Carl Salvaggio, Ph.D.

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Introduction

In the Chester F. Carlson Center for Imaging Science at the Rochester Institute of Technology, I hold the position of Full Professor. I teach and conduct research in image processing, computer vision, remote sensing, and scientific computing. My research interests address the development of solutions to applied, real-world, problems utilizing the appropriate imaging modalities and algorithmic approaches. My expertise are in thermal infrared imaging, phenomenology, exploitation, and simulation; design and implementation of novel imaging and ground-based measurement systems; three-dimensional geometry extraction from multi-view imagery; material optical properties measurement and modeling; radiometric and geometric calibration of imaging systems; still and motion image processing and machine/deep learning for various applications.

I serve as the Director of the Digital Imaging and Remote Sensing Laboratory. I also hold the position of Principal Investigator for the Signature Interdisciplinary Research Areas/Center for Unmanned Aircraft Systems Research at the Rochester Institute of Technology. My primary role in this organization is the development of novel radiometric and geometric calibration approaches for small unmanned aerial systems, as well as the facilitation of an interdisciplinary team of over 20 academic/applied researchers both in the development of sensing technologies as well as the use of these systems to find solutions to problems in precision agriculture, infrastructure and facility inspection, as well as novel uses of computer vision for guidance and discovery.

Career

2002 – present **Rochester Institute of Technology** / Professor and Director of the Digital Imaging and Remote Sensing (DIRS) Laboratory

1997 – 2005 **Imagery Solutions, Incorporated** / President and Principal Scientist

1996 – 2000 **MRJ Technology Solutions** / Principal Engineer

1994 – 1996 **Hughes Aircraft Company** / Scientist-Engineer

1986 – 1994 **Rochester Institute of Technology** / Research Scientist and Instructor

1983 – 1985 **Central Intelligence Agency** / Photographic Engineer

Education

1994 **State University of New York, College of Environmental Science and Forestry** / Ph.D. in Environmental Resource Engineering
Thesis title: *Multispectral synthetic scene generation using atmospheric propagation and thermodynamic models*

1987 **Rochester Institute of Technology, Chester F. Carlson Center for Imaging Science** / M.S. in Imaging Science
Thesis title: *Automated segmentation of urban features from Landsat Thematic Mapper imagery for use in pseudoinvariant feature temporal image normalization*

Rochester Institute of Technology, Chester F. Carlson Center for Imaging Science / B.S. in Imaging Science

Publications

Submitted / In Review

1. R. J. Connal, D. J. Walvoord, I. Rosario, M. G. Ross, T. D. Bauch, N. G. Raqueno, B. P. d'Entremont, A. J. Garrett, and C. Salvaggio, "Assessing the efficacy of deep learning architectures in the segmentation of condensed water vapor plumes," *submitted to* IEEE Transactions on Geoscience and Remote Sensing.
2. A. X. Mason, J. A. Irizarry, B. K. Eng, M. G. Saunders, A. A. Goodenough, S. D. Brown, and C. Salvaggio, "Demonstration of the feasibility of using synthetically generated condensed water vapor plume imagery to train an AI model to automatically segment real imagery," *submitted to* Synthetic Data for Artificial Intelligence and Machine Learning: Tools, Techniques, and Applications II, SPIE Defense + Commercial Sensing 2024.
3. G. G. Peters, S. D. Couwenhoven, D. J. Walvoord, and C. Salvaggio, "Application specificity of data for pre-training in computer vision," *submitted to* Disruptive Technologies in Information Sciences VIII, SPIE Defense + Commercial Sensing 2024.

Theses

1. C. Salvaggio, "Multispectral synthetic scene generation using atmospheric propagation and thermodynamic models," Ph.D. Dissertation, State University of New York, College of Environmental Science and Forestry, Syracuse, New York, United States of America, 1994.
2. C. Salvaggio, "Automated segmentation of urban features from Landsat Thematic Mapper imagery for use in pseudoinvariant feature temporal image normalization," M.S. Thesis, Rochester Institute of Technology, College of Science, Center for Imaging Science, Rochester, New York, United States of America, 1987.

Journal Articles

1. L. J. DeCoffe, D. N. Conran, T. D. Bauch, M. G. Ross, D. S. Kaputa, and C. Salvaggio, "Initial performance analysis of the at-altitude radiance ratio method for reflectance conversion of hyperspectral remote sensing data," *Sensors*, vol. 23, no. 1, p. 320, 2023. DOI: `https://doi.org/10.3390/s23010320`.
2. Y. Lu, Y. Wang, Z. Chen, A. Khan, C. Salvaggio, and G. Lu, "3D plant root reconstruction based on fusion of deep structure-from-motion and IMU," *Journal of Multimedia Tools and Applications*, vol. 80, no. –, pp. 17 315–17 331, Jan. 2021. DOI: `https://doi.org/10.1007/s11042-020-10069-3`.
3. D. S. Kaputa, T. D. Bauch, C. Roberts, D. McKeown, M. Foote, and C. Salvaggio, "MX-1: A new multi-modal remote sensing UAS payload with high accuracy GPS and IMU," *IEEE Xplore*, pp. 1–4, May 2019. DOI: `https://doi.org/10.1109/STRATUS.2019.8713292`.
4. B. G. Mamaghani and C. Salvaggio, "Comparative study of panel and panelless-based reflectance conversion techniques for agricultural remote sensing," *American Journal of Agricultural Science*, vol. 6, no. 4, pp. 40–58, Nov. 2019.
5. B. G. Mamaghani and C. Salvaggio, "Multispectral sensor calibration and characterization for sUAS remote sensing," *Sensors*, vol. 19, no. 20, pp. 4453–4482, Oct. 2019. DOI: `https://doi.org/10.3390/s19204453`.
6. B. G. Mamaghani, M. G. Saunders, and C. Salvaggio, "Inherent reflectance variability of vegetation," *Agriculture*, vol. 9, no. 11, pp. 246–270, Nov. 2019. DOI: `https://doi.org/10.3390/agriculture9110246`.
7. R. Kemker, C. Salvaggio, and C. Kanan, "Algorithms for semantic segmentation of multispectral remote sensing imagery using deep learning," *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 145, pp. 60–77, Nov. 2018. DOI: `https://doi.org/10.1016/j.isprsjprs.2018.04.014`.

8. M. Yousefhussien, D. J. Kelbe, E. J. Ientilucci, and C. Salvaggio, "A multi-scale fully convolutional network for semantic labeling of 3D point clouds," *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 143, pp. 191–204, Mar. 2018. DOI: https://doi.org/10.1016/j.isprsjprs.2018.03.018.

9. M. Mahdavi, C. Kanan, and C. Salvaggio, "Roof damage assessment using deep learning methods," *IEEE Xplore*, pp. 1–8, Oct. 2017. DOI: https://doi.org/10.1109/AIPR.2017.8457946.

10. T. R. McKay, C. Salvaggio, J. W. Faulring, and G. Sweeney, "Remotely detected vehicle mass from engine torque-induced frame twisting," *Optical Engineering*, vol. 56, no. 6, pp. 063101–1–063101–8, Jun. 2017. DOI: https://doi.org/10.1117/1.OE.56.6.063101.

11. T. D. Carson, C. M. Bachmann, and C. Salvaggio, "Soil signature simulation of complex mixtures and particle size distributions," *Optical Engineering*, vol. 54, no. 9, pp. 094103–1–094103–10, Sep. 2015. DOI: https://doi.org/10.1117/1.OE.54.9.094103.

12. T. D. Carson and C. Salvaggio, "Soil signature simulation in the thermal infrared," *Optical Engineering*, vol. 54, no. 10, pp. 104102–1–104102–6, Oct. 2015. DOI: https://doi.org/10.1117/1.OE.54.10.104102.

13. D. R. Nilosek, D. J. Walvoord, and C. Salvaggio, "Assessing geoaccuracy of structure from motion point clouds from long-range image collections," *Optical Engineering*, vol. 53, no. 11, pp. 113112–1–113112–10, Nov. 2014. DOI: https://doi.org/10.1117/1.OE.53.11.113112.

14. S. Sun and C. Salvaggio, "Aerial 3D building detection and modeling from airborne LiDAR point clouds," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 6, no. 3, pp. 1440–1449, Jun. 2013. DOI: https://doi.org/10.1109/JSTARS.2013.2251457.

15. J. A. van Aardt, D. McKeown, J. W. Faulring, N. G. Raqueno, M. V. Casterline, C. Renschler, R. Eguchi, D. W. Messinger, R. S. Krzaczek, S. Cavillia, J. Antalovich, N. Philips, B. D. Bartlett, C. Salvaggio, E. M. Ontiveros, and S. Gill, "Geospatial disaster response during the Haiti earthquake: A case study spanning airborne deployment, data collection, transfer, processing, and dissemination," *Photogrammetric Engineering and Remote Sensing*, vol. 77, no. 9, pp. 943–952, Sep. 2011. DOI: https://doi.org/10.14358/PERS.77.9.943.

16. B. D. Bartlett, M. G. Gartley, D. W. Messinger, C. Salvaggio, and J. R. Schott, "Spectro-polarimetric bidirectional reflectance distribution function determination of in-scene materials and its use in target detection applications," *Journal of Applied Remote Sensing*, vol. 4, no. 043552, pp. 1–21, Nov. 2010. DOI: https://doi.org/10.1117/1.3518394.

17. D. R. Nilosek and C. Salvaggio, "Applying computer vision techniques to perform semi-automated analytical photogrammetry," *IEEE Xplore*, pp. 1–5, Nov. 2010. DOI: https://doi.org/10.1109/WNYIPW.2010.5649777.

18. J. P. Kerekes, K. E. Strackerjan, and C. Salvaggio, "Spectral reflectance and emissivity of man-made surfaces contaminated with environmental effects," *Optical Engineering*, vol. 47, no. 10, pp. 106201/1–106201/10, Oct. 2008. DOI: https://doi.org/10.1117/1.3000433.

19. D. W. Messinger, C. Salvaggio, and N. M. Sinisgalli, "Detection of gaseous effluents from airborne LWIR hyperspectral imagery using physics-based signatures," *International Journal of High Speed Electronics and Systems (IJHSES)*, vol. 17, no. 4, pp. 801–812, 2007. DOI: https://doi.org/10.1142/S0129156407004990.

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1 L. J. DeCoffe, D. N. Conran, R. J. Connal, T. D. Bauch, N. G. Raqueño, and C. Salvaggio, "Error characterization of the at-altitude radiance ratio method for reflectance conversion of remote sensing data," in *Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping VII*, SPIE, vol. 12114, 2022, pp. 89–106.

2 J. Osterberg, T. Bauch, N. Raqueño, I. Rosario, and C. Salvaggio, "Machine learning based MTF estimation system evaluation utilizing slanted-edge targets in sUAS scenes," in *Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping VII*, SPIE, vol. 12114, 2022, pp. 107–119.

3 R. J. Connal, W. R. Pines, M. E. Borek, T. D. Bauch, N. G. Raqueno, B. d'Entremont, A. J. Garrett, and C. Salvaggio, "Utilizing Mask R-CNN for automated segmentation of condensed water vapor plumes from multi-view imagery," in *Proceedings of the SPIE, SPIE Optical Engineering + Applications, Applications of Machine Learning*, vol. 11843, San Diego, California, United States, Aug. 2021, pp. 1184309-1–1184309-13.

4 S. Khan, A. Lang, and C. Salvaggio, "Identify seismically vulnerable unreinforced masonry buildings using deep learning," in *Proceedings of the SPIE, SPIE Optical Engineering + Applications, Applications of Machine Learning*, vol. 11843, San Diego, California, United States, Aug. 2021, pp. 118430V-1–118430V-19.

5 S. Khan and C. Salvaggio, "Automatically gather address specific dwelling images using Google Street View," in *25th International Conference on Pattern Recognition, ICPR2020, Computer Vision*, Milano, Lombardia, Italy, Jan. 2021.

6 W. Pines, R. LaClair, C. Willey, B. Mamaghani, and C. Salvaggio, "Automated calibration pipeline for agricultural sUAS based remote sensing," in *Proceedings of the SPIE, Defense + Commercial Sensing, Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping VI, Maximizing Accuracy in UAV Remote-Sensing Data*, vol. 11747, Orlando, Florida, United States, 2021, pp. 1–20.

