Nitin Rai

CONTACT INFORMATION	North Dakota State University Department of Agricultural and Biosystems Engineering 1231 Ladd Hall, Albrecht Blvd, Room # 208C Fargo, ND 58102 USA

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RESEARCH STATEMENT

With over four years of research expertise, I specialize in utilizing advanced data analytics and artificial intelligence (AI) techniques for agricultural big data. Proficient in in-field drone data collection, I develop predictive AI models and implement them on edge platforms for site-specific precision agriculture tasks. As a precision agriculture researcher, I am proficient in Python, skilled in data visualization using RStudio, possess theoretical and applied understanding of AI algorithms. I have a track record of publishing research findings in top-tier journals, coupled with strong communication skills and the ability to thrive in a fast-paced environment.

EDUCATION

North Dakota State University (NDSU), Fargo, ND, USA

Ph.D. | Agricultural and Biosystems Engineering, GPA: 3.63/4.00 — Aug. 2019 – Oct. 2023

- Supervisor: Dr. Xin (Rex) Sun
- Dissertation title: Weed identification on drone-acquired images using edge device for spot spraying application
- Committee: Drs. Igathinathane Cannayen, Michael Ostlie, & Shuvashis Dey
- Coursework: *Precision agriculture principles for nutrient management, Applications of precision agriculture, Introduction to GIS, GIS pattern analysis and modeling, Applied computer imaging and sensing for biosystems, Machine learning for engineers, Image analysis, Field plot design I*

Indian Institute of Technology (IIT), Kharagpur, India

Masters | Agricultural Engineering, GPA: 8.08/10.00 — July 2017 – June 2019
Specialization: Agricultural Systems and Management

- Supervisor: Prof. Bhabani Sankar Das
- Thesis title: Development of a soil dryer for estimating soil hydraulic properties
- Coursework: *Digital soil mapping, Soil-plant-water relationships, Crop production systems, Crop process engineering, Soil physics*

Sam Higginbottom University of Agriculture, Technology and Science, India

Bachelors | Agricultural Engineering, GPA: 9.51/10.00 — July 2013 – June 2017

- Supervisor: Dr. Arpan Sherring
- Thesis title: Feasibility study of gravity drip irrigation for small-scale farmers
- Coursework: *Engineering mathematics I & II, Statistical methods, Operations research, Principles of agriculture, Systems approach in agriculture*

PROFESSIONAL EXPERIENCE

Postdoctoral Associate, NDSU — Nov. 2023 – *present*
NDSU Sun Lab, ABEN

Graduate research assistant, NDSU — Aug. 2019 – Oct. 2023
NDSU Sun Lab, ABEN

Master's research student, IIT-KGP — July 2018 – June 2019
Soil Physics Lab Lab, Department of Agricultural and Food Engineering

Undergraduate trainee — May 2016 - June 2016
Hindustan Machine Tools (HMT), India

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AWARDS AND HONORS			
	🏆	Awarded outstanding student presentation, AIM, ASABE[1]	Oct. 2023
		Attended the NDSU President's dinner and gave a talk in front of 250 alumni	Sept. 2023
		Featured in the NDSU foundation magazine	Aug. 2023
	🏆	Secured 2nd spot in ethics essay competition, AIM, ASABE	July 2023
	🏆	Achieved 9th spot among the top 25 students in 3MT thesis competition, WAGS[2]	March 2023
		Featured in NDSU news for winning the 3MT competition at NDSU	Feb. 2023
	🏆	Earned 1st spot in the championship round of 3MT thesis competition, NDSU	Feb. 2023
		Featured in NDSU news after winning an international video contest, AIM ASABE	Feb. 2021
	🏆	Won 1st place in an international video contest and featured on ASABE news	Feb. 2021
		Secured annual scholarship of $2,030 from the Ministry of India (MoI) for PG study	July 2017
		Qualified GATE[3] exam with All India Rank (AIR) of 105	April 2017

