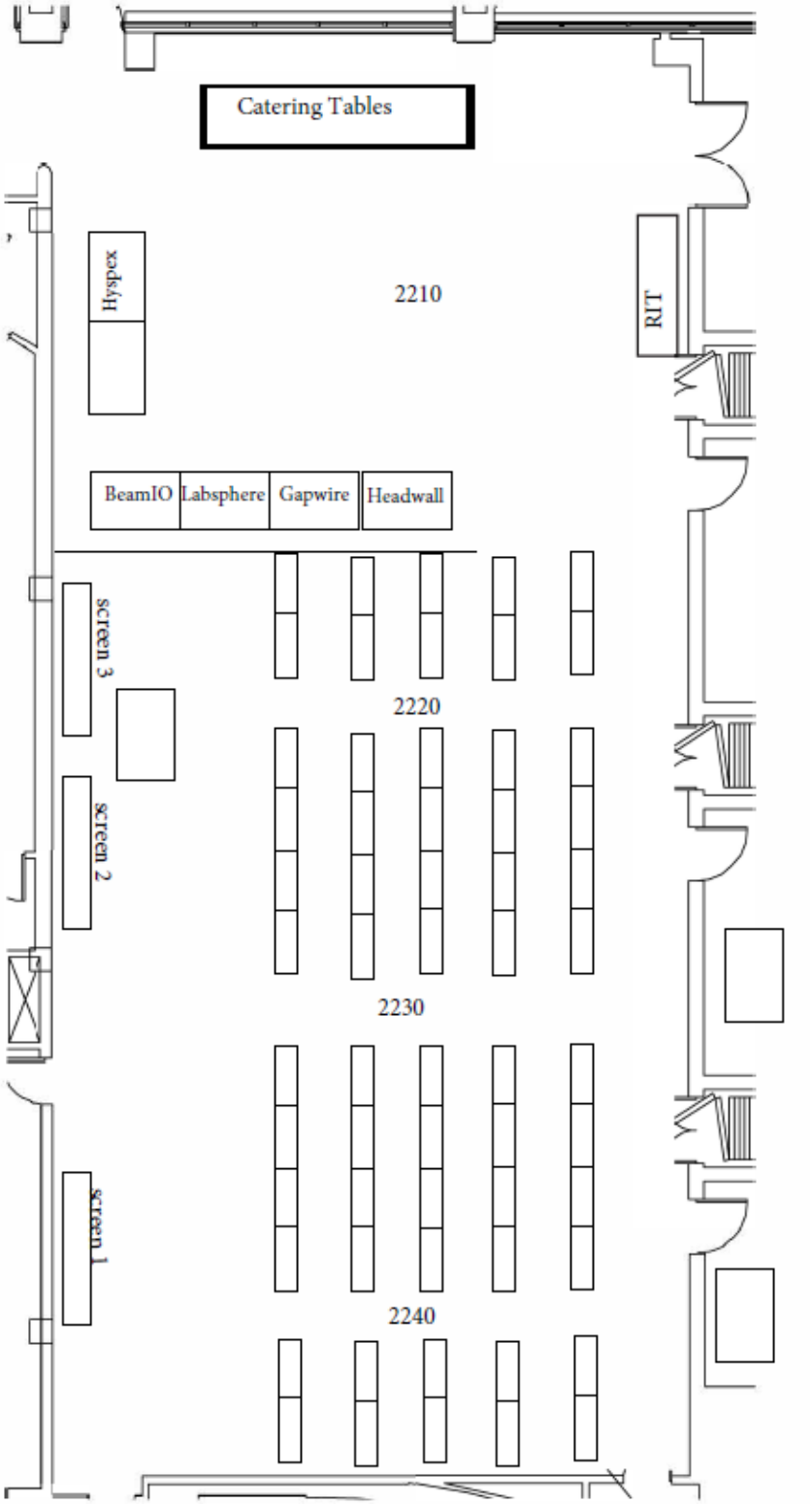
Building 78, Louise Slaughter Hall

Monday, Room 2140

Tuesday and Wednesday, Rooms 2210-2240

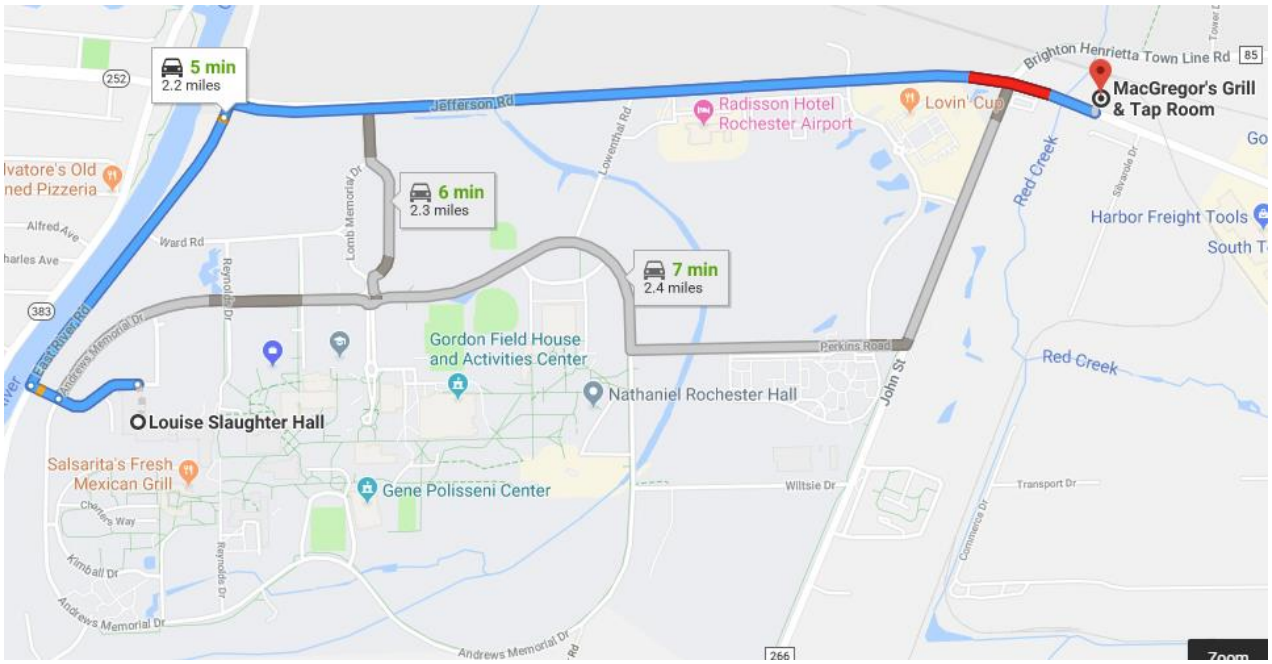


Room Layout


Catering Tables
Hyspex
2210
RIT
BeamIO
Labsphere
Gapwire
Headwall
screen 3
2220
screen 2
2230
screen 1
2240

Map to Social Gathering Tuesday Evening

- **Tuesday February 26**
- **5:30 PM**
- **Finger foods and one free drink**
- **2.2 miles from Louise Slaughter Hall**



MacGregor's Grill and Tap Room
www.macgregorsgtr.com
300 Jefferson Road
Rochester, NY 14623
585-427-8410

Finger foods and one free drink
2.2 miles from Louise Slaughter Hall

WiFi Instructions

Visitors to campus can connect to the RIT-Guest wireless network in all campus buildings. Please note that in order to register on the RIT-Guest, visitors must be able to provide a 10-digit cell phone number that is capable of receiving text messages.

How to connect to RIT Guest Network

1. Connect your device to: RIT-Guest
2. Open your web browser on your device.
3. Enter your 10 digit mobile phone number.*
4. Click on “I agree to RIT Terms.”
5. Enter your 4 digit pin on the web portal.
6. Click Validate Pin.
7. You will be connected to the RIT wireless network and will have access to the internet.
8. After 24 hours of use, you will have to re-agree to RIT’s Terms & Conditions.

*Standard messaging & data rates apply. RIT is not responsible for any mobile carrier charges

Sponsorship

We would like to graciously thank the financial support of our sponsors!