7 J. A. van Aardt, C. Salvaggio, T. D. Bauch, and N. G. Raqueno, "Unmanned aerial systems (UAS) and their precision agriculture applications - select case studies," in *Proceedings of the 3rd Annual Precision Agriculture Forum*, Franklin & Grant Isle Farmer's Watershed Alliance (FWA), Saint Albans, Vermont, United States, Mar. 2020.

8 M. Helvey, M. Ryckman, S. Ellis-Felge, J. A. van Aardt, and C. Salvaggio, "Duck nest detection through remote sensing," in *IGARSS 2020, UAV and Airborne Platforms Applications I, Mission, Sensors and Calibration*, Waikoloa, Hawaii, United States, Sep. 2020.

9 A. Soni, A. C. Loui, S. D. Brown, and C. Salvaggio, "High-quality multispectral image generation using conditional GANs," in *Proceedings of the IS&T, International Symposium on Electronic Imaging 2020, Imaging and Multimedia Analytics in a Web and Mobile World*, Burlingame, California, United States, 2020, pp. 086-1–086-6.

10 Y. Lu, S. Kourian, C. Salvaggio, C. Xu, and G. Lu, "Single image 3D vehicle pose estimation for augmented reality," in *IEEE Global Conference on Signal and Information Processing (GlobalSIP), GlobalSIP 2019, Image and Video Processing I*, Ottawa, Ontario, Canada, Nov. 2019, pp. 1–5.

11 J. A. van Aardt, E. Hughes, S. Pethybridge, J. Kikkert, and C. Salvaggio, "Transforming disease management through the use of unmanned aerial systems," in *International Congress of Plant Pathology (ICPP) 2018: Plant Health in A Global Economy*, vol. 108, Boston, Massachusetts, United States, 2018.

12 M. S. Accettura, T. D. Bauch, N. G. Raqueno, J. Mallia, and C. Salvaggio, "Hyperspectral detection of methane stressed vegetation," in *Proceedings of the SPIE, Commercial + Scientific Sensing and Imaging, Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping III, Thermal and Hyperspectral Imaging from UAVs*, vol. 10664, Orlando, Florida, United States, 2018, pp. 106640I-1–106640I-13.

13 E. Hughes, S. Pethybridge, J. Kikkert, C. Salvaggio, and J. A. van Aardt, "Snap bean flowering detection from UAS imaging spectroscopy," in *14th International Conference on Precision Agriculture*, Montreal, Quebec, Canada, 2018.

14 B. G. Mamaghani, G. V. Sasaki, R. J. Connal, K. Kha, J. S. Knappen, R. A. Hartzell, E. D. Marcellus, T. D. Bauch, N. G. Raqueno, and C. Salvaggio, "An initial exploration of vicarious and in-scene calibration techniques for small unmanned aircraft systems," in *Proceedings of the SPIE, Commercial + Scientific Sensing and Imaging, Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping III, Collecting Reliable Image Data with UAVs*, vol. 10664, Orlando, Florida, United States, 2018, pp. 1066406-1–1066406-20.

15 P. Sponagle and C. Salvaggio, "Automatic mission planning algorithms for aerial collection of imaging-specific tasks," in *Proceedings of the SPIE, Commercial and Scientific Sensing and Imaging, Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping II, Control Systems and Artificial Intelligence in Agricultural UAV Applications*, vol. 10218, Anaheim, California, United States, 2017, pp. 1021807-1–1021807-13.

16 C. Zhang, T. Nguyen, S. Sah, R. Ptucha, A. Loui, and C. Salvaggio, "Batch-normalized recurrent highway networks," in *2017 IEEE International Conference on Image Processing (ICIP)*, Beijing, Chaoyang District, China, Sep. 2017, pp. 640–644.

17 C. Zhang, S. Sah, T. Nguyen, D. Peri, A. Loui, C. Salvaggio, and R. Ptucha, "Semantic sentence embedding for paraphrasing and text summarization," in *IEEE Global Conference on Signal and Information Processing (GlobalSIP), GlobalSIP 2017, Knowledge-based Multimedia Computing*, Montreal, Quebec, Canada, Nov. 2017, pp. 1–5, ISBN: 978-1-5090-5990-4.

18 E. Bondi, C. Salvaggio, M. Montanaro, and A. D. Gerace, "Calibration of UAS imagery inside and outside of shadows for improved vegetation index computation," in *Proceedings of the SPIE, Defense + Commercial Sensing, Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping, Unmanned Aerial Vehicles in Precision Agriculture*, vol. 9866, Baltimore, Maryland, United States, 2016, 98660J-1–98660J-7.

19 T. D. Carson and C. Salvaggio, "Signature simulation of mixed materials," in *Proceedings of the SPIE, Defense + Security 2015, Active and Passive Signatures VI*, ser. Active and Passive Signatures, vol. 9461, Baltimore, Maryland, United States, Apr. 2015, 94611J-1–94611J-11.

20 A. M. Geniviva, J. W. Faulring, and C. Salvaggio, "Automatic georeferencing of imagery from high-resolution, low-altitude, low-cost aerial platforms," in *Proceedings of SPIE, Defense + Security, Geospatial InfoFusion and Video Analytics IV, Geospatial Data Processing, Exploitation, and Visualization I*, vol. 9089, Baltimore, Maryland, United States, May 2014.

21 K. N. Salvaggio, C. Salvaggio, and S. Hagstrom, "A voxel-based approach for imaging voids in three-dimensional point clouds," in *Proceedings of SPIE, Defense + Security, Geospatial InfoFusion and Video Analytics IV, Geospatial Data Processing, Exploitation, and Visualization I*, vol. 9089, Baltimore, Maryland, United States, Apr. 2014.

22 J. P. Kerekes, M. G. Gartley, C. DeAngelis, C. Salvaggio, C. Gittens, M. Costolo, and B. Cosofret, "Measurements and modeling of LWIR spectral emissivity of contaminated quartz sand," in *Workshop on Hyperspectral Image and Signal Processing, Evolution in Remote Sensing, Workshop on Hyperspectral Image and Signal Processing, Thermal Hyperspectral Imaging*, Gainesville, Florida, United States, Jun. 2013, pp. 1–4.

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26 E. M. Ontiveros, C. Salvaggio, D. R. Nilosek, N. G. Raqueno, and J. W. Faulring, "Evaluation of image collection requirements for 3D reconstruction using phototourism techniques on sparse overhead data," in *Proceedings of SPIE, SPIE Defense and Security Sensing, Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XVIII, Modeling and Simulation*, vol. 8390, Baltimore, Maryland, United States, 2012.

27 A. J. Rossi, H. E. Rhody, C. Salvaggio, and D. J. Walvoord, "Abstracted workflow framework with a structure from motion application," in *Western New York Image Processing Workshop*, Rochester, New York, United States, Nov. 2012, pp. 1–4.

28 S. Sun and C. Salvaggio, "Complex building roof detection and strict description from LiDAR data and orthorectified aerial imagery," in *Proceedings of IEEE, IGARRS 2012, Analysis Techniques: Image Processing Techniques, Feature Detection in Images*, Munich, Germany, Jul. 2012.

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Funding – $9,765,989

pending — **Savannah River National Laboratory / United States Department of Energy** / *Analysis of Data from Cooling Tower Plume* / RIT Project #xxxxx / $446,973 / DOE NA-22 has awarded additional funds to create a cooling tower discharge tool with the results of prior research. The life cycle plan for this work proposes additional work on the Savannah River National Laboratory's model and additional work to generalize the image processing techniques developed by RIT to be easily applied to new cooling tower sites and new camera systems. The objective of the project is a software tool that can ingest imagery and produce plume volume and dissipated power estimates.

20200221 – 20230521 — **Savannah River National Laboratory / United States Department of Energy** / *Mechanical Draft Cooling Tower Water Vapor Plume Volume Estimation* / RIT Project #32529 / $751,226 / RIT will develop, evaluate, and deploy an imaging system (ground-based and/or small unmanned aircraft-based) along with a computer vision/image processing-based analysis system to determine the volume of a water vapor plume. This project will carry out a long-term collection campaign where data will be gathered under seasonal variations and used to guide the development of processing algorithms and testing the efficacy of the system to predict plant operating characteristics.

Funding – $9,765,989 (continued)

20200901 – 20221231

L3Harris Corporation / *Trilobyte Autonomous Learning for Full-Spectrum Simulations* / RIT Project #37218 / $284,694 / RIT will generate valuable multimodal sUAS-based image data of a single scene. RIT will generate a corresponding DIRSIG scene and accompanying synthetic image data for training using deep learning techniques used in prior research to automatically build and label a synthetic scene.

20190610 – 20200630

L3Harris Corporation / *Deep Learning Data Integrity* / RIT Project #37149 / $123,500 / RIT has three goals in this project; to 1) generate valuable multimodal sUAS-based image data of a single scene, 2) generate a corresponding DIRSIG scene and accompanying synthetic image data for training, and to 3) test, evaluate, and understand the following deep learning activities; a) generative adversarial networks to simulated real scenes from DIRSIG simulations, and b) semantic segmentation using synthetically-augmented training data.

20160201 – 20210131

Rochester Institute of Technology / *Signature Interdisciplinary Research Areas - Center for Unmanned Aircraft Systems Research* / RIT Project #62434.15920 / $1,000,000 / The Center is built off of existing unique infrastructure and capabilities in the unique and very strong Imaging Science program in the College of Science and the Aeronautical Engineering program in the College of Engineering to create a Research Center in UAS-based imaging and operations that is second to none. Other RIT entities such as Public Policy in the College of Liberal Arts and Mechanical Engineering Technology in the College of Applied Science and Technology provide a well rounded view of this emerging technology area. The Unmanned Aircraft System (UAS) research center is focused on 1) the capture and processing of multi-modal image data from UAS for various applications, 2) collision avoidance and anti-drone technology for safer UAS operations, and 3) public policy with emphasis on privacy and economic impact.

20170515 – 20200514

Harris Corporation / *Infrastructure and Agricultural Monitoring Using UAS Imaging* / RIT Project #37038 / $247,500 / RIT will study and construct an end-to-end data processing pipeline that considers data capture thru information product generation. Harris Corporation has multiple system components such as OneButton, ENVI, Jagwire, etc. that will be studied for inclusion in the processing system pipeline. The project will also target specific applications focused on using UAS for infrastructure and agricultural monitoring as a means of evaluating the efficacy of UAS while jointly assessing the business potential and opportunities for Harris Corporation.

Funding – $9,765,989 (continued)

20170315 – 20190314

United States Department of Agriculture (USDA) / Cornell University / *Transforming White Mold Management in Snap Beans Through Remote Sensing* / RIT Project #31788 / $148,440 / RIT will support Cornell University in their study of remote sensing applied to the monitoring of disease in snap beans. Snap beans are the fifth largest vegetable crop nationally in terms of acreage. Last year, there were 158,920 acres harvested for processing and 71,170 acres harvested for fresh market, with a combined value of $416 million. New York ranks second in both processing (20,420 acres planted) and fresh market (10,200 acres planted) production. White mold caused by the fungus, Sclerotinia sclerotiorum is amongst the most devastating and recalcitrant plant diseases worldwide, and results in substantial annual losses to snap bean production across the United States. This project offers a unique multi-disciplinary approach to reducing crop loss from white mold in snap beans by improved detection of spectral signatures associated with phenological development to optimize the efficacy of tools currently available to growers. The outcomes will be immediately available for adoption by growers through enhanced utilization of existing technologies. The involvement of stakeholders and extension personnel in the inception and incubation of this project and continuing support by service in an advisory group role will ensure that robust digital tools and delivery platforms are identified and successfully integrated into future farming practices. This project will enhance the capacity of farmers to effectively capture the rapid advances recently made in the imaging sciences and precision agriculture for economic growth.

20170415 – 20180328

NYSEARCH / Northeast Gas Association / *Small Unmanned Aerial Systems (sUAS) Gas Infrastructure Inspection Research* / RIT Project #37003 / $110,000 / RIT will conduct a series of investigations that are foundational to the development of automated processes for inspecting gas transmission infrastructure using small Unmanned Aerial Systems (sUAS)-based imaging and image processing techniques.