TECHNICAL SKILLSET

- Programming languages: C, Java, Python, R
- Programming platform: ImageJ, Jupyter, RStudio
- Tools: Git (novice), Linux
- Libraries/Framework: Arcpy, DarkNet, ggplot2, torch, Keras, OpenCV, TensorFlow, PyTorch
- GIS Software: ArcGIS Pro/Map, Pix4DMapper, Yield Editor
- Embedded systems: Arduino, Nvidia Jetson Modules, Raspberry Pi
- Drone apps: DJI Go, Drone Harmony, Pix4Dcapture, WebODM
- Drones: DJI Phantom series, DJI Matrice 600 Pro, MG-1P
- Document preparation: LaTeX, MS Office, R Markdown

RESEARCH EXPERIENCE AND PROJECTS

NDSU Sun Lab

Graduate research assistant   Aug. 2019 - Oct. 2023

Weed identification on UAS-acquired images
- Worked on the project with an objective to identify common North Dakota weeds amongst multiple crop plants in high-resolution aerial images.
- Used state-of-the-art data analytic techniques that involved various computer vision concepts for in-field weed identification.

Open-source big dataset 📥
- Conducted multiple drone flights across three locations to capture in-field images of multiple weed species.
- Created an open-source repository of annotated weed database exported in multiple formats.
- Managed, pre-processed, and annotated around 10,000 aerial images, encompassing over 12,000 instances of different weed classes, crucial for training computer vision models.

Edge-device integration for site-specific application 🎧
- Customized and evaluated the effectiveness of the You Look Only Once (YOLOv4) architecture using the DarkNet framework.
- Implemented lightweight object detection models that achieved an impressive weed identification accuracy of over 85% on the Nvidia Jetson AGX Xavier platform, thus minimizing hardware costs.
- Achieved a remarkable processing speed of over 95 frames per second (FPS) for identifying multiple weed species in near real-time videos obtained through drone technology.

Model optimization using PyTorch modules
- Integrated re-parameterized convolutional layers within the YOLO architecture.

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[1] Annual International Meeting, American Society of Agricultural and Biological Engineers
[2] Western Association of Graduate Schools
[3] Graduate Aptitude Test in Engineering

- Performed filter-based structured pruning based on the base architecture to reduce trainable parameters.
- The optimization resulted in 78% parameter reduction while outperforming its base architecture with larger of parameters and training hours.
- Deployed the optimized architecture on an edge device for on-the-go applications in weed management.

Automation using Python in ArcGIS Pro
- Merged Python scripts in ArcGIS Pro by leveraging transfer learning to automate sunflower *(Helianthus annuus)* stand count. ⓞ
- Automation creation of weed prescription maps in ArcGIS Pro. ⓞ

Term projects and extras
- Applied various machine learning algorithms on the Plant Seedlings dataset obtained from Kaggle. ⓞ
- Employed deep learning techniques to classify images of Maize *(Zea mays)* and Sugar beet *(Beta vulgaris)* crops. ⓞ
- Enhanced WaterShed algorithm using OpenCV on Jetson TX2 module for real-time segmentation. ⓞ

Soil Physics Lab, IIT–KGP

Masters research student   July 2018 - June 2019
- Designed and developed a portable soil dryer using Arduino micro-controller as an additional attachment to the existing HYPROP apparatus.

GRANT WRITING

1. "Efficacy of AI-powered micro-local weather forecasting for precision agriculture and data-driven farming in the state of North Dakota." Proposal conceptualization and grant writing as a Co-PI with Dr. Leon Schumacher and PI, Dr. Xin Sun. Submitted to North Dakota Ag. Products Utilization Commission (APUC) for a total budget of $28,826. This project is a collaborative work between NDSU, Trilogy Network, Microsoft and Ottis Farms. ∼ *[Not funded]*

PEER-REVIEWED PUBLICATIONS

1. **Nitin, R**., Zhang, Y., Ram, G.B., Schumacher, L., Yellavajjala, K.R., Bajwa, S., Sun, X. (2023). Applications of deep learning in precision weed management: A review. *Computers and Electronics in Agriculture.* 🅐 [Most downloaded]

2. **Nitin, R**., Sun, X., Cannayen, I., Howatt, K., Ostlie, M. (2023). Aerial-based weed detection using low-cost and lightweight deep learning models on an edge platform. *Journal of the ASABE.* 🅐