GOLD PLUS LEVEL

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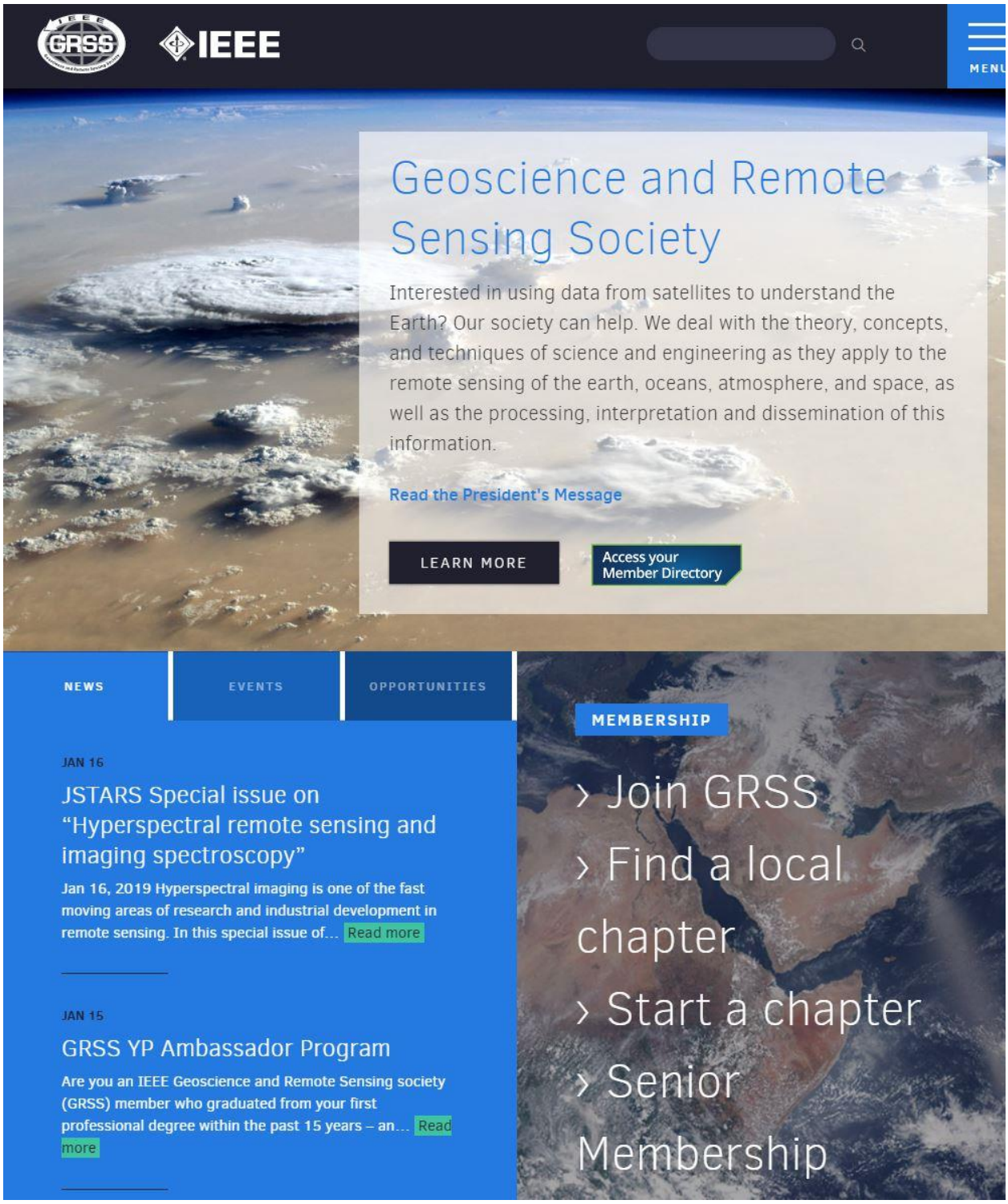
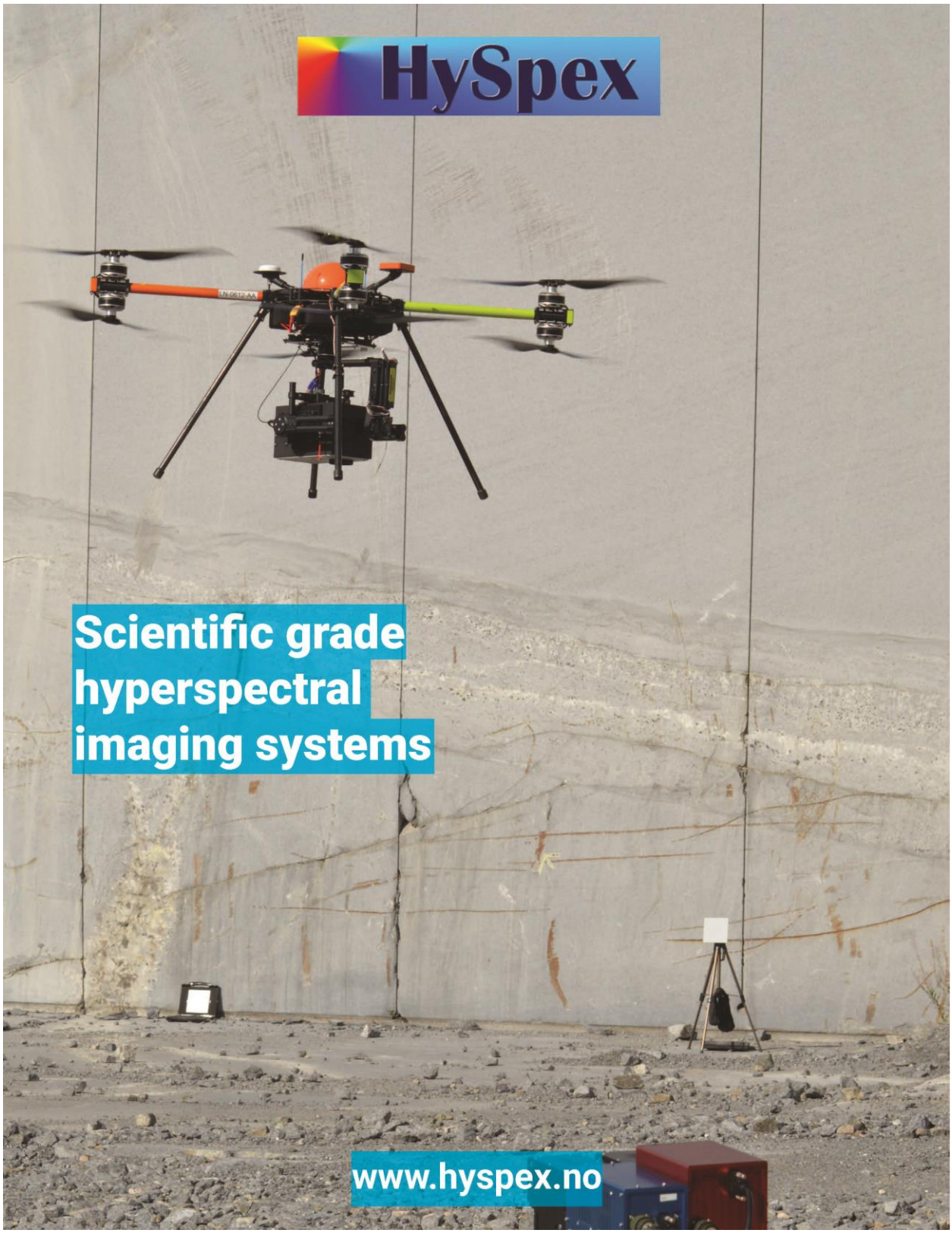
BRONZE LEVEL



Membership Includes:
IEEE Geoscience and Remote Sensing Magazine, IEEE Transactions on Geoscience and Remote Sensing, IEEE Geoscience and Remote Sensing Letters, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, and IEEE Geoscience and Remote Sensing Society Digital Library.

http://www.grss-ieee.org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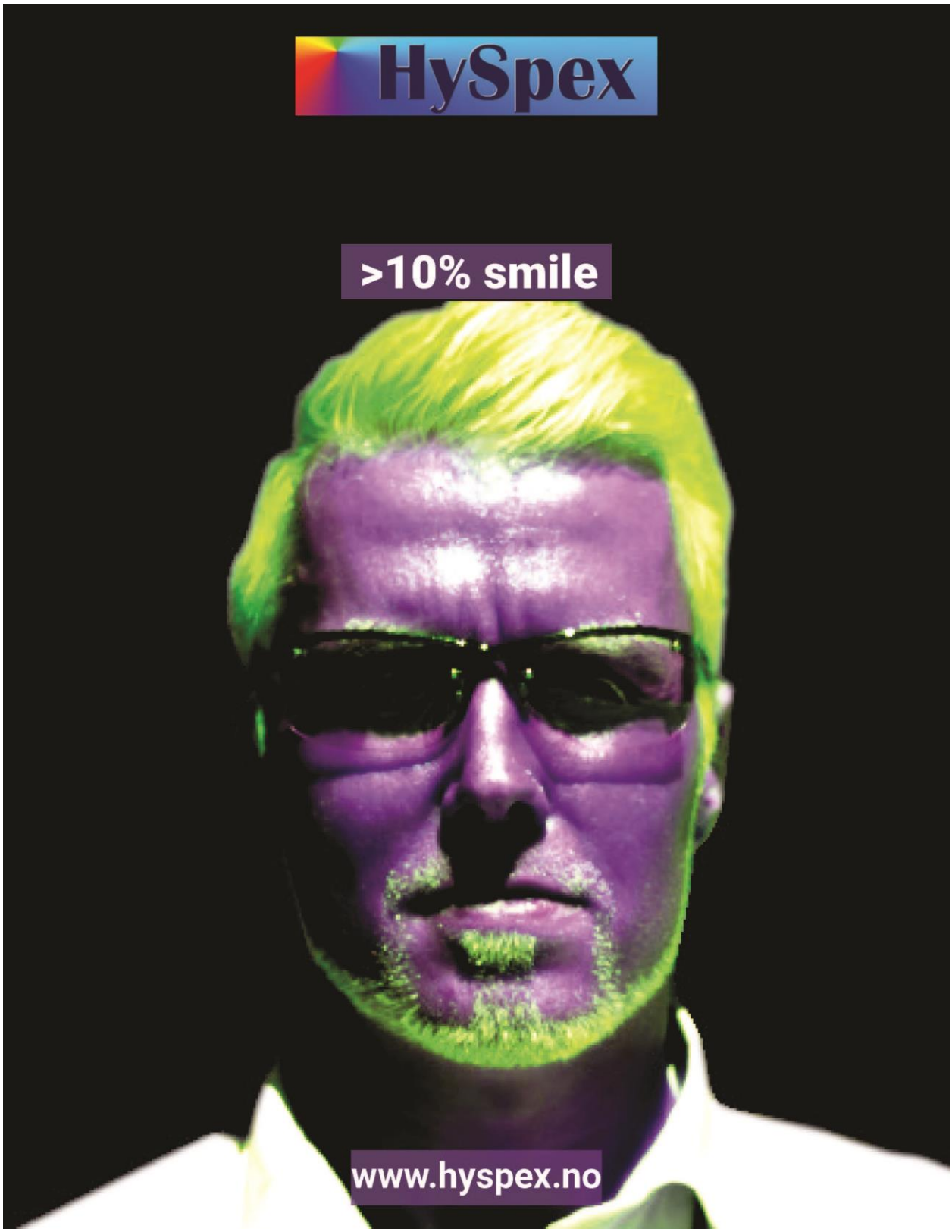
HySpex
>10% smile
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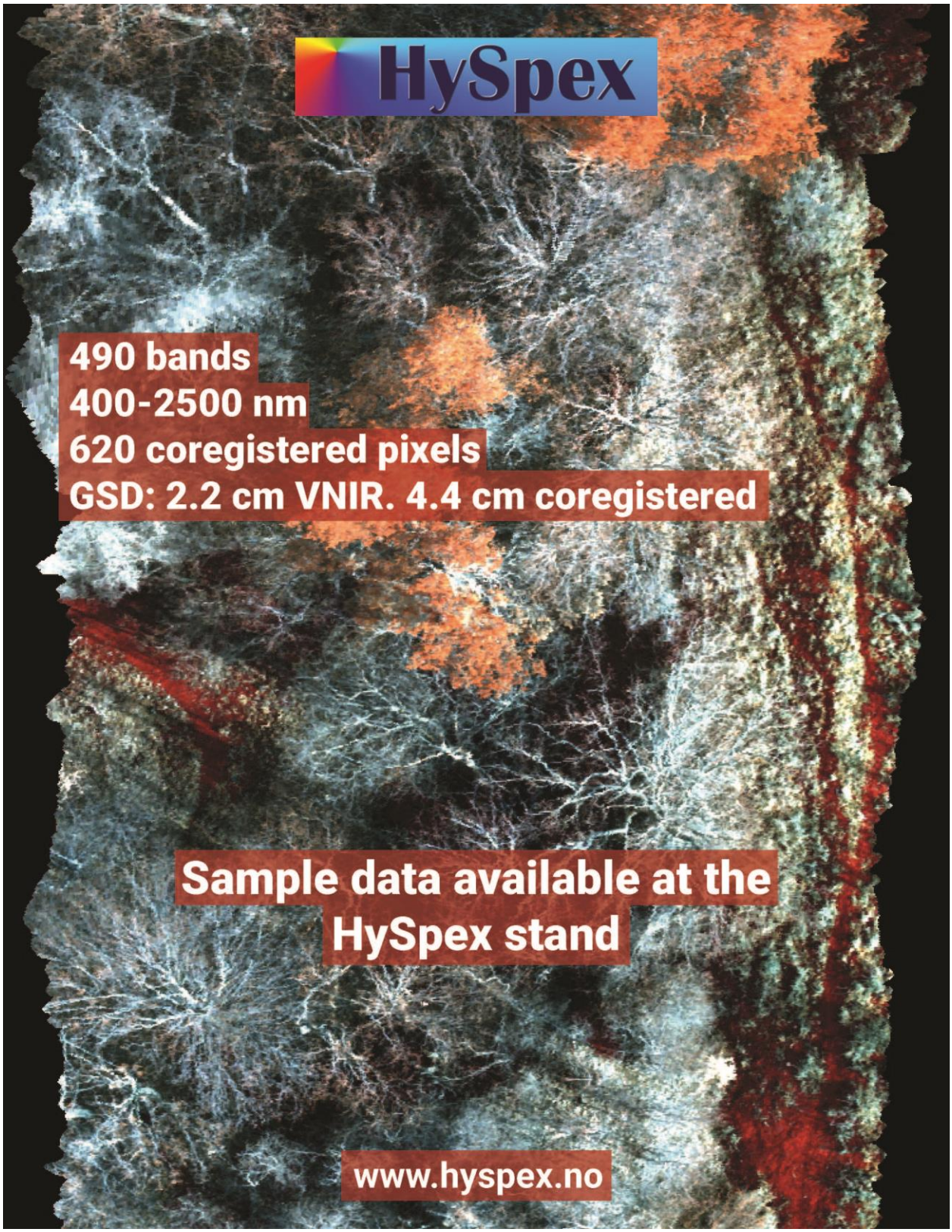
HySpex
490 bands
400-2500 nm
620 coregistered pixels
GSD: 2.2 cm VNIR. 4.4 cm coregistered
Sample data available at the
HySpex stand
www.hyspex.no