20160601 – 20171231

Property Drone Consortium / *Drone-Based Roof Inspection Research* / RIT Project #36983 / $187,893 / RIT will conduct a series of investigations that are foundational to the development of automated processes for determining roof health and for mapping defects using imaging and image processing techniques. Roofs can be relatively complex geometric structures constructed with a variety of materials. To make this a more tractable problem, the proposed research investigations will focus on residential buildings with gable roofs and asphalt shingles. Specifically the research will focus on understanding the phenomenology of various roof defects, identifying possible imaging techniques to detect those defects, and developing processing approaches to extract the desired information.

20160701 – 20170630

New York State - NYSTAR / University of Rochester - Center for Electronic Imaging Science / *Video Analysis and Summarization Research* / RIT Project #33692 / $11,378 / A cost-share project to 36963 under which RIT will obtain a high-performance computational machine capable of performing the training necessary for the deep learning aspects of the video segmentation process.

Funding – $9,765,989 (continued)

20151101 – 20171031

Kodak Alaris / *Video Analysis and Summarization Research* / RIT Project #36963 / $172,353 / RIT will advance the state-of-the-art in the areas of video content understanding and summarization through this effort. The goal of this research is to propose and validate a unified video analytics framework for automatically processing, analyzing, segmenting, and summarizing "unstructured" and "unrestricted" consumer videos published to the internet (YouTube, Facebook, etc). This research will also investigate and prototype new video and multimedia applications using the proposed framework and related algorithms developed.

20140813 – 20170812

Central Intelligence Agency IC Post Doctorate Fellowship Program (FY14) / *A three-dimensional visualization environment for archival and synthetic imagery to aid in analysis and tasking* / RIT Project #31478 / $360,000 / This fellowship will focus on the inclusion on three-dimensional models extracted from LiDAR or dervived from multiple-view imagery into a geographically-based visualization system for utilization by analysts in planning and exploitation scenarios. Existing geographically-tagged image products will be registered to the base imagery in these visualization systems so that they are available as applied texture to the created geometry using multimodal registration of disparate data sets (visible, NIR, SWIR, emissive infrared, maps, and charts) using techniques such as maximum mutual information (MMI). The geometries will be attributed with optical, thermodynamic, and RADAR properties so that the key parameters are in place to generate synthetic imagery under any temporal, meteorological, and geometric conditions collected with any of the currently available imaging modalities available in the Digital Imaging and Remote Sensing Image Generation (DIRSIG) simulation environment. The intent of this research is to create an integrated environment from which the currently "browsed" geometry may be either visualized using existing imagery or synthetically-derived imagery under analyst specified conditions. |

20140215 – 20170131

National Science Foundation / *NSF REU: Imaging in the Physical Sciences* / RIT Project #31421 / $273,044 / The NSF REU Program Imaging in the Physical Science (IPS) is a new proposed by the Chester F. Carlson Center for Imaging Science (CIS) at Rochester Institute of Technology (RIT). CIS is a highly interdisciplinary University Research and Education Center, dedicated to pushing the frontiers of imaging in all of its forms and users. THE IPS REU program will introduce young scientists to research in a highly interdisciplinary environment, where cross-disciplinary team problem solving is the norm. The IPS REU has the following seven specific goals: i) Involve undergraduates from very diverse majors (starting as early as summer after their freshmen or sophomore years in college) in a 10-week long coherent research experience in an interdisciplinary environment, while enabling them to produce scientific results of international caliber, ii) Involve undergraduates in problem-based research, encouraging them to think across boundaries and between fields. Encouraging students to understand how innovation and creativity can be strong tools for scientific research; iii) Specifically reach out the Deaf or Hard of Hearing students to develop an understanding of how to provide the community an engaging and welcoming arena in which to engage in STEM research opportunities; iv) Understand how to interact with Native Americans who may be key candidates to engage in STEM careers in a variety of settings, and learn how to engage them in research experiences, and continue that interest fields. We will also assess the implementation and impact of our REU Program. |

Funding – $9,765,989 (continued)

20131101 – 20140630

- **Chester F. Carlson Center for Imaging Science** / *RIT Immersive Living Room* / RIT Project #15859 / $3,000 / This effort aims at creating an "immersive living room" environment. Utilizing a television, projector, webcam, and Microsoft Kinect, the system will augment a traditional television-based living room media environment. The aim is to produce a platform that can be used to generate a variety of different augmentation experiences, including video games, motion picture augmentation, and retexturing of the living room environment.

20130718 – 20141231

- **Office of Naval Research / Department of the Navy / Department of Defense** / *Signatures Modeling, Derivation, and Exploitation* / RIT Project #31370 / $50,000 / This effort is intended to enhance the public's capability to derive spectral signatures from field measurements that can be used to develop new and enhance existing signature exploitation algorithms and foster recommendations for future imaging system designs to improve performance in experimental and operational situations.

20130118 – 20141231

- **Florida International University** / *ALTA Systems Imaging Module* / RIT Project #36823 / $180,279 /
- PHASE 3 - RIT will design and produce an analog-to-digital conversion (ADC) external-sensor recording module for the existing ALTA imaging platform. This module will consist of a custom-design printed circuit board (PCB) having the same form factor as the other components of the electronics stack in the imaging module so that it can be seamlessly incorporated into the existing architecture. This board will replace the current, heavily-modified, 'Zippy' board used for I/O with current imaging module devices and allow for greatly reduced assembly time and skill set that are required for future imaging module assembly. The board will replicate current capabilities; 3 pulse-width modulated servo motor controllers, camera multiplexer interface, asynchronous serial communications for GPS, I2C interface for the inertial measurement unit, and a SD card slot for on-board data storage. New to this board will be 8 analog input channels capable of recording the voltage produced by external sensors (e.g. temperature, humidity, barometric pressure, carbon dioxide levels, etc.). These sensor voltage readings will be able to be time-coincidently recorded with geographic positioning system (GPS) information already on the ALTA and stored to local memory on the balloon. These data will also be incorporated into the message regularly transmitted wirelessly to the ground-based server for later use or for immediate access from an iOS-based client.
- PHASE 4 - RIT will design and assemble the next generation ALTA imaging module (code named R1) that will attach to the upcoming rotational mount on the balloon platform. As part of this effort, RIT will explore the latest IMU and GPS modules available to assure the best performance and availability into the future.
- PHASE 5 - RIT will design and produce an analog-to-digital conversion (ADC) external-sensor recording module for the existing ALTA imaging platform. This module will consist of a custom-design printed circuit board (PCB) having the same form factor as the other components of the electronics stack in the imaging module so that it can be seamlessly incorporated into the existing architecture.

Funding – $9,765,989 (continued)

- PHASE 6 - RIT will perform server updates to support the R-series production testing, support the integration of collected imagery services, and participate in the design and prototyping of the S-series board and power supply, and investigate camera updates/alternatives, and provide ongoing support to the production teams. RIT will also participate in the design of the Parrot-series networking/downlink concept. Perform pre-prototype testing and develop design alternatives.
- PHASE 7 - RIT will provide consultation/oversight of the mechanical development of the gimbal (G) series prototype for a balloon mounted imaging system. RIT will design, integrate, prototype, and develop a production design for the next generation ALTA imaging platform based on commercially-available processors, cameras, guidance, and communications hardware with a custom daughterboard to integrate the components and provide external hardware control and interface to air quality sensors. The intent of this item is to enable the production of 1000 units in a timely fashion by ALTA/FIU personnel. Finally, RIT will develop a prototype "smart reel" that will communicate is position to the balloon-borne platform for inclusion in the downlinked metadata stream.
- PHASE 8 - RIT will be developing the electronic control systems for the Light-Force Technologies "smart reel" to control the ALTA imaging systems altitude during collection as well as provide a real-time video downlink for both visible and thermal infrared video cameras on board the platform. In addition, investigation into the feasibility of incorporating a multispectral camera (commercial or custom developed) and initial prototyping will be carried out for inclusion in the ALTA G-series imaging platform for costal water quality studies.

20130201 – 20130930

- **CACI** / *START-X ISP Signatures and SWIR Measurement Support* / RIT Project #31322 / $5,172 / RIT will provide technical support to CACI for joint activities with the DIA Signature Support Program (SSP) and the Joint Improvised Explosive Device Defeat Organization (JIEDDO) Integrated Signatures Program (ISP). Consultation and advisory support will be provided to CACI for data collection, training, and analytical services in support of the DIA SSP and JIEDDO in two main task areas; research and development support of new data base signature entries and measurements.

20121101 – 20130131

- **Florida International University** / *ALTA Lantern Imaging Module - PHASE 2* / RIT Project #36814 / $10,000 / RIT will construct, test, and deliver two prototype imaging modules with identical components to that initially constructed for ALTA Systems. These modules consist of a BeagleBoard ARM-based processor, two camera boards, GPS, magnetometer, attitude sensor, battery pack, on-board storage, and a cellular modem for wireless communication. In addition, these modules will contain a custom-designed servo motor control board for commanding the flight components of the system. All components are enclosed in a water-resistant plastic polymer enclosure.

Funding – $9,765,989 (continued)

20121201 – 20130701

Chester F. Carlson Center for Imaging Science / *Design and Development of an Open Source High-Speed Flash Trigger* / RIT Project #15819 / $5,150 / High-speed photography has long been an area of intense specialization, requiring thousands of dollars of investment before any images can be created. With modern computing technology, the creation of high-speed imaging systems is fairly straight-foward. Even though current technology enables the creation of these system with fewer obstacles than in the past, most current market options are prohibitively expensive. As a result, the development of an affordable Arduino-based high-speed imaging system fills a void in the high-speed imaging community. This project is directed at the development of an open-source platform enabling RIT to continue to build its reputation in the high-speed imaging community while simultaneously strengthening inter-departmental support and providing access to a useful tool for the instruction of high-speed photography on campus.

20110801 – 20120831

ALTA Pix Incorporated / *ALTA Lantern Imaging Module* / RIT Project #36742 / $104,020 / Alta Pix Incorporated (ALTA) is producing a lighter-than-air platform to be used in the collection of low-altitude aerial photography by individual "Alta Drifters" around the world. These "drifters" are expected to be individual hobbyists, corporations, and military personnel. Platform altitudes are expected to be between 50 and 200 feet above ground level (AGL) enabling extremely high-resolution imagery to be collected with low-cost equipment. The low cost and ease of use will enable membership and participation as a "drifter" by anyone wishing to become part of this community of imagery providers over areas of interest worldwide.

The scope of the RIT research is to develop a one-to-multiple camera module, capable of collecting and storing full resolution imagery on-board, while delivering low-resolution "scout" mode imagery to a web-accessible server in near real-time utilizing existing 3G cellular data networks available in most major population centers. The system will collect geolocation information and heading using GPS and imaging module attitude using on-board gyroscopes/accelerometers for each image collected.

20110501 – 20120531

Chester F. Carlson Center for Imaging Science / *A Feature-based Classifier for Dragonflies and Damselflies* / RIT Project #15705 / $5,000 / Unique patterns present in the wings of dragonflies and damselflies can be used to determine their family, genus, and species. A method for classifying dragonflies and damselflies using a particular pattern known as the triangle was developed using scanned images of the wings. Digital image processing techniques, such as image segmentation and feature detection, are used to determine properties of the triangle useful for classification. These properties are then compared against a triangle property database of known dragonflies and damselflies. A prototype implementing this method has been shown to demonstrate a high degree of accuracy.

Funding – $9,765,989 (continued)

20110801 – 20140731

Exelis Geospatial Systems / *3D Geometry Models from WAAS Data* / RIT Project #C1176 / $160,000 / The intent of this work is to extend current automated 3D point cloud extraction techniques on large format Wide Area Airborne System (WAAS) data sets. ITT will provide RIT with example visible and IR WAAS data of downtown Rochester, NY. ITT will also provide support in the understanding and processing of the WAAS data such as position/orientation data and image file formats. Under this contract, RIT will provide ITT software and resulting process workflows for the automatic creation of 3D point clouds. In addition, fusion of the 3D point cloud data with the high temporal WAAS data, both visible (panchromatic) and infrared will be accomplished with the intent of creating a value added product to the data for ITT.