3. **Nitin, R**., Mahecha, M.V., Christensen, A., Quanbeck, J., Zhang, Y., Howatt, K., Ostlie, M., Sun, X. (2023). Multi-format open-source weed image dataset for real-time weed identification in precision agriculture. *Data in Brief.* 🅐

4. **Nitin, R**., Zhang, Y., Villamil, M., Howatt, K., Ostlie, M., Sun, X. (2023). Agricultural weed identification in images and videos by integrating optimized deep learning architecture on an edge computing technology. *Computers and Electronics in Agriculture.* ∼ *[Accepted]*

PEER-REVIEWED PUBLICATIONS (SUBMITTED/IN-PREPARATION)

1. **Nitin, R**., Sun, X. (2023). WeedMask: A single-stage deep learning architecture to perform weed detection and segmentation using drone-acquired images. *Computers and Electronics in Agriculture.* ∼ *[Under-review]*

2. Upadhyay, A., Zhang, Y., Koparan, C., **Nitin, R**., Howatt, K., Bajwa, S., Sun, X. (2023). Advances in ground robotic technologies for site-specific weed management in precision agriculture: A review. *Computers and Electronics in Agriculture.* ∼ *[Submitted]*

3. Swain, R, S., **Rai, N**., Das, S, B. (2023). A recent trend in the application of multispectral remote sensing for soil assessment using machine learning approaches: A review. *International Journal of Remote Sensing.* ~ *[In-preparation]*

<table>
<tr><td>CONFERENCE
PROCEEDINGS</td><td>

1. **Nitin, R**., Zhang, Y., Quanbeck, J., Christensen, A., Sun, X. (2022). SpotWeeds: A multiclass UASs acquired weed image dataset to facilitate site-specific aerial spraying application using deep learning. Paper No. 8771. In: Proceedings of the ICPA. 📄

2. **Nitin, R**., Flores, P. (2021). Leveraging transfer learning in ArcGIS Pro to detect "doubles" in sunflower field. ASABE paper no. 2100742, 2021 ASABE Annual International Meeting (Virtual), July. 12-16, 2021. 📄

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<tr><td>PRESENTATIONS
AND INVITED TALKS</td><td>

1. **Nitin, R**. (2023). Drone spots illegal weed plants: The future of agriculture takes flight. Sept. 28th, 2023, Fargo, ND, USA. *[President's dinner invited talk]*

2. **Nitin, R**. (2023). Harvesting the benefits of artificial intelligence in agriculture: An ethical approach. July 9-12, 2023, Omaha, NE, USA. *[Ethics essay competition]* 📄

3. **Nitin, R**., Villamil, M., Zhang, Y., Howatt, K., Ostlie, M., Sun, X. (2023). Assessing the best augmentation approach for weed detection in aerial images using convolutional neural networks. Abstract No. 2300150, 2023 ASABE Annual International Meeting, July 9-12, Omaha, NE, USA. *[Oral presentation]*

4. **Nitin, R**. (2023). Drone spots illegal weed plants: The future of agriculture takes flight. March. 29th, 2023, Portland, OR, USA. *[Regional-level 3-min thesis competition]*

5. **Nitin, R**. (2023). Drone spots illegal weed plants: The future of agriculture takes flight. NDSU-Main Campus, Feb. 16th, 2023. *[3-minute thesis competition]*

6. **Nitin, R**., Zhang, Y., Quanbeck, J., Christensen, A., Sun, X. (2022). Near real-time weed recognition on UASs-acquired videos of field plots to aid in spot spraying application. Abstract No. 2200080, 2022 ASABE Annual International Meeting, July 17-20, 2022, Houston, TX, USA. *[Oral presentation]*

7. **Nitin, R**., Zhang, Y., Quanbeck, J., Christensen, A., Sun, X. (2022). SpotWeeds: A multiclass UASs-acquired weed image dataset to facilitate site-specific aerial spraying application using deep learning. Abstract No. 8771, 2022 International Conference on Precision Agriculture (ICPA) (Virtual), June 26-29, 2022. *[Oral presentation]*