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A single day of UAV missions can generate terabytes of data. You need a way to process that data quickly, but you also need to perform science on the results. That means black box solutions won't work.

With the open source Algorithm Toolkit and TileDriver Process™ from BeamIO, you get the best of both worlds: a repeatable, fast workflow engine with the ability to manipulate the algorithms used to process your data wherever it resides.

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BETTER DATA PROCESSING DELIVERED IN THE CLOUD OR ON YOUR HARDWARE

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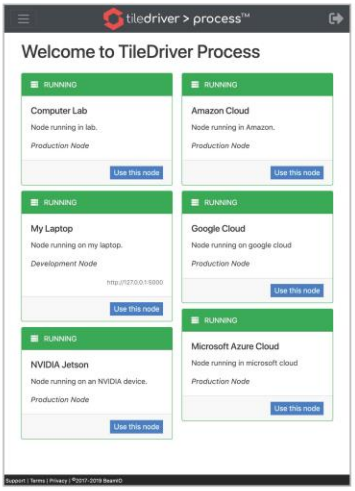
With our ChainLedger technology, you'll have a record of every data workflow process you ever ran so you can reproduce results and better yet: understand what the data are telling you.

Come see us at our STRATUS booth to learn more.



To learn more, visit https://beamio.net

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IEEE GRSS

CALL FOR PAPERS

10th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing
24-26 September 2019, Amsterdam, The Netherlands

Hyperspectral imaging is one of the fast moving areas of research and industrial development in sensing technologies. In this IEEE GRSS WHISPERS 2019 Conference, we aim at gathering high-level contributions dealing with the acquisition and processing of hyperspectral data. By hyperspectral data, we mean signals acquired by spectrometers at close-range as well as images acquired from airborne and satellite sensors. Papers must address relevant topics in hyperspectral signal and image processing, and include sound implementation and validation procedures.

The technical topics of interest include (but are not limited to)
- spectrometers and hyperspectral sensors: design and calibration
- physical modeling, physical analysis
- noise estimation and reduction
- dimension reduction
- unmixing, source separation, endmember extraction
- segmentation, classification
- high performance computing and compression
- deep learning and artifical intelligence

We warmly welcome application papers, including
- airborne and satellite remote sensing,
- monitoring of the environment, pollution, precision agriculture,
- land, soil and mineralogy,
- water bodies, oceans, coastal areas,
- forestry, vegetation,
- urban areas,
- defense applications,
- astrophysics and planetary exploration
- food safety
- detection of counterfeit products
- biomedical imaging

Important Dates
April 15, 2019 : Paper Submission (note that three different kinds of contributions can be submitted: full conference paper, abstract only, or already accepted journal paper)
September 24-26, 2019 : IEEE GRSS WHISPERS Conference, Beurs Van Berlage, Amsterdam, Netherlands.

Format
All submissions will be peer reviewed according to the IEEE GRESS WHISPERS 2019 guidelines. Submit your manuscript on https://easychair.org/conferences/?conf=whispers2019. Prospective authors should consult the site http://www.ieee-whispers.com/paper-submission/ for guidelines, templates and information on paper submission.

General Chairs
Uta Heiden, *DLR, Germany* (uta.heiden@dlr.de)
Jocelyn Chanussot, *Grenoble Institute of Technology, France* (Jocelyn@hi.is)

Program Chairs
Zebin Wu, *Nanjing University of Science and Technology, China* (zebin.wu@gmail.com)
Emmett Ientilucci, *Rochester Institute of Technology, USA* (emmett@cis.rit.edu)

Plenary Speakers
Steven Thomson, *United States Department of Agricultural -National Institute of Food and Agriculture (NIFA), USA*
Naoto Yokoya, *The University of Tokyo, Japan* Jun Li, *Sun Yat-Sen University, China*

WHISPERS 2019 - 24/26 September 2019
Beurs Van Berlage, Amsterdam, The Netherlands

Tutorial 1

Instructor Bio: Chris Durell, Director of Business Development, Remote Sensing. Chris graduated from Cornell University with an BSEE in 1993 and finished his MBA at Franklin Pierce College in 2003. Chris was the VP of Sales for both Labsphere and SphereOptics and has lead efforts to design optical, light measurement and remote sensing systems, products and technology for over 21 years. He is the chair of the IEEE P4001 Hyperspectral standards group and is a member of SPIE, IES, ASTM, CIE, CORM, ICDM and is a participant in CEOS/IVOS, QA4EO and other groups. He has several patents and has published papers in many applications of light metrology and remote sensing.

Tutorial Description

This tutorial will provide the attendee with an overview of optical radiometry. This introduction to radiometry will provide fundamental information about what radiometric units to use, how to use them, and how to perform the proper measurements to record specific radiometric quantities. The use of standard light sources will be discussed for calibration. The use of radiometry and calibration as applied to UAS applications, specifically, how to apply radiometric units to field applications in UAS space including visible, multispectral, LiDAR, SWIR and thermal cameras and sensor payloads will be discussed.

Topics will include

1) reflectance-based techniques
2) sources, visible to thermal, and
3) image-quality tests

Company Description

Labsphere is an internationally recognized photonics company located in central New Hampshire. Founded in 1979, it is now part of the Halma Group of companies. Labsphere, Inc. designs, manufactures, and sells precision standard and custom radiometric and photometric products to aerospace, automotive, electronic and medical imaging, laser diode, LED, lighting, and optics industries. It offers portable solutions for spectral flux measurement; light measurement systems for thermal, optical, and electrical characterization of LEDs; and integrating sphere solutions for light-based applications ranging from large area customized sphere-based systems to small hand-held instruments, which include integrating spheres and components, light measurement systems, uniform light source calibration systems, reflectance standards and targets, reflectance materials and coatings, and instruments. The company also provides custom product development services, such as sensor calibration and testing, remote sensing camera calibration, night vision sensor calibration, radiance and solar simulation, lamp testing, LED/SSL measurement, laser power/diode testing, LCD backlight testing, and fiber output testing; and order tracking, software and manual request, calibration, technical support, and custom product development services. In addition, it provides OEM products, including customized solutions for applications, such as spectroscopy, diode pumped solid state lasers, clinical diagnostic and analytical instrumentation, and industrial optical metrology.

Tutorial 2

Instructor Bio: Angad Singh is a Technical Sales Engineer, and training specialist for Pix4D based in San Francisco, USA. Prior to finishing his academic research and joining Pix4D, he helped Quidich Innovation Labs in India with GIS and photogrametry workflows. Angad's interest in UAS based photogrammetry started when he realized he could get incredibly high resolution data which would enable his research to make micro level insights, as well as change the narrative of how industries operate. Angad has a passion for enabling people to understand the power and limitations of UAS to create great geospatial data. Angad's research background is in Remote Sensing and Precision Agriculture from McGill University in Montreal, Canada.