20110401 – 20141001

National Science Foundation / *NSF REU: Imaging in the Physical Sciences* / RIT Project #31120 / $220,000 / The National Science Foundation (NSF) Research Experiences for Undergraduates (REU) program, Imaging in the Physical Sciences (IPS), will introduce young scientists to research in a highly interdisciplinary environment, where cross-disciplinary team problem solving is the norm. The IPS REU has the following seven specific goals: (i) involve undergraduates from a wide range of host institution type, gender, and ethnicities in a coherent and extendable (multi-year) research experience, starting after their freshman or sophomore years; (ii) involve undergraduates originating from a specific science or engineering major in a highly interdisciplinary research environment, engaging them to work in teams across traditional disciplinary boundaries in problem-based research; (iii) expose students to the emerging field of imaging science and its many and varied application areas; (iv) encourage students to pursue graduate studies in STEM; (v) assist students in the dissemination of their research; (vi) create an ongoing research incubator environment for the students, including feedback from advisory scientist external to RIT, mentoring in public speaking, scientific writing, and social engagement; (vii) assess the implementation and impact of our REU program. |

Funding – $9,765,989 (continued)

20100928 – 20130530

Savannah River National Laboratory / United States Department of Energy / *The Detection of Anamalous Vehicle Loading Using Remote Sensing Techniques* / RIT Project #31057 / $600,183 / In a scenario where nuclear fuel rods are being transported in a shielded transport truck concealed as a commercial vehicle, there may be several remotely detectable signatures. Assuming that payload and shielding material would result in an anomalous increase in the overall vehicle weight, increased frictional forces on the vehicle braking mechanism will result. These increased forces would elevate temperature differences relative to other vehicle components which would be greater than those for vehicles with a standard load. In addition, an overloaded vehicle will exhibit a decreased rate of acceleration and increased diesel exhaust when starting from a stopped position and increased acoustics from engine braking while decelerating at an upcoming traffic control signal. These observables could be indirect indicators of clandestine trafficking of nuclear material.

As a detection mechanism, thermal infrared remote sensing techniques may be used from a stationary position near a traffic-controlled intersection. With knowledge of meteorological conditions at the surveilled site, relative temperature differences between the braking hub, the tire sidewall, and other portions of the vehicle can be used as indicators that the vehicle is under unusual stress due to load. A second observable is the rate of acceleration of a previously flagged suspicious vehicle. This might confirm that the vehicle is indeed carrying a heavier than normal load when compared to historical traffic at that same intersection. Diesel exhaust plume density/size may provide a third observable that may be detected with a traditional visible imaging system or the previously described thermal infrared system. Third, an acoustical sensor and traditional frequency-domain processing techniques may be able to identify vehicles exhibiting anomalous engine braking patterns due to the increased vehicle load. |

20080919 – 20130918

Savannah River National Laboratory / United States Department of Energy / *Enhanced Image Rendering Engine for DIRSIG* / RIT Project #30958 / $700,000 / RIT will provide directed development support and interface definition to allow the DIRSIG environment to serve as an image-rendering engine for the three-dimensional physics-based modeling being carried out by the DOE. As DIRSIG is already a first-principles physics-based environment for optical interactions at the target surface, propagation through the atmosphere, interactions with the mechanics of the sensing platform, and sensor response and artifact modeling for most available types of imaging systems in use today, the further opening of this environment to allow input from the DOE modeling community with respect to phenomenological scenarios involving nuclear nonproliferation would allow a full, end-to-end system for which the imaging product produced can serve as data for a variety of purposes such as algorithm development and testing, system design trade-off studies, and scenario-driven modality selection.

Given current DIRSIG capabilities to model passive systems such as spectral and hyperspectral devices, thermal infrared sensors as well as active systems such as LIDAR and RADAR, and the physical process modeling available from current DOE researchers, this integration would enable very comprehensive system trade studies and future sensor system simulations directed at the complex nonproliferation problem. As part of this effort,

RIT will:

1. Enhance the current capabilities of DIRSIG for the prediction of target surface temperatures by incorporating the MuSES infrared signature prediction model. MuSES will allow DIRSIG to model active targets in a complex meteorological environment with far greater fidelity than is currently possible. The interface of this model will be accomplished in such a way that other current or future temperature prediction codes may be easily used in its place;

2. Improve the current automated vehicular traffic capabilities in DIRSIG by allowing for anomalous movements to occur such as unusual stops or off-road movements. RIT sees this as advantageous for a dynamic persistent surveillance scenario;

3. Develop a simplified flight-planning interface to allow the modeler to quickly plan a collection scenario using a UAV type collection platform. DIRSIG can currently follow a flight plan but this requires a great deal of user interaction and modification of configuration files. RIT will evaluate existing flight planning methods in use by the DOE and the community at large and apply a best effort at integrating these existing tools. If this is not possible, a custom approach will be developed that will emulate the best features found in the existing approaches;

4. Create automatic scene building for DIRSIG based upon contextual inputs including geographic information system descriptive layers and/or multi-view airborne imagery collections. The intent of this task is to greatly accelerate and automate the most time consuming task in the DIRSIG workflow, the scene creation process.

Funding – $9,765,989 (continued)

20080918 – 20130917

Savannah River National Laboratory / United States Department of Energy / *Accurate Radiometric Temperature Measurements Using Thermal Infrared Imagery of Small Targets, Physics-Based Modeling, and Companion High-Resolution Optical Image Data Sets* / RIT Project #30830 / $656,751 / A physics-based target space approach to small target temperature determination is being developed that will allow targets that are the same size as a thermal infrared sensor ground sampling distance to be interrogated for subsequent analysis.

Current approaches to this problem employ traditional frequency domain restoration techniques that are based upon an estimate of the point spread function of the sensing system. This approach, however, is subject to error for a number of reasons. The point spread function of the entire collection system includes spatial blurring due to atmospheric scattering and sensor motion. These parameters are typically not included in the solution and as such the process produce errant answers. Additionally, these traditional techniques work for targets that occupy several pixels in a scene, not for single or subpixel sized targets.

The proposed approach will use the DIRSIG synthetic image modeling code to produce hundreds or thousands of possible candidate images of the target/background under examination. Different positioning of the target relative to the sensor sampling array will be generated as well as varying background and target temperature combination. This create synthetic target space will be developed so as to include the actual scenario encountered. Image matching techniques will be used to compare the actual thermal image to each synthetic image in the target space to find the best match and therefore the most likely set of physical parameters.

A complete validation and verification of the developed technique will be carried out using modeled data, data collected from a fixed imaging platform with full control over all target space parameters, and in a real-world airborne image collection experiment. Data will be collected so that an assessment of accuracy of this proposed technique may be assessed. |

20080904 – 20120420

Central Intelligence Agency IC Post Doctorate Fellowship Program (FY08) / *Image-Based Determination of Polarized Bidirectional Reflectance Distribution Function For In-Field Characterization of Materials* / RIT Project #30866 / $359,960 / This fellowship will focus on the development of novel experimental techniques and complementary modeling tools to accurately predict the polarized bi-directional reflectance distribution function (BRDF) of a variety of materials of interest to the remote sensing community. In addition, the research will develop a collection methodology for measuring polarized BRDF remotely for denied targets. The experimental techniques will take advantage of an image based approach to BRDF measurement with emphasis on deriving the polarized Mueller scattering matrix form of the BRDF.

Funding – $9,765,989 (continued)

20080122 – 20110930

Savannah River National Laboratory / United States Department of Energy / *Ice Characterization Using Remote Sensing Techniques* / RIT Project #30789 / $849,971 / RIT is collaborating with the Savannah River National Laboratory (SRNL) to extend the capabilities of the ALGE hydrodynamic code to include simulations of surface ice formation and melting in cooling lakes that receive heated effluent from nuclear reactors operating in cold climates and collect the data needed to validate this extended version of the ALGE code at suitable locations in the northern US or Canada. SRNL uses the ALGE code to perform technical analyses of heat-generating industrial facilities for DOE and other government agencies. At present, ALGE simulations of cooling lakes and other bodies of water being used to dissipate waste heat from nuclear reactors are restricted to ice-free conditions. This restriction prevents imagery analysis for more than one-half the year at some northern sites. The extension to the ALGE code proposed here will allow year-round applications of the code which will result in more rapid completion of technical analyses.

20060202 – 20090630

Savannah River National Laboratory / United States Department of Energy / *Exploitation Tool For Mechanical Draft Cooling Towers* / RIT Project #30571 / $457,820 / RIT will provide support to gain insight into the phenomenology that influences the radiance field leaving the interior of a mechanical-draft cooling tower (MDCT). The DIRSIG modeling capability will be enhanced such that the models produced reflect, as accurately as possible, the actual data gathered with real airborne infrared imaging systems. These modeling efforts will focus on the phenomenology associated with "cavern-like" targets with numerous material types internally contained. This effort will be cyclical in nature with modeling approaches continually modified based on newly discovered phenomenology observed in real image data. The desired outcome of the modeling will be accurate internal-element emissivities and temperatures for the components that comprise the cooling tower for use with an external process model developed by Savannah River National Laboratory.

Funding – $9,765,989 (continued)

20060817 – 20090216

Central Intelligence Agency IC Post Doctorate Fellowship Program (FY06) / *Effects of Humidity On Atmospheric Transmission For Infrared Sensors* / RIT Project #30632 / $239,926 / This fellowship will perform a comparative analysis of ship-based thermal infrared spectroradiometer measurements against MODTRAN simulations incorporating humidity dependent aerosol nucleation effects.

It is commonly assumed that scattering effects are negligible in the thermal infrared region. This, however, is based on standard atmospheric and aerosol models that have particle size distributions that are heavily weighted and have maximum concentrations in the sub-micron range. While particle concentrations in the super-micron range are orders of magnitude smaller than its submicron counterparts, certain conditions of high humidity may significantly increase their concentrations to levels that may impart scattering effects in the thermal infrared regions.

This hypothesis will be tested using the MODTRAN radiative transfer model (Berk 1989) coupled with the NOVAM - Navy Oceanic Vertical Aerosol Model (Gatham 1993). Given the nature of the data set from Explorer of the Seas ARM facility, this is a logical approach since oceanic aerosols will be inherent to the environment of the surface based measurements. The NOVAM model will be used to obtain first order estimates of potential aerosol effects and indicate possible aerosol nucleation mechanisms describing the concentrations of larger hygroscopic aerosols and their particle size distributions (Leeuw 1992). Currently, the NOVAM model supports three mode radii (peak of the particle size distribution) of 0.03, 0.24, and 2.0 microns. Modifications to the model to include larger mode radii will be investigated to support the thermal scattering hypothesis. |

20050201 – 20070731

MITRE Corporation / Central Intelligence Agency / *ITIC Spectroradiometry Program Support* / RIT Project #30517/30654 / $56,289 / RIT will provide support to the government as a critical participant in the National Signatures Program (NSP) working group monthly meetings. The NSP is responsible for the establishment of spectral measurements standards for solid, liquid, and gaseous materials. Standards in the form of measurement methodologies, formats, metadata, etc. fall within the purview of this group. RIT has been asked to be the representative for the government organization that funds and oversees this program to provide guidance, experience, and critical review to/of this programs efforts and to report back to the supporting organization with impressions and advice.

20060501 – 20061130

DP Instruments / Environmental Protection Agency / *Gaseous Effluent Detection System* / RIT Project #30603/30652 / $47,400 / RIT will perform a system integration of the DP Instruments MARLIN high-speed FTIR spectrometer with a FLIR Systems GasFindIR camera to create a bore-sighted or common-optic system capable of imaging effluent gas plumes and making spectral signature measurements at a central location in the field of view. RIT will further perform a proof-of-concept field study with this system against controlled gas releases. Once the data is collected, RIT will continue to analyze this data by producing an analysis software capability to perform gas identification and volume/rate-of-release estimations.

Funding – $9,765,989 (continued)

20041101 – 20060531

National Reconnaissance Office (NRO) - LASS 2004/05 (CLIN 002) / *Spectral Database Development* / RIT Project #30483 / $40,000 / RIT will provide support through the Laboratory for Advanced Spectral Sensing for the development of an enhanced full spectrum material reflectance database to support more realistic simulations in the DIRSIG model. Current database holdings will be evaluated and test plan developed and executed to provide additional spectra to fill in voids in the current database.