8. **Nitin, R**., Sun, X. (2022). Aerial-based spot spraying for site-specific weed management. Graduate Student Council Research Symposium, April 19th, 2022, NDSU, Fargo, USA. *(Oral presentation)*

9. **Nitin, R**., Flores, P. (2021). Leveraging transfer learning in ArcGIS Pro to detect "doubles" in sunflower field. Abstract No. 2100742, 2021 ASABE Anuual International Meeting (Virtual), July 12-16, 2021. *[Oral presentation]*

10. **Nitin, R**., Flores, P. (2021). Solutions to detect and extract plot-level data from field trials using UASs imagery to support high throughput phenotyping. Abstract No. 2100784, 2021 ASABE Anuual International Meeting (Virtual), July 12-16, 2021. *[Oral presentation]*

11. **Nitin, R**., Flores, P. (2021). Sunflower stand detection and counting using transfer learning in ArcGIS Pro. 3rd Annual Symposium, Gamma Sigma Delta (GSD) Competition (Virtual), April 22nd, 2021. *[Oral presentation]*

12. **Nitin, R**., Flores, P. (2021). Sunflower stand detection and counting using transfer learning in ArcGIS Pro. Red River Valley section meeting (RRV-ASABE) (Virtual), April 20th, 2021. *[Oral presentation]*

13. **Nitin, R**. (2021). Streamlining crop stand count using an intelligent flying machine. 4th IEEE Robosoft Workshop on Agricultural Soft Robotics (Virtual), April 12th, 2021. *[3-min teaser talk]*

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TEACHING EXPERIENCE	**Department of Agricultural and Biosystems Engineering**, NDSU, Fargo, ND, USA	
	Lab instructor	Fall 2023
	Designed and taught a 3-week lab on the course titled, Introduction to Precision Agriculture (PAG 115L), 16 undergraduate students.	
	Lab instructor	Spring 2023
	Designed and taught a 3-week lab on the course titled, Mapping of Precision Ag. Data (PAG 215), 12 undergraduate students.	
	Lab assistant	Fall 2022
	Assisted a Postdoc in a lab for the course titled, Electronics Systems in Precision Agriculture (PAG 315), 16 undergraduate students.	

PROFESSIONAL MEMBERSHIPS		
	Served as the President of ABEN Graduate Student Association	Jan. 2021 - Oct. 2022
	Student member of AABFEIO	Dec. 2021 – *present*
	Student member of ASABE	Dec. 2020 – *present*
	Student member of International Society of Precision Agriculture (ISPA)	Dec. 2020 – *present*
	Student member of Alpha Epsilon Honor Society	Nov. 2020 – Oct. 2023

COURSE CERTIFICATIONS		
	DataCamp [Certificate]	
	Introduction to TensorFlow in Python	Jan. 2023
	DataCamp [Certificate]	
	Intermediate data visualization with `ggplot2`	Sept. 2022
	DataCamp [Certificate]	
	Introduction to data visualization with `ggplot2`	Aug. 2022
	Nvidia Deep Learning Institute [Certificate]	
	Fundamentals of deep learning for computer vision	June 2020
	ESRI	
	Creating python scrips for raster analysis	June 2020
	CADD Center, India	
	Diploma in AutoCAD 2D	June 2015

JOURNAL REVIEWER		
	Computers and Electronics in Agriculture, Elsevier	Feb. 2023 – *present*
	Journal of the ASABE, ASABE	March 2023 – *present*

OUTREACH WORK AND OTHER ACTIVITIES		
	Demoed various ground-robots in the Autonomous Nation Conference, Grand Farm	Aug. 2023
	Manned a booth in UAS Summit and Expo, Grand Forks, ND	Oct. 2022
	Participated in Digital Agriculture Hackathon hosted by Purdue University	July 2022
	Organized a LaTeX workshop for NDSU graduate students	April 2022
	Participated in robotics competition, AIM, ASABE	July 2021
	Participated in "STEM @ NDSU" event to educate Fargo high school students	April 2021
	Demoed DJI MP-1P spray drone in the Autonomous Nation Conference	March 2021
	Manned a booth during Fargo AirSho	July 2021