Tutorial Description

This tutorial will be aimed at geospatial professionals, and will include the following concepts:

- Introduction to Photogrammetry concepts used by Pix4D
- Image Capture, camera types, and platforms used
- Cloud vs desktop processing
- Georeferencing
- Verifying accuracy
- Creating a project
- Live demonstration of interface
- Outputs workflow
- Reviewing the quality report

Company Description

Pix4D SA provides image processing software solutions for professional unmanned aerial vehicles (UAV). The company offers Pix4UAV, a general cloud computing service and standalone desktop software solution that provides a way to process images. Its solution includes georeferenced orthomosaic and georeferenced digital surface model generation; automatic aerial triangulation, bundle block adjustment, and camera calibration; automatic reconstruction and accuracy report; images processing; ground control points and coordinate reference system support; thermal, infrared, and multispectral; multi-camera support; DSM and cloud of points with dense matching; and rapid processing mode features. The company offers its products for mine and quarry surveys, emergency response, and vegetation monitoring applications. It offers its solution as a cloud service and as a desktop license. The company sells its products to UAV manufacturers for bundling; and directly to farming, mining, construction, and exploration companies that need to create a timeline of 3D maps. It serves the United Nations, mining companies, and local surveying companies all over the world. The company was founded in 2011 and is based in Ecublens, Switzerland.

Tutorial 3

Instructor Bios:
This tutorial will be led by Chris Willey and Dr. Brent Bartlett of BeamIO.

Mr. Willey has over 20 years of experience in the IT industry helping many organizations realize the potential of technology through a series of senior roles. Mr. Willey was the first Chief Information Officer (CIO) for the Consumer Financial Protection Bureau where he led the creation of the agency's entire technology operation. Mr. Willey has had several other leadership roles including Deputy CIO at the Office of Personnel Management, and Interim CTO for the Government of the District of Columbia where he was named one of the "Top 50 Government CIOs" by InformationWeek. He is a graduate of the Robert H. Smith School of Business at the University of Maryland where he received a Master of Business Administration, and the University of Massachusetts where he earned Bachelor of Arts degrees in English and Comparative Literature.

Dr. Bartlett has over 10 years of expertise working with remote sensing hardware and software systems including both physics and deep learning based algorithms. During his tenure at various research organizations, he has designed and deployed automated processing pipelines that execute complex workflows at scale both on premises and in the cloud. He excels at bringing lessons learned from operational experience to projects of all sizes. Dr. Bartlett received his Ph.D. in Imaging Science from the Rochester Institute of Technology for research performed with the Digital Imaging and Remote Sensing lab.

Tutorial Description
For our STRATUS tutorial, BeamIO engineers will provide an overview for using algorithms on UAS data to extract useful information. We will demonstrate how anyone can use our Algorithm Toolkit (ATK) and TileDriver platform to process data and imagery with algorithm chains. We will set up the ATK on a computer from scratch, download a few useful algorithms from our public Registry, and create an example batch processing chain. A use case will be demonstrated with the following items:

- Introduction to neural networks for use with multi-band imagery
- A 'how-to' for extending the ATK to train and use neural networks
- Example of deploying and running the solution on locally and in the cloud

Participants will be provided with a ready-made processing chain and will learn how to download, use, and create algorithms with the ATK registry.

Company Description

BeamIO helps users process and manage huge amounts of imagery and other data. Our Algorithm Toolkit (ATK) allows researchers, scientists and engineers chain algorithms together quickly to solve complex problems. Our core focus is enabling the rapid transition of state of the art algorithms from research communities to real industry solutions. The technology we have developed allows groups to turn their solutions into usable tools, which they can then share with others. This allows our customers to solve problems in a fraction of the time and cost of traditional approaches.

We also have a SaaS product, called TileDriver, that helps users store, manage and visualize imagery and geospatial data. TileDriver integrates with algorithm nodes running the ATK to provide a powerful data management tool and content delivery mechanism. The ATK itself can be hosted anywhere: customers can use their own computers, their institutions' compute infrastructure, or we can provide cloud-based hosting that scales with their needs. Researchers can develop entire solutions with nothing but a laptop.

MONDAY 25 FEBRUARY

Louise Slaughter Hall, Room 2140

TUTORIALS

TUTORIAL 1 . . . . . 8:00 AM TO 10:30 AM

Introduction to UAV Radiometry and Reflectance, *Chris Durell of Labsphere, Inc.*

This tutorial will provide the attendee with an overview of optical radiometry. This introduction to radiometry will provide fundamental information about what radiometric units to use, how to use them, and how to perform the proper measurements to record specific radiometric quantities. The use of standard light sources will be discussed for calibration. The use of radiometry and calibration as applied to UAS applications, specifically, how to apply radiometric units to field applications in UAS space including visible, multispectral, LiDAR, SWIR and thermal cameras and sensor payloads will be discussed. Topics will include reflectance-based techniques, sources, visible to thermal, and image-quality tests

10:30 AM . . . . . **Coffee Break**

TUTORIAL 2 . . . . . 11:00 AM TO 1:30 PM

UAS Focused Photogrammetry / Mapping with Pix4D, *Angad Singh of Pix4D, Inc.*

This tutorial will be aimed at geospatial professionals, and will include the following concepts, Introduction to Photogrammetry concepts used by Pix4D, Image Capture, camera types, and platforms used, Cloud vs desktop processing, Georeferencing, Verifying accuracy, Creating a project, Live demonstration of interface, Outputs workflow, Reviewing the quality report

1:30 PM . . . . . **Lunch**

TUTORIAL 3 . . . . . 2:30 PM TO 5:00 PM

Creating automated processing workflows for multi-band UAS data using the Algorithm Toolkit, *Dr. Brent Barlett of BeamIO*

For our STRATUS tutorial, BeamIO engineers will provide an overview for using algorithms on UAS data to extract useful information. We will demonstrate how anyone can use our Algorithm Toolkit (ATK) and TileDriver platform to process data and imagery with algorithm chains. We will set up the ATK on a computer from scratch, download a few useful algorithms from our public Registry, and create an example batch processing chain. A use case will be demonstrated with the following items, Introduction to neural networks for use with multi-band imagery, A 'how-to' for extending the ATK to train and use neural networks, Example of deploying and running the solution on locally and in the cloud, Participants will be provided with a ready-made processing chain and will learn how to download, use, and create algorithms with the ATK registry.

TUESDAY 26 FEBRUARY

Louise Slaughter Hall, Rooms 2210-2240

REGISTRATION & BREAKFAST. . . . 8:00 AM

WELCOME . . . . . 8:30 AM TO 9:00 AM
Dr. Emmett Ientilucci, RIT, CoChair
Dr. David Messinger, RIT, Director CIS
Dr. Ryne Rafellee, RIT, VP Research

KEYNOTE . . . . . 9:00 AM TO 9:45 AM
Moderator. . . . . .Emmett Ientilucci, RIT

Dr. Sally Rockey, **The Role of Technology in Agriculture**, Executive Director of the Foundation for Food and Agriculture Research (FFAR)

SESSION 1

UAS HARDWARE 1

Session Chair: **Emmett Ientilucci**, RIT

9:45 AM **Identifying and Quantifying DJI Camera Limitations**, Aswin Balasubramaniam, Univ. of Cincinnati (USA) . . . . . [02]

10:05 AM **Spectrometer Design and Analysis for Unmanned Aerial System Applications**, Ethan Hughes, RIT (USA). . . . . .[07]

10:25 AM **Low Cost UAS Radiometer for Landsat Land Surface Temperature Verification**, Jonathan Miller, Jarrett Wehle, Aaron Gerace, Matt Montanaro and Robert Kremens, RIT (USA). . . . . .[21]

10:45 AM . . . . . Coffee Break

SESSION 2

UAS FOR ENVIRONMENTAL MONITORING

Session Chair: **Bahram Salehi**, SUNY ESF

11:15 AM **Pipeline Oil Spill Mapping from UAV Imagery and Ancillary Electromagnetic Induction Survey Data, Alberta Canada**, Masoud Mahdianpari, Memorial University (Canada); Bahram Salehi, SUNY ESF (USA); Fariba Mohammadimanesh, Memorial University (Canada); Glen Larsen, AKS Geoscience (Canada); Derek Peddle, University of Lethbridge (Canada) . . . . . [17]

11:35 AM **UAV Image Processing for Iceberg 3D Modelling**, Bahram Salehi, SUNY ESF (USA); Somayeh Yavari, Memorial University (Canada); Rob Briggs, C-Core (Canada) . . . . . .[25]

11:55 AM **Integrated UAV Data Flow Analysis for Rapid Decision-making in Runoff and Sediment Redistribution Risk and Remediation Planning,** Chris Renschler, University at Buffalo (USA); Willard Schulmeister, Jacob Albright, EagleHawk One Inc. (USA) . . . .[22]

12:15 PM **Geospatial Assessments of environmental impacts of marine debris in the Gulf-of Guinea Coast,** Samuel Akande, Federal University of Technology Akure (Nigeria). . . . . .[09]

GROUP PHOTO. . . . .12:35 PM TO 12:45 PM

NETWORKING
LUNCH . . . . . .12:45 PM TO 2:00 PM
Moderator. . . . . .Emmett Ientilucci, RIT

SESSION 3

UAS IMAGE PROCESSING/ALGORITHM DEVELOPMENT

Session Chair: **Chris Renschler**, Univ. at Buffalo

2:05 PM **A New Point Cloud Refinement Method for Tree Height Estimation of UAV Imagery**, Bahram Salehi, SUNY ESF (USA); Sepideh Yavari, Memorial University (Canada) . . . . . .[10]

2:25 PM **Hyperspectral and LiDAR Data Acquisition and Processing**, Carson Roberts, Headwall Photonics, Inc. (USA). . . . . .[12]

2:45 PM **Scientific grade hyperspectral data quality from UAV platform, in the VNIR-SWIR range, focusing on real time processing for mine face scanning.**, Trond Loke, Norsk Elektro Optikk AS-NEO, (Norway) . . . . . [14]

3:05 PM **Applying reconfigurable algorithm chains to multi-band UAS data using the Algorithm Toolkit**, Brent Bartlett, BeamIO (USA). . . . . .[16]

3:25 PM . . . . . Coffee Break

SESSION 4

AGRICULTURAL APPLICATIONS OF UAS

Session Chair: **Peter Spacher**, Hobart and William Smith Colleges

3:55 PM **Monitoring Crop Growth Using UAS and Satellite Imagery**, Emily Myers, John Kerekes, Timothy Bauch, Nina Raqueño, Grady Saunders, RIT (USA); Craig Daughtry, Andrew Russ, USDA Hydrology and Remote Sensing Lab (USA) . . . . . [03]