20040501 – 20060930

ITT Industries / Space Systems Division (ICAP) / *Three-Band Temperature Extraction Algorithm* / RIT Project #30459 / $188,873 / RIT will provide support for the development of new and/or evaluation of existing temperature extraction methodologies for infrared imagery. Techniques using a single band, multiple band, or multispectral/hyperspectral image data will be within the scope of this task. RIT will provide modeling support to produce synthetic imagery for evaluation of these algorithms using DIRSIG as requested. This support will may be in the form of assistance in the development of specific sensor models, specific imaging scenarios, and/or to provide a robust data set as a test-bed for new and existing algorithms. RIT will attend community meetings to report on the algorithm and modeling tasks as well as to provide critical review and/or insight into other proposed methodologies.

20040615 – 20051111

Mission Research Corporation / Air Force Research Laboratory (WPAFB) / *Calibration Test Target Development For Longwave Infrared Test Chambers* / RIT Project #30463 / $150,009 / RIT will be providing modeling support in the development of calibration test targets for longwave infrared (IR) test chamber characterization. RIT will utilize its DIRSIG model to represent the interior environment of the IR test chamber located at the WPAFB facility and the potential calibration targets that will be used, performing trade-off and optimization studies as top the efficacy of the designs to choose the proper target to manufacture. RIT will also place certain targets of interest into a cluttered IR background to assist in the design of future chambers with enhanced background capability.

20031201 – 20041130

BAE Systems / *Dynamic Range Adjust Algorithm For Forward-Looking Infrared Imagers* / RIT Project #20157 / $34,306 / RIT will be utilizing funds provided to the current capital campaign by BAE Systems to support a graduate student in Imaging Science. The student will work on a project of interest to both RIT and BAE Systems for their thesis research project. The student will spend a Summer quarter working at BAE Systems with their scientist and engineers to gain real-world experience during their academic work.

20030501 – 20030930

LaSen, Incorporated / Army Research Laboratory / *Feasibility Study For Incorporating LIDAR Into DIRSIG* / RIT Project #30903 / $7,000 / RIT performed two (2) tasks for LaSen, Incorporated in support of their aircraft-based LIDAR system. RIT investigated the feasibility of modeling a LaSen midwave infrared LIDAR system using DIRSIG with particular attention to spectral resolution, pulse generation, ground resolution, and atmospheric interaction. In addition, RIT made several high-spectral resolution reflectance measurements in the 3 to 5 micron region to aid in current exploitation task being carried out by the sponsor.

Funding – $9,765,989 (continued)

20030905 – 20040904 **Pictometry International Corporation / CEIS** / *Automated Tie-Point Selection From Oblique Air Photo Imagery* / RIT Project #36291/C3320/33320 / $26,300 / RIT is determining the feasibility of automated tie point identification on numerous oblique air photos collected with the Pictometry system. Once a feasible approach is identified, RIT will be developing prototype software to assist Pictometry in this now largely manual process. This research was funded in part by CEIS, a NYSTAR-designated Center for Advanced Technology.

20040404 – 20040904 **New York State Office of Cyber Security and Critical Infrastructure Coordination** / *Selective Degradation Algorithm For Air Photo Imagery Database Applications* / RIT Project #33315 / $21,039 / RIT will be providing a software tool that will allow the NYS OCSCIC to selectively degrade their online statewide library of aerial photographs to protect critical infrastructure information. As part of the Homeland Security initiative afoot in New York State, the OCSCIC desires a tool that would let them selectively degrade the resolution of their archives of air photos that are available to the public so that potential organizations that would aspire to do harm to these facilities do not have high quality data available to them, while maintaining the quality of the data in other regions for legitimate users. RIT will develop this software tool to key off of OSCCIC supplied shape files and apply the degradation to the library of imagery.

20021016 – 20040920 **General Dynamics / National Air Intelligence Center** / *NAIC Spectral Exploitation Center Spectral Library Support* / RIT Project #30340 / $470,540 / RIT is supporting the NAIC Spectral Exploitation Center (NSEC) Spectral Library Support initiative by developing laboratory and field spectral library protocols to assure high quality spectral measurements are provide to the library expansion task. In addition, RIT personnel and students are measuring the spectral signatures of materials supplied by the library expansion team as well as those encountered during field exercises using laboratory and field spectrometers. Spectral reflectance measurements are being made from 0.35 through 20 microns for all materials.

Research Advisees

Doctor of Philosophy

current

- **Chase Canas** / *End-to-end systems limitations for hyperspectral target detection using parametric models and novel subpixel targets for validation* (Primary Advisor: John Kerekes)
- **Ryan Connal** / *Methodology for volumetric estimation of condensed water vapor plumes from remotely sensed imagery* (Primary Advisor: **Carl Salvaggio**)
- **David Conran** / *A new vicarious technique for radiometric and spatial calibration of drone-based multispectral and hyperspectral imaging systems* (Primary Advisor: Emmett Ientilucci)
- **Isabella Cox** / *Evolution of galaxies' stellar mass assembly around cosmic noon using JWST* (Primary Advisor: Jeyhan Kartaltepe)
- **Lucy Falcon** / *TBD* (Primary Advisor: Aaron Gerace)
- **Chowdhury Sadman Jahan** / *Transfer learning across modalities and across domains* (Primary Advisor: Andreas Savakis)
- **Christopher Lapszynski** / *A remote sensing approach to determining sediment grain size for littoral trafficability and stability* (Primary Advisor: Charles Bachmann)

Research Advisees (continued)

- **Chris Lee** / *Angular reflectance spectroscopy for remote sensing applications* (Primary Advisor: Charles Bachmann)
- **James Lui** / *Classification of galaxies from JWST NIRCam images using unsupervised machine learning* (Primary Advisor: Jeyhan Kartaltepe)
- **Tahrir Siddiqui** / *TBD* (Primary Advisor: Jan van Aardt)
- **Mohammad Shahriar Saif** / *On the potential of unmanned aerial systems-based (UAS) imaging techniques in broadacre agriculture: A table beet case study* (Primary Advisor: Jan van Aardt)

2023
- **Austin Bergstrom** / *Understanding image quality for deep learning-based computer vision*, July 2023 (Primary Advisor: David Messinger)
- **Roshan Reddy Upendra** / *A deep-learning based pipeline to generate patient-specific anatomical models of the heart using cardiac MRI*, April 2023 (Primary Advisor: Cristian Linte)
- **Anjali Jogeshwar** / *Look at the bigger picture: Analyzing eye tracking data with multi-dimensional visualization*, March 2023 (Primary Advisor: Jeff Pelz)

2022
- **Fei Zhang** / *Toward structural characterization of broadacre crops using UAS-based 3D point clouds*, September 2022 (Primary Advisor: Jan van Aardt)
- **Dylan Shiltz** / *Radiometric effects of centimeter scale roughness of bare soils*, September 2022 (Primary Advisor: Charles Bachmann)
- **Sanketh Satyanarayana Moudgalya** / *Cochlear compartments segmentation and pharmacokinetics using micro computed tomography images*, July 2022 (Primary Advisor: Nathan Cahill)
- **Amirhossein Hassanzadeh** / *On the use of imaging spectroscopy from unmanned aerial systems (UAS) to model yield and assess growth stages of a broadacre crop*, April 2022 (Primary Advisor: Jan van Aardt)
- **Abu Md Niamul Taufique** / *Deep feature learning and adaptation for computer vision*, April 2022 (Primary Advisor: Andreas Savakis)
- **Charles Tabor** / *Reflectance and emittance spectra of intimately mixed and layered mixed media*, March 2022 (Primary Advisor: Charles Bachmann)

2021
- **Cody Webber** / *An examination of environmental applications for uncooled thermal infrared remote sensing instruments*, August 2021 (Primary Advisor: John Kerekes)
- **Fu Jiang** / *High dynamic range (HDR) display perception*, March 2021 (Primary Advisor: Mark Fairchild)

2020
- **Mahshad Mahdavi** / *Query-driven global graph attention model for visual parsing: Recognizing handwritten and typeset math formulas*, August 2020 (Primary Advisor: Richard Zanibbi)
- **Ali Rouzgeh Kargar** / *On the use of rapid-scan, low point density terrestrial laser scanning (TLS) for structural assessment of complex forest environments*, July 2020 (Primary Advisor: Jan van Aardt)
- **Ricardo Figueroa** / *Bayesian methods for radiometric calibration in motion picture encoding workflows*, June 2020 (Primary Advisor: Pengcheng Shi)

2019
- **Baabak Mamaghanni** / *An analysis of the radiometric quality of small unmanned aircraft system imagery*, December 2019 (Primary Advisor: **Carl Salvaggio**)
- **Rehman Eon** / *The characterization of earth sediments using radiative transfer models from directional hyperspectral reflectance*, August 2019 (Primary Advisor: Charles Bachmann)
- **Mohammed Yousefhussein** / *Deep learning methods for 3D aerial and satellite data*, April 2019 (Primary Advisor: **Carl Salvaggio**)

2018
- **Zhaoyu Cui** / *System engineering analyses for the study of future multispectral land imaging satellite sensors for vegetation monitoring*, December 2018 (Primary Advisor: John Kerekes)

Research Advisees (continued)

- **Shagan Sah** / *Multi-modal deep learning to understand vision and language*, December 2018 (Primary Advisor: Raymond Ptucha)
- **Chi Zhang** / *Evolution of a common vector space approach to multi-modal problems*, October 2018 (Primary Advisor: **Carl Salvaggio**)
- **Ronald Kemker** / *Low-shot learning for the semantic segmentation of remote sensing imagery*, August 2018 (Primary Advisor: Christopher Kanan)

2017
- **Timothy Gibbs** / *Physical property extraction of powder contaminated surfaces from longwave infrared hyperspectral imagery*, September 2017 (Primary Advisor: David Messinger)
- **Fan Wang** / *Understanding high resolution aerial imagery using computer vision techniques*, August 2017 (Primary Advisor: John Kerekes)
- **Colin Axel** / *Towards automated analysis of urban infrastructure after natural disasters using remote sensing*, June 2017 (Primary Advisor: Jan van Aardt)
- **Kelly Laraby** / *Landsat surface temperature product: Global validation and uncertainty estimation*, May 2017 (Primary Advisor: John Schott)

2016
- **Troy McKay** / *Detection of anomalous vehicle loading*, August 2016 (Primary Advisor: **Carl Salvaggio**)
- **Rajagopalan Rengarajan** / *Evaluation of sensor, environment and operational factors impacting the use of multiple sensor constellations for long term resource monitoring*, July 2016 (Primary Advisor: John Schott)
- **Justin Harms** / *The design and implementation of GRIT-T: RIT's next-generation field-portable goniometer system*, July 2016 (Primary Advisor: Charles Bachmann)
- **Siyu Zhu** / *Text detection in natural scenes and technical diagrams with convolutional feature learning and cascaded classification*, May 2016 (Primary Advisor: Richard Zannibi)

2015
- **Tyler Carson** / *Signature simulation and characterization of mixed solids in the visible and thermal regimes*, July 2015 (Primary Advisor: **Carl Salvaggio**)
- **Katie Salvaggio** / *A voxel-based approach for imaging voids in three-dimensional point clouds*, May 2015 (Primary Advisor: **Carl Salvaggio**)

2014
- **Jiangqin Sun** / *Temporal signature modeling and analysis*, December 2014 (Primary Advisor: David Messinger)
- **Monica Cook** / *Atmospheric compensation for a Landsat land surface temperature product*, October 2014 (Primary Advisor: John Schott)
- **David Nilosek** / *Analysis and exploitation of automatically generated scene structure from aerial imagery*, April 2014 (Primary Advisor: **Carl Salvaggio**)

2013
- **Shaohui Sun** / *Automatic 3D building detection and modeling from airborne LiDAR point clouds*, December 2013 (Primary Advisor: **Carl Salvaggio**)
- **Alvaro Rojas Arciniegas** / *Towards the control of electrophotographic-based 3-dimensional printing: Image-based sensing and modeling of surface defects*, December 2013 (Primary Advisor: Marcos Esterman)
- **May Casterline** / *Physics-based surface energy model optimization for water bodies in cold climates using visible and calibrated thermal infrared imagery*, November 2013 (Primary Advisor: **Carl Salvaggio**)
- **Weihua Sun** / *Knowledge-based feature extraction and spectral image enhancement from remotely sensed images*, November 2013 (Primary Advisor: David Messinger)
- **Sarah Paul** / *Subpixel temperature estimation from single-band thermal infrared imagery*, August 2013 (Primary Advisor: **Carl Salvaggio**)

Research Advisees (continued)

2012
- **Nima Pahlevan** / *An integrated physics-based approach to demonstrate the potential of the Landsat Data Continuity Mission (LDCM) for monitoring coastal/inland waters*, February 2012 (Primary Advisor: John Schott)

2011
- **Feng Li** / *Optimizations and applications in head-mounted video-based eye tracking*, August 2011 (Primary Advisor: Jeff Pelz)
- **Alvin Spivey** / *Multiple scale landscape pattern index interpretation for the persistent monitoring of land-cover and land-use*, May 2011 (Primary Advisor: Anthony Vodacek)
- **Xiofeng Fan** / *Automatic registration of multi-modal airborne imagery*, May 2011 (Primary Advisor: Harvey Rhody)
- **Brian Flusche** / *An analysis of multimodal sensor fusion for target detection in an urban environment*, January 2011 (Primary Advisor: John Schott)

2010
- **Rodolfo Montez** / *X-rays from planetary nebulae*, September 2010 (Primary Advisor: Joel Kastner)
- **Chabitha Devaraj** / *Polarimetric remote sensing system analysis: Digital Imaging and Remote Sensing Image Generation (DIRSIG) model validation and impact of polarization phenomenology on material discriminability*, August 2010 (Primary Advisor: John Schott)
- **Aaron Weiner** / *A systems level characterization and tradespace evaluation of a simulated airborne Fourier transform infrared spectrometer for gas detection*, July 2010 (Primary Advisor: David Messinger)
- **Karl Walli** / *Relating multimodal imagery data in 3D*, July 2010 (Primary Advisor: John Schott)
- **Jaqueline Speir** / *Validation of 3D radiative transfer in coastal-ocean water systems as modeled by DIRSIG*, July 2010 (Primary Advisor: John Schott)
- **Aaron Gerace** / *Demonstrating Landsat's new potential to monitor coastal and inland waters*, May 2010 (Primary Advisor: John Schott)
- **Ariel Schlamm** / *Characterization of the spectral distribution of hyperspectral imagery for improved exploitation*, April 2010 (Primary Advisor: David Messinger)

2009
- **Shawn Higbee** / *A Bayesian approach to identification of gaseous effluents in passive LWIR imagery*, September 2009 (Primary Advisor: David Messinger)
- **Matthew Montanaro** / *Radiometric modeling of mechanical draft cooling towers to assist in the extraction of their absolute temperature from remote thermal imagery*, May 2009 (Primary Advisor: **Carl Salvaggio**)

2008
- **Marcus Stefanou** / *Spectral image utility for target detection applications*, July 2008 (Primary Advisor: John Kerekes)
- **Derek Walvoord** / *Advanced correlation-based character recognition applied to the Archimedes palimpsest*, May 2008 (Primary Advisor: Roger Easton)

2007
- **Marvin Boonmee** / *Land surface temperature and emissivity retrieval from thermal infrared hyperspectral imagery*, October 2007 (Primary Advisor: John Schott)
- **Zhen Wang** / *Modeling wildland fire radiance in synthetic remote sensing scenes*, August 2007 (Primary Advisor: Anthony Vodacek)
- **Michael Foster** / *Using LIDAR to geometrically constrain signature spaces for physics-based target detection*, August 2007 (Primary Advisor: John Schott)
- **Brent Bartlett** / *Improvement of retrieved reflectance in the presence of clouds*, August 2007 (Primary Advisor: John Schott)
- **Yan Li** / *An integrated water quality modeling system with dynamic remote sensing feedback*, July 2007 (Primary Advisor: Anthony Vodacek)
- **Michael Gartley** / *Polarimetric modeling of remotely sensed scenes in the thermal infrared*, May 2007 (Primary Advisor: John Schott)

Research Advisees (continued)

2005
- **James Shell** / *Polarimetric remote sensing in the visible to near infrared*, November 2005 (Primary Advisor: John Schott)
- **Susan Hojnacki** / *A source classification algorithm for astronomical X-ray imagery of stellar clusters*, May 2005 (Primary Advisor: Joel Kastner)

Master of Science

current
- **Abhijan Wasti** / *TBD* (Primary Advisor: Gabriel Diaz)

2023
- **Touseef Ahmed** / *Effect of pooling layer on weakly labeled semantic segmentation using class activated heat maps*, December 2023 (Primary Advisor: **Carl Salvaggio**)
- **Arnab Ghosh** / *Space variant image deconvolution using deep learning*, December 2023 (Primary Advisor: Grover Swartzlander)
- **Yuval Levental** / *LIDAR voxel segmentation using 3D convolutional neural networks*, July 2023 (Primary Advisor: Jan van Aardt)
- **Eric Montag** / *Utilizing deep ensembles for open set recognition*, April 2023 (Primary Advisor: **Carl Salvaggio**)

2022
- **Lucy Zimmerman** / *Comparison of methane detection for shortwave and longwave infrared hyperspectral sensors under varying environmental*, August 2022 (Primary Advisor: John Kerekes)
- **Nicholas Quattrociocchi** / *A depth-based computer vision approach to unmanned aircraft system landing with optimal positioning*, April 2022 (Primary Advisor: Agamemnon Crassidis)
- **Jacob Osterberg** / *Machine learning based MTF estimation system evaluation utilizing slanted-edge targets in sUAS scenes*, April 2022 (Primary Advisor: **Carl Salvaggio**)

2021
- **Luke DeCoffe** / *Progressing sUAS-based remote sensing data collection automation: Performance analysis of the at-altitude radiance ratio method for reflectance conversion of multispectral and hyperspectral remote sensing data*, December 2021 (Primary Advisor: **Carl Salvaggio**)

2020
- **Matthew Casella** / *Development of a UAS based downwelling irradiance spectrometer for instrument compensation without the use of panels*, November 2020 (Primary Advisor: **Carl Salvaggio**)
- **Salman Khan** / *The use of deep learning methoids to assist in the classification of seismically vulnerable dwellings*, September 2020 (Primary Advisor: **Carl Salvaggio**)
- **Matthew Helvey** / *Application of thermal and ultraviolet sensors in remote sensing of upland ducks*, August 2020 (Primary Advisor: Jan van Aardt)
- **Devarth Parikh** / *Gaze estimation based on multi-view geometric neural networks*, July 2020, (Primary Advisor: Jeff Pelz)

2019
- **Ethan Hughes** / *Spatially-explicit snap bean flowering and disease prediction using imaging spectroscopy from unmanned aerial systems*, December 2019 (Primary Advisor: Jan van Aardt)
- **Nicholas Bitten** / *TIRS-2 and future thermal instrument band study and stray light study*, December 2019 (Primary Advisor: Aaron Gerace)
- **Ronnie Izzo** / *Combining hyperspectral imaging and small unmanned aerial systems for grapevine moisture stress assessment*, July 2019 (Primary Advisor: Jan van Aardt)

2018
- **Margot Accettura** / *Methods for the detection of subterranean methane leakage*, August 2018 (Primary Advisor: **Carl Salvaggio**)
- **McClelland Michael** / *An assessment of small unmanned aerial systems in support of sustainable forestry management initiatives*, July 2018 (Primary Advisor: Jan van Aardt)
- **Monika McKeown** / *Fuzzing and analysis of AV1 multimedia codec*, July 2018 (Primary Advisor: Jonathan Weissman)

Research Advisees (continued)

2017
- **Jiang Fu** / *Evaluation of stray light correction for the thermal infrared sensor (TIRS) from Landsat 8*, September 2017 (Primary Advisor: **Carl Salvaggio**)
- **Jeganathan Nirmalan** / *Hyperspectral and hypertemporal longwave infrared data characterization*, August 2017 (Primary Advisor: John Kerekes)
- **Paul Sponagle** / *Automated flight planning for roof inspection using a face-based approach*, July 2017 (Primary Advisor: **Carl Salvaggio**)

2016
- **Grant Anderson** / *An evaluation of the silicon spectral range for determination of nutrient content of grape vines*, July 2016 (Primary Advisor: Jan van Aardt)

2015
- **Sean Archer** / *Empirical measurement and model validation of infrared spectra of contaminated surfaces*, August 2015 (Primary Advisor: John Kerekes)
- **Katherine Grzedzicki** / *Evaluating 3D building extraction from image-derived point clouds*, May 2015 (Primary Advisor: **Carl Salvaggio**)
- **Ming Li** / *Building model reconstruction from point clouds derived from oblique imagery*, May 2015 (Primary Advisor: John Kerekes)

2014
- **Michael Harris** / *Supervised material classification in oblique aerial imagery using Gabor filter features*, October 2014 (Primary Advisor: David Messinger)
- **Christian Lewis** / *The development of a performance assessment methodology for activity based intelligence: A study of spatial, temporal, and multimodal considerations*, August 2014 (Primary Advisor: David Messinger)
- **Jordyn Stoddard** / *Toward image-based three-dimensional reconstruction from cubesats: Impacts of spatial resolution and SNR on point cloud quality*, August 2014 (Primary Advisor: David Messinger)
- **Adam Rossi** / *Abstracted workflow framework with a structure from motion application*, May 2014 (Primary Advisor: Harvey Rhody)
- **Ming Zhang** / *Towards 3D matching of point clouds derived from oblique and nadir airborne imagery*, May 2014 (Primary Advisor: John Kerekes)

2013
- **Jie Zhang** / *Dense point cloud extraction from oblique imagery*, November 2013 (Primary Advisor: John Kerekes)
- **Cara Perkins** / *Spatial heterodyne spectroscopy: Modeling and interferogram processing*, July 2013 (Primary Advisor: John Kerekes)
- **Danielle Simmons** / *Hyperspectral monitoring of chemically sensitive plant sensors*, May 2013 (Primary Advisor: John Kerekes)
- **Rachel (Obajtek) Kitzmann** / *An implementation of vehicle tracking using motion layers*, May 2013 (Primary Advisor: **Carl Salvaggio**)
- **Philip Nau** / *A study of the deer herd on the RIT campus and the relationship of herd activity and habitat to the incidence of deer-vehicle collisions*, May 2013 (Primary Advisor: Karl Korfmacher)

2012
- **Greg Rafalski** / *Automated model creation from aerial photography*, December 2012 (Primary Advisor: **Carl Salvaggio**)
- **Kyle Ausfeld** / *Tracking of various targets in the infrared and issues encountered*, August 2012 (Primary Advisor: Zoran Ninkov)
- **Disa Walden** / *A benchmarking assessment of known visual cryptography algorithms*, May 2012 (Primary Advisor: Roger Dube)

2011
- **Linda Le** / *Improving signal-to-noise ratio in remotely sensed imagery using an invertible blur technique*, May 2011 (Primary Advisor: **Carl Salvaggio**)
- **Andrew Scott** / *Language-based procedural modeling for randomized scene construction*, May 2011 (Primary Advisor: **Carl Salvaggio**)

Research Advisees (continued)

- **Dave Snyder** / *Text detection in natural scenes through weighted majority voting of DCT high pass filters, line removal, and color consistency filtering*, May 2011 (Primary Advisor: Richard Zanibbi)

2010
- **Donald Taylor** / *Atmospheric compensation over Case II waters: Simultaneous aerosol and water constituent retrieval*, November 2010 (Primary Advisor: John Schott)
- **Jonathan Miller** / *Historic thermal calibration of Landsat 4 TM through an improved physics based approach*, June 2010 (Primary Advisor: John Schott)

2009
- **Ling Ouyang** / *A symbol layout classification for mathematical formula using layout context*, November 2009 (Primary Advisor: Richard Zanibbi)
- **Cynthia Scigaj** / *Study and simulation of remote sensing system: COMPACT Airborne Spectral Sensor (COMPASS)*, July 2009 (Primary Advisor: **Carl Salvaggio**)
- **Kristen Powers** / *DIRSIG cloud modeling capabilities: A parametric study*, January 2009 (Primary Advisor: **Carl Salvaggio**)
- **Alexander Cherekos** / *Gaseous plume detection using projective K-means method*, May 2009 (Primary Advisor: **Carl Salvaggio**)