4:15 PM **Combining Spatial and Temporal Corn Yield Variability for Development of Management Zones**, Tulsi Kharel, Angel Maresma, Karl Czymmek, Emmaline Long, Sheryl Swink, Cornell University (USA); Erasmus Oware, University at Buffalo (USA); Quirine Ketterings, Cornell University (USA) . . . . . .[15]

4:35 PM . . . . . **Wrap Up**

5:30 PM . . . . . **Social Gathering**

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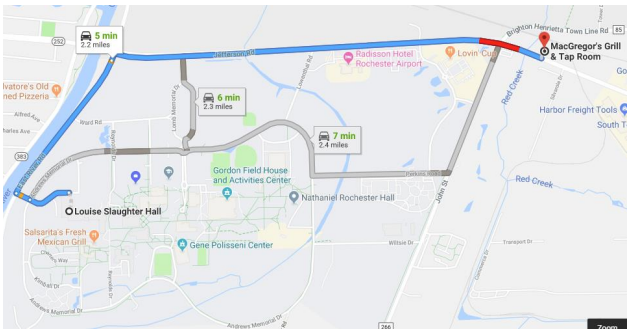

WEDNESDAY 27 FEBRUARY

Louise Slaughter Hall, Rooms 2210-2240

REGISTRATION & BREAKFAST. . . . 8:15 AM

WELCOME DAY 2 . . . . .8:50 AM TO 9:00 AM
Dr. Chris Renschler, Univ. at Buffalo, CoChair
Dr. Bahram Salehi, SUNY ESF, Program Chair

KEYNOTE . . . . . 9:00 AM TO 9:45 AM
Moderator. . . . . Chris Renschler, Univ. At Buffalo

Dr. Steven Thomson, **Applications of UAS and UGV's within Agricultural Cyber-Physical and Robotic Systems,** National Program Leader, United States Department of Agriculture (USDA), National Institute of Food and Agriculture (NIFA).

SESSION 5

UAS HARDWARE 2

Session Chair: **Emmett Ientilucci, RIT**

9:45 AM **Sensor Characterization and Calibration**, Baabak Mamaghani and Carl Salvaggio, RIT (USA) . . . . . [27]

10:05 AM **Spectral Analysis of Magnetometer Swing in High-Resolution UAV-borne Aeromagnetic Surveys**, Callum Walter, Alexander Braun, Georgia Fotopoulos, Queen's University (Canada). . . . . .[11]

10:25 AM **MX-1: A New Multi-Modal Remote Sensing UAS Payload with High Accuracy GPS and IMU**, Daniel Kaputa, Timothy Bauch, RIT (USA); Carson Roberts, Headwall Photonics (USA); Don McKeown, Mark Foote, Carl Salvaggio, RIT (USA) . . . . . [24]

10:45 AM . . . . . Coffee Break

SESSION 6

FOREST APPLICATIONS OF UAS

Session Chair: **Jan van Aardt**, RIT

11:15 AM **Ground classification algorithm sensitivity analysis using digital aerial photogrammetry over conifer forest stands**, Alex Graham, University of British Columbia (Canada) . . . . . [13]

11:35 AM **Shadow Detection in Aerial and UAS data Using Neural Networks,** Prasanna Reddy Pulakurthi, Emmett Ientilucci, RIT (USA). . . . .[26]

POSTER AND VENDOR SESSION . . . . . 11:55 AM TO 12:35PM
Vendors include:

1) Hyspex
2) Headwall Photonics
3) Beamio
4) Labsphere
5) GapWireless
6) RIT

POSTERS:

Study of Harmful Algae Blooms Using UAS Imagery, Peter Spacher, Ileana Dumitriu, John Halfman, Hobart and William Smith Colleges (USA); Lisa Cleckner, Finger Lakes Institute (USA). . . . . .[08]

Evaluation of UAS imagery for forest regeneration surveys, Muhammet Ali Ozderya Eddie Bevilacqua, SUNY ESF (USA) . . . . . .[18]

Evaluation of UAS imagery for aboveground biomass assessment in mature forests, Mehmet Ozen, Eddie Bevilacqua, SUNY ESF (USA). . . . . .[20]

LUNCH . . . . . .12:35 PM TO 2:00 PM

SESSION 7

SPECIAL INVITED TALKS

Session Chair: **Don McKeown**, RIT

2:05 PM **UAV's Impact on Secondary Education in Precision Agriculture**, Mark Mancari, Perry Central School District (USA). . . . . .[29]

2:25 PM **UAS Safety, and the Role of the Flight Standards District Office**, Robert Lacourse, Federal Aviation Administration (FAA) (USA)[28]

SESSION 8

WATER APPLICATIONS OF UAS

Session Chair: **Anthony Vodacek, RIT**

2:45 PM **Real-time, sUAS-based detection of grapevine water status in the Finger Lakes Wine Country of Upstate New York**, Rinaldo Izzo, RIT (USA); Alan Lasko, Cornell University (USA); Evan Marcellus, Tim Bauch, Nina Raqueño Jan van Aardt, RIT (USA) . . . . . .[05]

3:05 PM **Preliminary Testing of the senseFly thermoMAP Infrared Camera for Surface Water Temperature Measurements of a Small Lake - Wilmot, Ontario, Canada**, Marie Hoekstra, Marzieh Foroutan, University of Waterloo (Canada); Kevin Kang, H2O Geomatics Inc. (Canada); Claude Duguay, University of Waterloo (Canada). . . . . .[06]

3:25 PM . . . . . Coffee Break

3:55 PM **Glint Correction of Unmanned Aerial System Imagery**, Ryan Ford and Anthony Vodacek, RIT (USA) . . . . . .[23]

STUDENT AWARDS. . . . . 4:15 PM

CLOSING REMARKS. . . . . 4:35 PM

Tuesday Keynote Speaker

Dr. Sally Rockey, Executive Director of the Foundation for Food and Agriculture Research (FFAR)

Dr. Sally Rockey Dr. Sally Rockey became the inaugural Executive Director of the Foundation for Food and Agriculture Research (FFAR) in September 2015. Prior to this role, Dr. Rockey was a leader in Federal research, overseeing the operations of the extramural programs in both agriculture and biomedicine. She spent 19 years with the U.S. Department of Agriculture where she held a number of positions within the Cooperative State Research, Education, and Extension Service. Very early in her career she became the head of the competitive grants program, overseeing the extramural grants process and portfolio. In her last few years with USDA she was the Chief Information Officer, applying her breadth of government knowledge to IT. From there she moved to and spent 11 years with the National Institutes of Health. As Deputy Director for Extramural Research, Dr. Rockey oversaw the operations of the largest Federal extramural research program and led groundbreaking initiatives and activities that have and will have a lasting positive impact on the research community.

Dr. Rockey spent 19 years with the U.S. Department of Agriculture where she held a number of positions within the Cooperative State Research, Education, and Extension Service which is now the National Institute of Food and Agriculture. She became the head of the competitive grants program, overseeing the extramural research grants process and portfolio. In her final years with USDA she was the Chief Information Officer, applying her breadth of government knowledge to IT. From there she moved to the National Institutes of Health (NIH). As Deputy Director for Extramural Research at NIH, Rockey oversaw the operations of the largest extramural research program in the world. She led groundbreaking initiatives on scientific workforce, research administration, and electronic government. As a principal leader for research administration in the government, she headed numerous federal committees such as the National Science and Technology-Committee on Science-Research Business Models. Rockey transformed the relationship of NIH with the academic and scientific research communities by promoting transparency in NIH decisionmaking rocesses and using social media, particularly her blog “RockTalk” which served as a model for government communication, to make a lasting positive impact on the research community. She served as Vice President of the Human Frontiers of Science program, an international life-science grant program which funded multinational teams of scientists conducting groundbreaking research. Dr. Rockey has been recognized for her numerous professional accomplishments with the Presidential Rank Award for excellence in government leadership, the Joseph F. Carrabino award for promoting government university relationships, and the Association of Independent Research Institutions Public Service Award. Rockey retired from the government in 2015 and to become the first Executive Director of FFAR.

Wednesday Keynote Speaker

Dr. Steven J. Thomson, National Program Leader, USDA NIFA

Dr. Steven J. Thomson Dr. Steven J. Thomson is a National Program Leader with the USDA National Institute of Food and Agriculture (NIFA). He engages Universities, other federal agencies, and industry to provide national leadership in Capacity and Competitive Grant programs. He leads four programs that focus on engineering processes to improve systems relevant to agriculture. These research, education, and outreach activities include precision agriculture, robotics (NSF collaborative), cyber-physical systems (NSF collaborative), and instrumentation and controls. Dr. Thomson co-leads two programs that involve youth farm safety and access to assistive technologies by disabled farmers and veterans. Dr. Thomson has research background in statistics, aerial application of crop protection materials, irrigation management, water balance and crop modeling, decision support systems, agricultural safety, sensor systems and electronics, remote sensing, unmanned aerial systems, and precision agriculture. He has been involved in research, extension, and instruction both as a faculty member at Virginia Tech, where he received the Alpha Epsilon Award for his Research and Extension program, and (more recently) as Research Lead Scientist with the USDA ARS.

Abstracts

SESSION 1:

UAS HARDWARE 1

[Paper 02] **Identifying and Quantifying DJI Camera Limitations**, Aswin Balasubramaniam, Univ. of Cincinnati (USA)

To augment inspections of structure a user can use UAVs to capture images of the structure in a certain pattern with front and side overlap and use Pix4D generated outputs to inspect it in detail. Applications like DJI DS Pro allows users to automate this process using UAVs by creating automated flight plans based on user inputs of flight parameters and camera settings. If a camera's limitations are unknown to a user, images are captured with insufficient overlaps which in turn produce errors in Pix4D. The study focusses to identify and quantify the limitations of the DJI XTR camera when used with the DJI GS Pro flight planning application, which can be extended to other cameras/sensors. The DJI XTR camera is a thermal camera and differs from the traditional visual camera. Initial experimental results revealed the XTR requires higher triggering intervals when images are captured during motion (equal-timed mode of capture) which in turn affects the resolution of images captured and/or increases the general flight time. This is addressed in this study along with the triggering interval values that allows the camera to function properly as well as not function as required. In this study a characteristic hyperplane using important flight parameters (GSD, Overlap, Speed, and Triggering Interval) for the DJI XTR camera was created using MATLAB and the values of parameters above and below the plane were used to create flight plans to capture images and their Pix4D outputs were generated and compared.