2008
- **Francis Padula** / *Historic thermal calibration of Landsat 5 TM through an improved physics based approach*, October 2008 (Primary Advisor: John Schott)
- **Gregory Gosian** / *A non-probabilistic, compact compression algorithm suitable for deep space solar system mission image transmission*, February 2008 (Primary Advisor: **Carl Salvaggio**)

2006
- **Brian Dobbs** / *The incorporation of atmospheric variability into DIRSIG*, October 2006 (Primary Advisor: John Schott)
- **Seth Weith-Glushko** / *Quantitative analysis of infrared contrast enhancement algorithms*, September 2006 (Primary Advisor: **Carl Salvaggio**)
- **Kristin-Elke Strackerjan** / *Modelling the spectral effects of water and soil as surface contaminants in a high resolution optical image simulation*, July 2006 (Primary Advisor: John Kerekes)
- **Timothy Grabowski** / *Effects of pixel size on apparent emissivity signatures of materials with long-wave infrared spectral characteristics*, May 2006 (Primary Advisor: **Carl Salvaggio**)
- **Timothy Hattenberger** / *A psychovisual investigation of global illumination algorithms used in augmented reality*, March 2006 (Primary Advisor: Mark Fairchild)

2005
- **Erin O'Donnell** / *Detection and identification of effluent gases using invariant hyperspectral algorithms*, August 2005 (Primary Advisor: **Carl Salvaggio**)
- **Melissa Hofer** / *A website and corresponding database to support the Digital Imaging and Remote Sensing (DIRS) lab in the Chester F. Carlson Center for Imaging Science at the Rochester Institute of Technology*, June 2005 (Primary Advisor: **Carl Salvaggio**)
- **David Pogorzola** / *Gas plume species identification in LWIR hyperspectral imagery by regression analyses*, April 2005 (Primary Advisor: **Carl Salvaggio**)

2004
- **Erin Peterson** / *Synthetic landmine scene development and validation in DIRSIG*, August 2004 (Primary Advisor: John Schott)
- **Kris Barcomb** / *High-resolution, slant-angle scene generation and validation of concealed targets in DIRSIG*, August 2004 (Primary Advisor: John Schott)
- **Marianne Lipps** / *Task influence of scene content selected by active vision*, August 2004 (Primary Advisor: Jeff Pelz)

2003
- **Neil Scanlan** / *Comparative performance analysis of texture characterization models in DIRSIG*, August 2003 (Primary Advisor: John Schott)

1995
- **Elizabeth Frey** / *An examination of distributional assumptions in Landsat TM imagery*, June 1995 (Primary Advisor: **Carl Salvaggio**)

Research Advisees (continued)

1994 **Gary Ralph** / *Characterization of the radiometric performance of an IR scene projector*, June 1994 (Primary Advisor: John Schott)

1993 **Richard Stark** / *Synthetic image generator model: Application of specular and diffuse reflectivity components and performance evaluation in the visible region*, September 1993 (Primary Advisor: John Schott)

Kaleen Moriarty / *Automated image-to-image rectification for use in change detection analysis as applied to forest clearcut mapping*, August 1993 (Primary Advisor: **Carl Salvaggio**)

Adam Hanson / *Character recognition of optically blurred textual images using moment invariants*, June 1993 (Primary Advisor: Roger Easton)

1992 **David Ehrhard** / *Application of Fourier-based features for classification of synthetic aperture radar imagery*, September 1992 (Primary Advisor: John Schott)

Gustav Braun / *Quantitative evaluation of six multispectral, multiresolution image merger routines*, July 1992 (Primary Advisor: John Schott)

Robert Merisko / *Enhancement to atmospheric-correction techniques for multiple thermal images*, July 1992 (Primary Advisor: John Schott)

Sharon Cady / *Multi-scene atmospheric normalization of airborne imagery: Application to the remote measurement of lake acidification*, April 1992 (Primary Advisor: John Schott)

Donna Rankin / *Validation of DIRSIG an infrared synthetic scene generation model*, February 1992 (Primary Advisor: John Schott)

1991 **Jonathan Wright** / *Evaluation of LOWTRAN and MODTRAN for use over high zenith angle/long path length viewing*, May 1991 (Primary Advisor: John Schott)

1990 **Curtis Munechika** / *Merging panchromatic and multispectral images for enhanced image analysis*, August 1990 (Primary Advisor: John Schott)

Wendy Rosenblum / *Optimal selection of textural and spectral features for scene segmentation*, May 1990 (Primary Advisor: John Schott)

Eric Shor / *3-D longwave infrared synthetic scene simulation*, May 1990 (Primary Advisor: John Schott)

1989 **Jan North** / *Fourier image synthesis and slope spectrum analysis of deep water, wind-wave scenes viewed at Brewster's angle*, December 1989 (Primary Advisor: John Schott)

John Francis / *Pixel-by-pixel reduction of atmospheric haze effects in multispectral digital imagery of water*, May 1989 (Primary Advisor: John Schott)

Denis Robert / *Selection and analysis of optimal textural features for accurate classification of monochrome digitized image data*, May 1989 (Primary Advisor: John Schott)

Bachelor of Science

current **Eric Luba** / *Archaeological landscape classification using hyperspectral imagery analysis* (Primary Advisor: **Carl Salvaggio**)

Anna Mason / *Demonstration of the feasibility of using synthetically generated condensed water vapor plume imagery to train an AI model to automatically segment real imagery* (Primary Advisor: **Carl Salvaggio**)

Alex Slotter / *Smart weightlifting form analysis system* (Primary Advisor: **Carl Salvaggio**)

Luke Spinosa / *Real-time recognition and tracking in LIDAR* (Primary Advisor: **Carl Salvaggio**)

2023 **Gabriel Peters** / *Pre-training architecture design for computer vision applications and remotely-sensed overhead feature transfer*, December 2023 (Primary Advisor: **Carl Salvaggio**, Derek Walvoord)

Research Advisees (continued)

2022 **Jackson Glozer** / *Locating defects in railroad rails using an image based approach*, May 2022 (Primary Advisor: **Carl Salvaggio**)

2021 **Wade Pines** / *Automated calibration pipeline for agricultural sUAS based remote sensing*, May 2021 (Primary Advisor: **Carl Salvaggio**)

Aidan Herbery / *Comparative analysis of atmospheric scene normalization methods*, May 2021 (Primary Advisor: **Carl Salvaggio**)

2020 **Vlad Simion** / *Hockey puck tracking using computer vision for television*, May 2020 (Primary Advisor: **Carl Salvaggio**)

Julianna Fioravanti / *Comparison of methods to detect panels in aerial imagery*, May 2020 (Primary Advisor: May 2020 **Carl Salvaggio**)

2019 **Kevin Kha** / *Yield modeling of corn silage with multispectral cubeSat imagery*, May 2019 (Primary Advisor: **Carl Salvaggio**, Jan van Aardt)

2018 **Geoffrey Sasaki** / *Small unmanned aircraft system calibration exploration*, April 2018 (Primary Advisor: **Carl Salvaggio**)

Ryan Hartzell / *Automatic spatio-temporal registration of disparate video feeds for 3D reconstruction*, May 2018 (Primary Advisor: **Carl Salvaggio**)

2017 **Sadie Wolters** / *Assessing the efficacy of white mold fungicides in snap beans using hyperspectral remote sensing*, May 2017 (Primary Advisor: **Carl Salvaggio**, Jan van Aardt)

Lindsay Martinescu / *Differentiating crop treatments using UAS multispectral imagery: Fertilization in corn*, May 2017 (Primary Advisor: **Carl Salvaggio**, Jan van Aardt)

Seth Baker / *On mapping corn yield using structure-from-motion data from unmanned aerial systems*, May 2017 (Primary Advisor: **Carl Salvaggio**, Jan van Aardt)

2016 **Victoria Scholl** / *Unmanned aerial vehicle imaging system creation for water quality analysis*, May 2016 (Primary Advisor: **Carl Salvaggio**)

Elizabeth Bondi / *Calibration of UAS imagery inside and outside of shadows for improved vegetation index computation*, May 2016 (Primary Advisor: **Carl Salvaggio**)

Timothy Bauch / *Low-cost and effective structure-from-motion 3-dimensional geometric reconstructions of targets at macroscopic scale*, December 2016 (Primary Advisor: **Carl Salvaggio**)

2015 **Brandon Scott** / *A comparison of object detection techniques*, August 2015 (Primary Advisor: **Carl Salvaggio**)

Christian Taylor / *Radiometric calibration of a modified DSLR for NDVI*, May 2015 (Primary Advisor: **Carl Salvaggio**)

2014 **Daniel Goldberg** / *Seamless texture mapping of 3D point clouds*, December 2014 (Primary Advisor: **Carl Salvaggio**)

Jacob DeBoer / *Digital watermarking for video: A forensic solution to movie piracy*, May 2014 (Primary Advisor: **Carl Salvaggio**)

2013 **Stephanie Darling** / *A novel approach to temperature-emissivity separation using a multiple-window smoothness criteria*, December 2013 (Primary Advisor: **Carl Salvaggio**)

Scarlett Montanaro / *Using non-contact ultrasound to characterize deteriorating metal and wood*, April 2013 (Primary Advisor: **Carl Salvaggio**)

2012 **Kyle Ryan** / *A feature-based classifier for dragonflies and damselflies*, May 2012 (Primary Advisor: **Carl Salvaggio**)

2010 **Katie Salvaggio** / *Phenomenological study of passive image-based observables used to determine standard from overladen vehicles*, May 2010 (Primary Advisor: **Carl Salvaggio**)

2009 **Meredith Curtis** / *Application of image reconstruction techniques to Mars neutron spectroscopy data*, February 2009 (Primary Advisor: **Carl Salvaggio**)

Research Advisees (continued)

2008
- **Paul Romanczyk** / *Creation of a psychovisually lossless image independent look up table for color image compression*, May 2008 (Primary Advisor: **Carl Salvaggio**)
- **Russell Barkley** / *Tracking fluorescent particles used in lung simulation studies using high-speed video imagery*, May 2008 (Primary Advisor: **Carl Salvaggio**)

2007
- **Michael Denning** / *Classification of astronomical infrared sources using Spitzer space telescope data*, February 2007 (Primary Advisor: **Carl Salvaggio**)

2006
- **Bethany Choate** / *Investigating the use of agglomerative hierarchical clustering as a method for multispectral image classication*, May 2006 (Primary Advisor: **Carl Salvaggio**)
- **William Pfeister** / *Automation of a laboratory-based goniometer for measurment of bidirectional reflectance distribution functions*, May 2006 (Primary Advisor: **Carl Salvaggio**)

2005
- **Christopher Bayer** / *Development of algorithm for fusion of hyperspectral and multispectral imagery with the objective of improving spatial resolution while retaining spectral data*, May 2005 (Primary Advisor: **Carl Salvaggio**)

2004
- **Brandon Migdal** / *Extraction methods of watermarks from linearly-distorted images to maximize signal-to-noise ratio*, May 2004 (Primary Advisor: **Carl Salvaggio**)
- **Seth Weith-Glushko** / *Automatic tie-point generation for oblique aerial imagery: An algorithm*, May 2004 (Primary Advisor: **Carl Salvaggio**)