[Paper 07] **Spectrometer Design and Analysis for Unmanned Aerial System Applications**, Ethan Hughes, RIT (USA)

With the advent and commercial availability of unmanned aerial systems (UAS) and small hyperspectral imaging spectrometers, researchers as well as individuals in the remote sensing industry have been marrying the two technologies to explore solutions to problems new and old. The objectives of this talk are to i) investigate the designs of prism and grating spectrometers and their respective pros and cons, ii) compare an in depth analysis of a UAS sized Czerny–Turner grating spectrometer to AVIRIS (Airborne Visible InfraRed Imaging Spectrometer), and iii) identify ways to spatially and spectrally calibrating a spectrometer.

[Paper 21] **Low Cost UAS Radiometer for Landsat Land Surface Temperature Verification**, Jonathan Miller, Jarrett Wehle, Aaron Gerace, Matt Montanaro and Robert Kremens, RIT (USA)

Land Surface Temperature (LST) is the radiative temperature of the Earth's surface measured by an overhead airborne or satellite sensor. LST is widely used for hydrological, meteorological, and agricultural industries. LST products are becoming more sought after which requires data providers to create accurately calibrated data sets. In this paper we investigate the feasibility of building a radiometer to collect ground truth temperature measurements to validate an LST product, specifically the Level 2 product produced by Landsat 8. We designed and fabricated a multi-channel radiometer, that can be flown on an Unmanned Aerial System (UAS), to replicate Landsat's thermal infrared sensor (TIRS) bands 10 and 11. Experimental results using a Blackbody radiator show the radiometer successfully records accurate temperature measurements and is ready for flight testing with coordinated Landsat collects.

SESSION 2

UAS FOR ENVIRONMENTAL MONITORING

[Paper 17] **Pipeline Oil Spill Mapping from UAV Imagery and Ancillary Electromagnetic Induction Survey Data, Alberta Canada**, Masoud Mahdianpari, Memorial University (Canada); Bahram Salehi, SUNY ESF (USA); Fariba Mohammadimanesh, Memorial University (Canada); Glen Larsen, AKS Geoscience (Canada); Derek Peddle, University of Lethbridge (Canada)

Pipelines are used extensively to transport oil and gas throughout the world. However, pipeline leaks have significant economic and environmental impacts and thus operational methods are required for pipeline monitoring. Towards that goal, we propose a method for mapping soil contamination due to pipeline leakage and test it in Alberta, Canada. Very high-resolution Unpiloted Aerial Vehicle (UAV) imagery and Electromagnetic Induction (EM) survey data were analyzed using a hierarchical object-based Random Forest (RF) algorithm. A land cover map was first produced using UAV data. Next, all land cover classes, excluding contaminated soil, were masked out. Then, the contaminated soil class was further partitioned into three subclasses representing varying degrees of contamination. To achieve that, a new salinity index, named the normalized salinity index [NSI] was proposed to help improve the detection of soil contamination areas. The NSI was used with other salinity indices, EM data and UAV bands as input features to achieve an overall classification accuracy of 77%. The results demonstrated that the synergistic use of high spatial resolution UAV imagery and EM data has promise for detecting soil contamination and examining ecosystem disturbance due to pipeline leaks. Next steps are identified based on these results.

[Paper 25] **UAV Image Processing for Iceberg 3D Modelling**, Bahram Salehi, SUNY ESF (USA); Somayeh Yavari, Memorial University (Canada); Rob Briggs, C-Core (Canada)

The use of UAV images in 3D iceberg profiling has potential for use in studies of global warming and in risk assessment procedures for ocean oil and gas pipelines and marine transportation. Since there has been little research done in this field, our main focus is to study the feasibility and assess the accuracy of UAV images in 3D iceberg profiling. For this purpose, a flight plan is designed for UAV image acquisition over a number of icebergs located near the coast of Bonovista in Newfoundland captured in June 2017. A 3D model of iceberg using UAV imagery is generated and compared with a LiDAR-based 3D model of the iceberg. Early results confirm the feasibility and high level of accuracy of photogrammetry-based iceberg profiling using UAV imagery. Combined with sonar observations, the method has a great potential for operational iceberg profiling and monitoring, an important challenge for off-shore oil/gas, transportation, and tourism industries in Newfoundland and other world's cold regions.

[Paper 22] **Integrated UAV Data Flow Analysis for Rapid Decision-making in Runoff and Sediment Redistribution Risk and Remediation Planning,** Chris Renschler, University at Buffalo (USA); Willard Schulmeister, Jacob Albright, EagleHawk One Inc. (USA)

Bare soil conditions with initial vegetative regrowth of grass cover on construction and industrial waste sites are especially vulnerable to storm runoff and potentially contaminated sediment redistribution. To be able to rapidly respond or plan ahead for a drastic vegetation change (e.g. earth relocation, fire, etc.) in a particular season, an aerial drone with a 20 megapixels camera was used to gather topography and vegetation coverage. The flight time of 26 minutes was used capturing 427 images over 200 acres yielding a 1.6 in/pixel orthomosaic image resolution upon processing. In order to consider the surface soil conditions and potential climate/weather conditions, publicly available digital soil map and climate records of federal sources were utilized to generate the return periods of storm events in a particular year or season to model the potential storm water surface runoff, soil erosion, sediment redistribution, sediment yield and runoff peak rates for a former industrial site. The integrated data flow analysis from UAV information gathering, data processing, process-based modeling with the Geospatial interface for the Water Erosion Prediction Project (GeoWEPP) will be presented and discussed in detail. The UAV-modeling approach presented is capable to support decision-making in rapid response to a sudden or planned change in topography or vegetation for an accidental or present contamination of water, sediments or soil organic matter (e.g. radioactivity). Possible options would assess several vegetated and structural Best Management Practices (BMP) to reduce surface runoff and sediment relocation such as soil amendments, vegetation buffer strips, check dams, etc..

[Paper 09] **Geospatial Assessments of environmental impacts of marine debris in the Gulf-of Guinea Coast,** Samuel Akande, Federal University of Technology Akure (Nigeria)

Research on the ocean current systems have revealed that the accumulation, distribution and movement of marine debris from land- and ocean-based sources have resulted in generation of ocean mesoscale eddies and gyres globally. The study was conducted in the Gulf of Guinea region of the North Atlantic which stretches from the Senegal in the West to Gabon to the South-Eastern part of Africa. It is home to a large number people and economic activities with over fifty (50) million African population. In order to ensure the preservation of preserving natural resources and marine ecological features, a modified methodological approached was developed to evaluate risk of marine ecosystem. Monthly annual sea surface temperature data were obtained the National Oceanic and Atmospheric Administration (NOAA) and Advanced very-high-resolution radiometer (AVHRR) over the Gulf-of-Guinea region between 1972 to 2017 (45 years) were analysed in relation to acess the long term trend of ocean heat transport and changes in ocean circulations within the study area High resolution Sentinel-2, and ASTER satellite images and aerial photographs were acquired to track the distribution of marine pollutants along the Gulf-of-Guinea Ocean. Physical ground-truthing inspections using the Real-Time Differential Global Positioning System (RTK-DGPS) device were used to derive satellite altimetry and geometric correction. Classification modeler techniques and machine learning algorithms were used to estimate the quantitative and qualitative information about the abundance and accumulation of marine plastics and micro plastics would be obtained by developing a threshold model for monitoring transparent plastic-mulched coasts. The UAVs with spectral information , textural and spatial features on coastal surfaces would provide useful information for optimal mapping. The recommendations from this research thus improve strategies and policy measures needed to fight the observable and projected climate change impacts on marine life.

SESSION 3

UAS IMAGE PROCESSING/ALGORITHM DEVELOPMENT

[Paper 10] **A New Point Cloud Refinement Method for Tree Height Estimation of UAV Imagery**, Bahram Salehi, SUNY ESF (USA); Sepideh Yavari, Memorial University (Canada)

Unmanned Aerial Vehicle (UAV) images, due to their unique characteristics, are increasingly attracting attention in the Earth Observation (EO), remote sensing and photogrammetry communities, and applications such as forest and environmental mapping and monitoring. For forest characterization which is our main emphasis, UAV is used to measure different properties of forest such as tree heights and types, volume determination, biomass estimation and trees' health, as well as change detection in terms of deforestation and degradation. Our particular focus in this work is accurate tree height estimation. To estimate tree heights using UAV images, an accurate Digital Surface Model (DSM) over the desired area is required. For this purpose, feature extraction and matching in the overlapping images is the first step. The match features (e.g. linear features or points) are then used in a photogrammetric procedure to generate the point cloud. The most well-known matching method is Scale Invariant Feature Transform (SIFT). In this regard, a huge number of SIFT-based matching derivations have been introduced in recent years. They are categorized based on the number of matched features, accuracy, robustness, and computational time. Nonetheless, SIFT matching often results in a considerable number of mismatched points (or noise) which in turn lead to an inaccurate point cloud containing an enormous amount of noise. This problem is even more challenging in the UAV image as the resolution is super high, often in cent metric ranges. To mitigate this problem, a noise removal method should be used to remove as much noise as possible without removing correct matches. In this regard, a newly developed and tested matching method which is called Structural LInear feature-based Matching Method (SLIM) is proposed to use as a noise removal.In this study, the combination of SIFT and SLIM has been used to find maximum number of correct matches for UAV images of forest areas. The preliminary results show the superiority of combining SIFT and SLIM in terms of decreasing the number of mismatched points (noise), and also increasing the number of correct matches over the standard SIFT method. The method was applied to forest areas, for individual tree height estimation, and the results were compared with those of commercial software packages including Pix4D mapper and Agisoft PhotoScan. We observed significant improvement, of our proposed method over the aforementioned commercial software packages, in terms of both finding individual trees and estimating height with higher accuracy. The method shows a promising potential in improving the DSM generation of ever-increasing UAV image data, and has many applications in height estimation and 3D modelling.

[Paper 12] **Hyperspectral and LiDAR Data Acquisition and Processing**, Carson Roberts, Headwall Photonics, Inc. (USA)

Headwall Photonics has produced several compact payloads including imagers and LiDAR systems which can be flown on small UAS. Most of the systems have been integrated with the DJI M600 platform. The integrated sensor package includes one or more hyperspectral imagers, a data acquisition and control computer, a Global Positioning System and Inertial Measurement Unit (GPS/IMU), and the LiDAR. Proprietary software is used to combine the raw LiDAR data and the position and pose of the aircraft into a geolocated point cloud in LAS format. Recent additions to the Headwall LiDAR processing software (developed in partnership with BeamIO) include the ability to generate a high-resolution Digital Elevation Model (DEM) of the surveyed area. This can be useful in areas where accurate DEM data are not available, as for example in remote areas. The Headwall hyperspectral imagers are "pushbroom" line scanners which take one line of image data with each captured frame, repeated at hundreds of wavelengths. The process of combining a series of line scan images into a geolocated photomosaic is called orthorectification. The orthorectification process requires accurate GPS data and an accurate DEM. The DEM is required because the process involves calculating the size of each projected pixel in each line image on the ground. In addition to being able to generate DEMs from the LiDAR point clouds, the DEM and the orthorectified hyperspectral image can be combined into a three-dimensional hyperspectral image. Results of this fusion, for imagers of varying wavebands will be presented.

[Paper 14] **Scientific grade hyperspectral data quality from UAV platform, in the VNIR-SWIR range, focusing on real time processing for mine face scanning.**, Trond Loke, Norsk Elektro Optikk AS-NEO, (Norway)

The HySpex VS-620 hyperspectral camera provides a unique combination of small form factor and low mass combined with high performance and scientific grade data quality. A rugged design with good thermal and mechanical stability makes this camera an excellent option for a wide range of scientific applications for UAV operations and field applications. The optical architecture is based on the high-end ODIN-1024 system and features a total FOV of 20 degrees. With a total mass of less than 6Kg including hyperspectral cameras in both VNIR and SWIR range, data acquisition unit, battery, IMU and GPS, the system is suitable for a wide range of UAVs. In this presentation, we will present results from tests of the performance and stability of the system and give an overview of the complete system from the hyperspectral camera to computer, navigation system and software. We will also present the methods used to calibrate and characterize this system. We will also introduce a new real-time processing software that will be running on the data acquisition unit inside Mjolnir. This software will enable real-time georeferencing and rectification, real-time indices maps and real-time classification for various applications. We will also present a way of doing mine face scanning from the same UAV platform.

[Paper 16] **Applying reconfigurable algorithm chains to multi-band UAS data using the Algorithm Toolkit**, Brent Bartlett, BeamIO (USA)

As the capabilities of UAV systems continue to grow, an ever increasing number of applications have become possible. These applications require sophisticated processing workflows to extract data products reliably that are actionable to the end user. Rising to this challenge, the research community has produced innovative processing approaches that often rely on chaining multiple algorithms together to extract the desired information. Additionally, modern UAV systems with multi-band payloads produce massive data volumes. To cope with this, a cohesive framework is needed that allows researchers to apply algorithm chains that can be easily reconfigured and batch-processed. We present the Algorithm Toolkit, an open source framework that enables easy algorithm creation and chaining, metadata tracking, and web-enabled processing. We will demonstrate an example use case, processing UAV imagery captured with a Micasense multi-band camera to show how different calibration algorithms can be quickly configured and applied.

SESSION 4

AGRICULTURAL APPLICATIONS OF UAS

[Paper 03] **Monitoring Crop Growth Using UAS and Satellite Imagery**, Emily Myers, John Kerekes, Timothy Bauch, Nina Raqueño, Grady Saunders, RIT (USA); Craig Daughtry, Andrew Russ, USDA Hydrology and Remote Sensing Lab (USA)

Many imaging systems exhibit design tradeoffs between spatial, spectral, and temporal resolution, making it difficult to acquire high-quality data at an ideal frequency. Combining imagery from multiple sensors can alleviate some of these sampling issues. This study collected Unmanned Aerial System (UAS) imagery and satellite imagery, along with in-situ measurements, over a corn field during the 2018 growing season with the goal of monitoring crop growth at a high spatial, spectral, and temporal resolution. The field, owned and maintained by researchers at USDA Beltsville, was subdivided into plots subjected to different nitrogen and irrigation treatments during the season. Ground truth measurements of crop height, leaf chlorophyll, leaf area index (LAI), and color photography were acquired once or twice a week; some other measurements, such as canopy radiometry, were collected less frequently. Mostly cloud-free multispectral PlanetScope satellite imagery was acquired on a regular basis. Finally, UAS collections were performed to coincide with two PlanetScope overpass dates. The UAS system payload included multispectral and hyperspectral imaging sensors (Headwall Photonics Nano; 400-1000 nm) as well as LIDAR and thermal sensors. The satellite time-series is being used to estimate key phenological transition dates and predict yield for the corn, while the UAS imagery is being used to investigate the scalability and reliability of the satellite measurements. The ultimate goal of the research is to investigate temporal requirements for future satellite systems for vegetation phenology monitoring.

[Paper 15] **Combining Spatial and Temporal Corn Yield Variability for Development of Management Zones**, Tulsi Kharel, Angel Maresma, Karl Czymmek, Emmaline Long, Sheryl Swink, Cornell University (USA); Erasmus Oware, University at Buffalo (USA); Quirine Ketterings, Cornell University (USA)

Precision agriculture requires an understanding of both spatial and temporal variability in yield. We evaluated spatial and temporal variability of corn (Zea mays, L.) silage yields using whole-farm yield monitor datasets of six New York dairy farms. The datasets (2015, 2016, and 2017) included 847 fields (9084 ha). Raw yield data were cleaned of errors using a standardized post-harvest data cleaning protocol. The evaluation showed variability in average yield per farm, yield per field, and within fields, in addition to variability across years. Spatial and temporal variability (expressed as standard deviation [SD] across years for fields with three years of data) were not correlated. Thus, management zones need to take into account both spatial and temporal variability to be effective. Data showed that field classifications need to be relative to the production level of the individual farm, reflecting each farm has unique opportunities for improvement. The temporal SD and the area-weighted farm average yield across years were used to divide fields into four quadrants (Q1 and Q4, consistently higher and lower yielding than the farm average, respectively; Q2 and Q3, variable in yield over years and higher and lower than the farm average, respectively). The area classified as variable (Q2 and Q3) ranged from 39 to 51% of the total farm area illustrating the importance of implementation of precision agriculture technologies and in-season management adjustments. Research is needed to determine the optimum number of zones per farm and number of crop years to include for development of yield stability zones.

SESSION 5

UAS HARDWARE 2

[Paper 27] **Sensor Characterization and Calibration**, Baabak Mamaghani and Carl Salvaggio, RIT (USA)

Critical applications require the highest data collection accuracy that is obtainable. In order to accomplish this in the field of remote sensing, calibration of sensors/cameras is a necessity. As sensors are utilized, they degrade due to mechanical and electrical issues. It is important to ensure the calibration functions are as up-to-date as possible. For the purposes of this study, a MicaSense RedEdge Multispectral sensor was analyzed. This sensor was characterized by computing its relative spectral response (RSR) functions, a vignette correction, radiometric calibration, along with a temperature noise analysis. This approach was applied to the RedEdge camera and compared against the RedEdge Camera Radiometric Calibration Model. This talk will describe both methodologies, and display the results from both calibration methods.

[Paper 11] **Spectral Analysis of Magnetometer Swing in High-Resolution UAV-borne Aeromagnetic Surveys**, Callum Walter, Alexander Braun, Georgia Fotopoulos, Queen's University (Canada)

Electromagnetic interference produced by multi-rotor UAVs has the potential to compromise the integrity of UAV-borne total magnetic field (TMI) measurements collected with high-resolution optically pumped magnetometer payloads. One method to overcome this challenge, involves suspending the magnetometer sensor below the zone of electromagnetic interference via a semi-rigid mount. The semi-rigid mount allows the magnetometer payload to freely move in the pitch and roll axes, while rigidly fixing the yaw of the magnetometer to that of the multi-rotor UAV. As such, the swinging motions of the magnetometer suspended below the UAS have the potential to introduce periodic variations in the collected magnetic field data. Within this study, spectral analysis was applied to UAV-borne TMI measurements, collected using a semi-rigid mount to assess contributions to the signal from the swinging magnetometer payload. Overall, it was concluded that when the magnetometer was placed outside the zone of electromagnetic interference created by the UAV, compensation and filtering was not required to achieve industry standard measurements. However, when the magnetometer was placed within the zone of UAV-induced electromagnetic interference, a periodic, relatively high-frequency signal was apparent in the TMI measurements, due to the swinging of the magnetometer within the high-gradient electromagnetic field. This periodic signal (~0.35 Hz), was successfully identified and removed with a low-pass filter in the frequency domain, resulting in measurements of industry standard quality. Filtering is a necessary step to avoid contaminating signals originating from sub-surface magnetic targets with swinging noise. The flight speed modulates the swinging frequency into varying wavelengths in the TMI profiles. This relationship must be considered in order to avoid removing important target signals at those wavelength scales during the filtering process.

[Paper 24] **MX-1: A New Multi-Modal Remote Sensing UAS Payload with High Accuracy GPS and IMU**, Daniel Kaputa, Timothy Bauch, RIT (USA); Carson Roberts, Headwall Photonics (USA); Don McKeown, Mark Foote, Carl Salvaggio, RIT (USA)

or drones have captured the imagination of a new generation of developers that see these systems as disruptive technologies that can completely transform entire markets. Due to their low cost, ease of use, and unprecedented spectral, spatial, and temporal resolutions, remote sensing is one such market that is being transformed by these revolutionary new devices. As sensors become smaller and UAV payload capacities increase, the researcher has the ability to create various sensing payload combinations. This is very fortuitous as for many research projects the simultaneous collection of multiple sensing modalities is required. By collecting all modalities simultaneously and in a single flight, one can collect data with the same weather conditions and light levels, thus increasing the veracity of the data. The multi-modal payload approach also eliminates the need to change gimbals in the field and reduces wear and tear on the equipment due to multiple payload changes. This article outlines the development of the MX-1 UAV-capable payload which was a joint development between the Rochester Institute of Technology Department of Imaging Science and Headwall Photonics. MX-1 is a revolutionary new multi-modal remote sensing UAV payload that allows for simultaneous collection of four different imaging modalities namely RGB, LWIR, LiDAR and Hyperspectral.