Courses Taught

- **IMGS.180 / Object-Oriented Scientific Programming**
  This project-based course is an introduction to object-oriented computer programming directed at solving scientific problems related to imaging. The student will learn the concepts of object-oriented programming using the most recent C++ programming language standard. Popular project management and modern compilation/build systems will be presented and utilized. Fundamentals of streamed input and output, data types, objects and classes, templates, lambda expressions, flow control, repetition, program decomposition and library development, software engineering/design concepts, and problem-solving approaches such as the use of randomness, divide-and-conquer, Monte Carlo simulation, ill-posed solutions, and search will be examined in detail and applied to scientific, mathematical, and imaging-specific problems. In addition to the base language concepts, students will utilize popular open-source and public-domain libraries such as Boost, Eigen, and OpenCV. (2141, 2151, 2155, 2161, 2195, 2198, 2205, 2215, 2225)
- **IMGS.361 / Image Processing and Computer Vision I**
  This course is an introduction to the basic concepts of image processing and computer vision. The student will be exposed to image capture and image formation methodologies, sampling and quantization concepts, statistical descriptors and enhancement techniques based upon the image histogram, point processing, neighborhood processing, and global processing techniques based upon kernel operations and discrete convolution as well as the frequency domain equivalents, geometrical operations for scale and rotation, and grey-level resampling techniques. The student will be introduced to the computation of the discrete and fast Fourier transforms for one- and two-dimensional functions and the techniques of frequency domain filtering. Emphasis is placed on applications and efficient algorithmic implementation using modern programming languages. (2141, 2151, 2161, 2171, 2181, 2191, 2201, 2211, 2221)

Courses Taught (continued)

- **IMGS.362 / Image Processing and Computer Vision II**
  This course is an introduction to the more advanced concepts of image processing and computer vision. The student will be exposed to color image formation, feature detection and point correspondence, automated image registration, image reconstruction, noise sources and techniques for noise removal, information theory, image compression, wavelet transformations, image watermarking and steganography, face detection and identification, inpainting and content-aware resizing, and other contemporary topics in the field. Emphasis is placed on technical paper preparation, public presentation, independent thinking, and efficient algorithmic implementation using the student's programming language of choice. (2145, 2155, 2165, 2175, 2185, 2195, 2205, 2215, 2225)
- **IMGS.589 / sUAS Remote Sensing**
  Small unmanned aircraft systems (sUAS) provide access to imagery data with extremely high-spatial resolution, extremely high-temporal resolution, and a freedom of operation that provides the remote sensing community access to vast amounts of information. These opportunities do not come without complications. This highly-experiential and project-based course will take the students through the data acquisition portion of the utilization cycle: task definition, image-observable phenomenology identification, sensor selection, mission planning and execution, and ground-reference data collection. While these steps in the utilization cycle are not unique to sUAS, there are unique considerations that must be accounted for due to the improved resolution that is inherent in these data and they need careful treatment to generate quality information for the end user. Students will be expected to participate in several field experiments outside of regularly scheduled class time in order to collect the data to solve the selected image analysis task. Students should be comfortable in the use of a programming language of their choice (2171, 2175)
- **1051.211 / Programming for Imaging Science**
  This course will introduce the student to the IDL environment as a data visualization tool and a programming language. The student will learn the various capabilities of the package and how they can rapidly prototype solutions to various science and engineering problems. As these solutions are developed, fundamental concepts of programming and data structures will be introduced. Programming assignments will include fundamental imaging related problems and will work with scalar, vector and array processes. This course will emphasize the need for concrete problem definition, problem decomposition into smaller sub-problems, implementation/testing, and presentation/documentation of the algorithms and results. (2002-1, 2003-1, 2004-1, 2005-1, 2006-1, 2007-1, 2008-1, 2009-1, 2010-1)
- **1051.361 / Digital Image Processing I**
  This course is an introduction to the basic concepts of digital image processing. The student will be exposed to image capture and image formation methodologies, sampling and quantization concepts, statistical descriptors and enhancement techniques based upon the image histogram, point processing, neighborhood processing, and global processing techniques based upon kernel operations and discrete convolution as well as the frequency domain equivalents, geometrical operations for scale and rotation, and grey-level resampling techniques. The student will be introduced to the computation of the discrete and fast Fourier transforms for one- and two-dimensional functions and the techniques of frequency domain filtering. Emphasis is placed on applications and efficient algorithmic implementation using the IDL programming language. (2002-1, 2003-1, 2004-1, 2005-1, 2006-1, 2007-1, 2008-1, 2009-1, 2010-1, 2011-1, 2012-1, 2013-1)
- **1051.462 / Digital Image Processing II**
  This course is an introduction to the more advanced concepts of digital image processing. The student will be exposed to image reconstruction, noise sources and techniques for noise removal, information theory, image compression, video compression, wavelet transformations and the basics of digital image watermarking. Emphasis is placed on applications and efficient algorithmic implementation using the IDL programming language. (2002-2, 2003-2, 2004-2, 2005-2, 2006-2, 2007-2, 2008-2, 2009-2, 2010-2, 2011-2, 2012-2, 2013-2)

Courses Taught (continued)

- **1051.463 / Digital Image Processing III**
  This course discusses the digital image processing concepts and algorithms used for the analysis of hyperspectral, multispectral and multi-channel data in remote sensing and other application areas. Concepts are covered at the theoretical and implementation level using current, popular commercial software packages and high-level programming languages for examples, homework and programming assignments. The requisite multivariate statistics will be presented as part of this course as an extension of the univariate statistics that the students have previously been exposed to. Topics to be covered will include methods for supervised data classification, clustering algorithms and unsupervised classification, multispectral data transformations, data redundancy reduction techniques, image-to-image rectification, and data fusion for resolution enhancement. (2002-3, 2003-3, 2004-3, 2005-3, 2006-3, 2007-3, 2008-3, 2009-3, 2010-3, 2011-3, 2012-3, 2013-3)
- **1051.553 / Special Topics - Programming for Imaging Science II**
  This course emphasizes the algorithm development and implementation of advanced digital imaging applications. Modular programming concepts are emphasized along with good coding and documentation practices. The course will be carried out in the UNIX operating environment and IDL will be the programming language utilized. Language specific characteristics such as the use of IDL widgets for graphical user interface development, the use of IDL objects, the use of ENVI specific functions and procedures, further treatment of image data types, and color management will be explored. Example algorithmic areas that may be explored are image compression, color space transformations, frequency domain image reconstruction, and the use of multi-band imagery. (2009-1)
- **1051.553 / Special Topics - Applied Computing for Imaging Science**
  This course is intended to develop the students skills in applied computing and research techniques. A prerequisite to scientific advancement is a thorough understanding of historical and recent literature relevant to the field of study. This often involves repeating experiments that predecessors and current colleagues have performed. Often, insights are gained when experiments are repeated that cannot be realized simply by reading an article in a professional journal or conference proceeding. In this course, the student will choose an article from the historical or recent literature that describes a computational technique used in the field of imaging science. The student will implement the described algorithm in the computer language of their choice, and attempt to repeat the results obtained by the author. Along the way, the student will make three oral presentations during class, the first describing the referenced research, the second, a report on their progress in re-implementing the referenced work, and the third, describing the success, failure or questions that arose during execution of the project. The intent is to develop a critical approach to reading published research, questioning both implementation and results in order to gain a thorough understanding of the work. (2010-1, 2011-1)
- **1051.762 / Remote Sensing Systems, Sensors and Radiometeric Image Analysis**
  Introduction to the governing equations for radiance reaching an aerial or satellite based imaging system, covering the properties of these imaging systems with an emphasis on their use as quantitative scientific instruments. Methods for inverting the remotely sensed image data using the governing radiometric equation are assessed. Multidimensional image analysis (e.g. multispectral, polarimetric, multidate) is emphasized and includes issues such as image registration to support image analysis. Parameters and processes governing spatial, spectral and radiometric image fidelity are studied with an emphasis on how each step in the image chain impacts the final image or image product. (2011-2)
- **1051.782 / Introduction to Digital Image Processing**
  This course will provide the basic understanding of imaging systems, image transformation and associated mathematics and computational processes needed for upper-level classes in the imaging science graduate program. Topics covered include linear vector spaces, image mathematics, image statistics and point processing, linear and nonlinear image filters, image transforms and computer algorithms. Computational methods and techniques for essential processes for imaging systems are used as the course framework. (2007-3, 2008-3, 2009-3, 2010-3, 2011-3, 2012-3)

Courses Taught (continued)

- **2076-511 / High-Speed Photography**
  The theory and practice of photographic systems designed to permit analysis of events of very short or extended duration. Included are operational characteristics of time-lapse cameras, sequencing and timing control devices, time magnification relationships. Also, characteristics of intermittent and rotating prism cameras, rotating mirror and drum cameras, synchronization system and timing controls and high-speed flash and spark gap systems. Students gain experience not only in the use of the basic equipment but also in proper planning, setup and data reduction techniques through a series of practical experiments. (2012-1, 2013-1)

University Service

2019 – present	Digital Imaging and Remote Sensing Laboratory - Director
2002 – present	Center for Imaging Science Undergraduate Curriculum Committee
2022 – 2023	Center for Imaging Science Faculty Search Committee [Bartosz Krawczyk, Dima Dera]
2016 – 2017	Center for Imaging Science Faculty Search Committee [Guoyu Lu] (Chair)
	Center for Imaging Science Pre-Tenure Review (Chair)
2003 – 2015	Center for Imaging Science Minor Coordinator
2014 – 2015	Center for Imaging Science Immersion Coordinator
2006 – 2014	Center for Imaging Science Undergraduate Coordinator
2012 – 2013	Center for Imaging Science Faculty Search Committee [Jie Qiao/Gabriel Diaz]
2003 – 2012	Center for Imaging Science Computer Advisory Committee (Chair)
2009 – 2010	Center for Imaging Science Faculty Search Committee [Jinwei Gu]
2006	Center for Imaging Science System Administrator Search Committee [Brett Matzke] (Chair)
2003 – 2004	Center for Imaging Science Director Search Committee [Stefi Baum]
2023 – present	RIT College of Science Honors and Awards Committee
2022 – 2023	RIT College of Science Mid-tenure Review Committee (Chair)
2019 – 2021	RIT College of Science Promotion Review Committee (Chair)
2017 – 2019	RIT College of Science Tenure Review Committee
2014 – 2019	RIT College of Science Undergraduate Research Council
2011 – 2015	RIT College of Science Promotion Review Committee (Chair)
	RIT College of Science Curriculum Committee
2009 – 2013	RIT College of Science Academic Conduct Committee
2004 – 2012	RIT College of Science Computer Committee
2007 – 2008	RIT College of Science Administrative Council
2004 – 2007	RIT College of Science Academic Conduct Committee
2006 – 2012	RIT Research Computing Advisory Board (Co-chair)
2007	RIT Research Computing System Administrator Search Committee [Paul Mezzanini] (Chair)
2004-2005	RIT Head of Research Computing Search Committee (Gurcharan Khanna)
2007 – 2008	RIT College of Imaging Arts and Sciences Faculty Search Committee (Digital Cinema) [Ricardo Figueroa]

Awards/Nominations Received

- 2023-2024 — Recipient of the "M. Herbert and Elsa Bausch Eisenhart Award for Outstanding Teaching" representing RIT's highest honor for tenured faculty, recognizing faculty members who excel at teaching and enhancing student learning
- 2022 — Nominated for the "RIT Board of Trustees Scholarship Award"
- 2022 — Nominated for the "RIT Excellence in Faculty Mentoring Award"
- 2020 — Recipient of the "RIT College of Science Scholar of the Year Award"
- 2020 — Nominated for the "RIT Excellence in Faculty Mentoring Award"
- 2016 — Nominated for the "RIT Board of Trustees Scholarship Award"
- 2015 — Nominated for the "RIT Board of Trustees Scholarship Award"
- 2013 — Recipient of the "Outstanding Student Advisor" award at the "RIT College of Science Annual Dean's Honors, Awards, and Recognitions" ceremony for dedication and outstanding mentoring of our students
- 2012 — Nominated for the "The M. Herbert and Elsa Bausch Eisenhart Award for Outstanding Teaching" at RIT
- 2009 — Nominated for the "Exemplary Online Learning Faculty Award" sponsored by the Online Learning department at RIT
- 2008 — Nominated for the "Exemplary Online Learning Faculty Award" sponsored by the Online Learning department at RIT
- 2007 — Nominated for the "The M. Herbert and Elsa Bausch Eisenhart Award for Outstanding Teaching" at RIT
- 2006 — Nominated for the "The M. Herbert and Elsa Bausch Eisenhart Award for Outstanding Teaching" at RIT
- 2004 — Nominated for the "The M. Herbert and Elsa Bausch Eisenhart Award for Outstanding Teaching" at RIT
- 2004 — Recipient of the "RIT Student Government Faculty of the Year Award"