SESSION 6

FOREST APPLICATIONS OF UAS

[Paper 13] **Ground classification algorithm sensitivity analysis using digital aerial photogrammetry over conifer forest stands**, Alex Graham, University of British Columbia (Canada)

Analysis of forest structure can be conducted using imagery captured by unmanned aerial systems (UAS) and the subsequent generation of dense point clouds through recent advancements in Structure from Motion (SfM) algorithms, a process known as digital aerial photogrammetry (DAP). A drawback of DAP is the limited capacity to produce accurate digital elevation models (DEM) in complex forested environments. The task of correctly identifying ground-points is known to be challenging in complex terrain covered by vegetation. In this study, a DJI Phantom IV was flown over three ~100 ha forested areas within temperate conifer forest stands of central British Columbia, Canada. Using 1 ha sample areas stratified into classes of terrain slope, a sensitivity analysis was conducted on three ground classification algorithms designed for use on point clouds generated from airborne laser scanning (ALS). The algorithms tested were progressive triangulated irregular network (TIN) densification (PTD), hierarchical robust interpolation (HRI) and simple progressive morphological filtering (SMRF). Algorithm parameters were varied systematically in order to establish optimal parameterizations given the study area characteristics. Once DAP ground-points were established from each classification algorithm, the points were converted to a TIN from which a 1 m x 1m DEM was extracted. Using root mean square error (RMSE), DAP derived DEM surfaces were compared to reference ground-points.

[Paper 26] **Shadow Detection in Aerial and UAS data Using Neural Networks,** Prasanna Reddy Pulakurthi, Emmett Ientilucci, RIT (USA)

Shadows are present in a wide range of images, from forested scenes to urban environments. The presence of shadows degrades the performance of computer vision algorithms in a diverse set of applications such as image registration, object segmentation, object detection and recognition. Therefore, detection and mitigation of shadows is of paramount importance and can significantly improve the performance of computer vision algorithms in the aforementioned applications. Several shadow detection algorithms have been proposed in the literature over the years predominantly based on color space transformations. A recent approach, to be illustrated in this presentation, involves the utilization of a neural network (NN). This network is initially trained using synthetic shadow data created from the Digital Imaging and Remote Sensing Image Generation (DIRSIG) model. We additionally augment the training of the DIRSIG model with some shadow data from the image under test. In this presentation, we will show results using aerial urban and UAS collected imagery. Results show improvement using the augmented model over the chromaticity method or DIRSIG model alone.

POSTERS

[Poster 08] **Study of Harmful Algae Blooms Using UAS Imagery**, Peter Spacher, Ileana Dumitriu, John Halfman, Hobart and William Smith Colleges (USA); Lisa Cleckner, Finger Lakes Institute (USA)

Harmful Algal Blooms (HABs) occurrence has increased in recent decades. The transient nature of HABs in both space and time result in monitoring challenges, which add to the difficulty in understanding the criteria that trigger HABs. Traditional monitoring programs are expensive and time consuming. The use of UAS (Unmanned Aerial Systems) assures high-resolution space and time monitoring for HABs, and is economical for small bodies of water. By using UAS (Matrice100 and Phantom3) we obtained aerial photographs of eight Finger Lakes which span the oligotrophic to eutrophic spectrum of algal productivity. Water samples were collected and analyzed simultaneously. Preliminary comparison between the Green/Blue (G/B) ratio extracted from the aerial photos was proportional to chlorophyll-a data. The algal pigments are also characterized by unique light absorbance and reflectance features, and spectral images obtained from two up-down visible spectrometers revealed a prominent feature ~790 nm which correlates to the concentration of algae in the lake water.

[Poster 18] **Evaluation of UAS imagery for forest regeneration surveys**, Muhammet Ali Ozderya Eddie Bevilacqua, SUNY ESF (USA)

Accurate and reliable methods of assessing forest regeneration success are necessary to improve forest inventories and assist management decisions. Unmanned aerial systems (UAS) offer the potential to provide timely and cost-effective data of forest regeneration status for research and management applications. This research evaluates the effectiveness of using high spatial resolution UAS imagery to assess the abundance and structure of forest regeneration. Specifically, the size distribution of young Norway spruce (Picea abies) trees derived from digital aerial photogrammetric were compared to complete a census of trees from field measurements. Results indicate that UAS-acquired imagery has a potential to provide quick, accurate, and reliable highly detailed structural information on forest regeneration.

[Poster 20] **Evaluation of UAS imagery for aboveground biomass assessment in mature forests,** Mehmet Ozen, Eddie Bevilacqua, SUNY ESF (USA)

The main purpose of this study is to evaluate the potential improvements in forest biomass estimation studies by using commercially accessible and affordable Unmanned Aerial System (UAS) imagery. For this purpose, total aboveground biomass quantified by: field enumeration of aboveground biomass is completed for all individuals in a Norway Spruce (Picea abies) plantation, obtaining UAV imagery from over the plantation, indirect estimations of tree size distribution data obtained from the imagery, after that, creating a correlation between ground measurements and imagery information.

SESSION 7

SPECIAL INVITED TALKS

[Talk 29] **UAV's Impact on Secondary Education in Precision Agriculture**, Mark Mancari, Perry Central School District (USA)

How can we involve high school students in meaningful research? Research that requires cross curriculum cooperation. Research that provides new and relevant information to key stakeholders, businesses, universities, and community organizations in the local area/region. We believe use of UAVs to conduct research related Precision Agriculture and Environmental Science can allow students to have a meaningful interaction and a positive impact in their local community all while learning and applying 21st century skills. Our Precision Agriculture program has been under constant development since the debut of the pilot program in 2016. Now in our third year we are developing processes that will allow us to conduct soil samples analysis with industry grade equipment. We will also use VRT seeding/treatments maps, yield maps, and schedule UAV NDVI data collects. Once all of this data is collected a comprehensive dynamic report can be created using a GIS system. This report will be presented and given to the participating farmer so they can to determine effectiveness of their management practices. In the past three years we have received tremendous support from the local and region community, business, and educational entities which has enabled us to increase our capabilities at a rapid pace. We are grateful for all the support we have received and for the partners we have.

[Talk 28] **UAS Safety, and the Role of the Flight Standards District Office**, Robert Lacourse, Federal Aviation Administration (FAA) (USA)

The talk will be centered around FSDO role in UAS safety. To include an update of current new rules, and types/levels of compliance programs

SESSION 8

WATER APPLICATIONS OF UAS

[Talk 05] **Real-time, sUAS-based detection of grapevine water status in the Finger Lakes Wine Country of Upstate New York**, Rinaldo Izzo, RIT (USA); Alan Lasko, Cornell University (USA); Evan Marcellus, Tim Bauch, Nina Raqueño Jan van Aardt, RIT (USA)

The quality of grapes in the production of wine is highly influenced by vine water status, where optimal water deficits improve berry composition for higher quality product. Rapid advancement in small unmanned aerial system (sUAS) technology has empowered the potential application of real-time, high-spatial resolution hyperspectral imagery for optimal irrigation scheduling and harvest timing in vineyards. This study seeks to further sUAS hyperspectral imagery as a tool to model water status in a commercial vineyard in the Finger Lakes wine region of Upstate New York. High-spatial resolution (2.5 cm ground sample distance) hyperspectral data were collected in the visible/near-infrared regime on three flight days. A Scholander pressure chamber was used to directly measure the midday stem water potential (ψstem) within imaged vines at the time of flight. High spatial resolution pixels enable the targeting of pure (sunlit) vine canopy with vertically trained shoots and significant shadowing. We used partial least squares regression (PLS-R) to correlate our hyperspectral imagery with measured field water status, to enable dimensionality reduction and to avoid the problem of multicollinearity. Optimization techniques were employed for wavelength band selection and outlier detection. Regression results indicated R2 fit of greater than 0.9 and performance was further verified via k-folds cross-validation with R2 of greater than 0.8. Variable Importance in Projection (VIP) scores were utilized to establish spectral regions of importance. We will present more comprehensive results and postulate on the use of sUAS platforms as an affordable, reliable vineyard management tool.

[Talk 06] **Preliminary Testing of the senseFly thermoMAP Infrared Camera for Surface Water Temperature Measurements of a Small Lake - Wilmot, Ontario, Canada**, Marie Hoekstra, Marzieh Foroutan, University of Waterloo (Canada); Kevin Kang, H2O Geomatics Inc. (Canada); Claude Duguay, University of Waterloo (Canada)

Small lake systems are a critical part of regional hydrology and ecology throughout Canada and are easily influenced by many physical processes. As the effects of climate change continue to threaten inland water ecosystems, small lakes provide an invaluable opportunity for environmental monitoring. This task is made difficult by various limitations including a lack of historical in-situ measurements, and the coarse spatial and temporal resolution of most satellite data. Unmanned Aerial Systems (UAS) fill the critical gap between satellite imagery and field measurements, allowing for high spatial and temporal resolution surveying of these small water bodies. Though these systems show promise, few studies have employed them over water leaving uncertainties about the reliability of data collected. Our team has employed the senseFly thermoMAP thermal infrared camera onboard the eBee Plus fixed-wing UAV (unmanned aerial vehicle) to study Sunfish Lake, a small glacial lake located in Wilmot, Ontario, Canada. This work compares surface water temperature measured by the thermoMAP system with water temperature measured using HOBO TidbiT sensors deployed on multiple buoys in the lake, as well as with a YSI water quality sonde. Preliminary results show some discrepancies between datasets, with the thermoMAP reporting temperatures ± ~3 °C different from field measurements. These discrepancies are hypothesized to be related to the time of day as well as season, and to be a reflection of the highly responsive nature of lake surface skin to changes in temperature and/or incoming solar radiation.

[Talk 23] **Glint Correction of Unmanned Aerial System Imagery**, Ryan Ford and Anthony Vodacek, RIT (USA)

Glint in high spatial resolution imagery captured by Unmanned Aerial Systems (UAS) cannot be corrected by methods developed for space-based imaging systems, requiring new approaches. Two processes were developed augmenting the Empirical Line Method (ELM) for atmospheric compensation using in-situ radiometric data in order to remove glint from UAS imagery. The results of this correction were compared to in-situ spectroradiometer and atmospherically compensated satellite measurements which showed good agreement. The RMSE of the UAS retrieved spectrum was as low as 0.0004 1/sr and outperformed the traditional panel-based ELM.

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