#### University of Nebraska - Lincoln

#### DigitalCommons@University of Nebraska - Lincoln

Conference Presentations and White Papers: Biological Systems Engineering

**Biological Systems Engineering** 

7-2023

#### Development of a Scalable Edge-Cloud Computing Based Variable Rate Irrigation Scheduling Framework

Eric J. Wilkening University of Nebraska-Lincoln, ewilkening@huskers.unl.edu

Derek M. Heeren University of Nebraska-Lincoln, derek.heeren@unl.edu

Yeyin Shi University of Nebraska-Lincoln, yshi18@unl.edu

Abia Katimbo University of Nebraska-Lincoln, abia.katimbo@unl.edu

Precious N. Amori University of Nebraska-Lincoln, pamori2@huskers.unl.edu

See next page for additional authors

Follow this and additional works at: https://digitalcommons.unl.edu/biosysengpres

Part of the Bioresource and Agricultural Engineering Commons

Wilkening, Eric J.; Heeren, Derek M.; Shi, Yeyin; Katimbo, Abia; Amori, Precious N.; Balboa, Guillermo R.; Puntel, Laila A.; Zhang, Kuan; and Rudnick, Daran R., "Development of a Scalable Edge-Cloud Computing Based Variable Rate Irrigation Scheduling Framework" (2023). *Conference Presentations and White Papers: Biological Systems Engineering*. 78. https://digitalcommons.unl.edu/biosysengpres/78

This Article is brought to you for free and open access by the Biological Systems Engineering at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Conference Presentations and White Papers: Biological Systems Engineering by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

#### Authors

Eric J. Wilkening, Derek M. Heeren, Yeyin Shi, Abia Katimbo, Precious N. Amori, Guillermo R. Balboa, Laila A. Puntel, Kuan Zhang, and Daran R. Rudnick

# Development of a Scalable Edge-Cloud Computing Based Variable Rate Irrigation Scheduling Framework

Eric Wilkening<sup>1</sup>, Derek M. Heeren<sup>1</sup>, Yeyin Shi<sup>1</sup>, Abia Katimbo<sup>1</sup>, Precious Amori<sup>1</sup>, Guillermo Raul Balboa<sup>2</sup>, Laila Puntel<sup>2</sup>, Kuan Zhang<sup>3</sup>, Daran Rudnick<sup>1</sup>

<sup>1</sup>University of Nebraska-Lincoln Department of Biological Systems Engineering, <sup>2</sup>University of Nebraska-Lincoln Department of Agronomy and Horticulture, <sup>3</sup>University of Nebraska-Lincoln Department of Electrical and Computer Engineering



## Background

- Current precision irrigation scheduling methods require large amounts of data and long processing times
- Irrigated crops continue to develop water stress during data processing time
- Equipment or online subscriptions to support current precision scheduling methods can be costly

## Theory

Build scalability upon increasing complexity:

### Level Zero:

• Traditional scheduling methods (i.e., hand-feel method)

### Level One:

• Current mechanistic computerized methods

### Level Two:

## Discussion

Infrastructure cost, availability, and producer needs dictates level of complexity implementable:

- More rural areas may not have access to necessary wireless data transmission infrastructure to support cloud interaction
- Smaller scale operations may not have room in their operating budgets to fully invest in sensing and computer

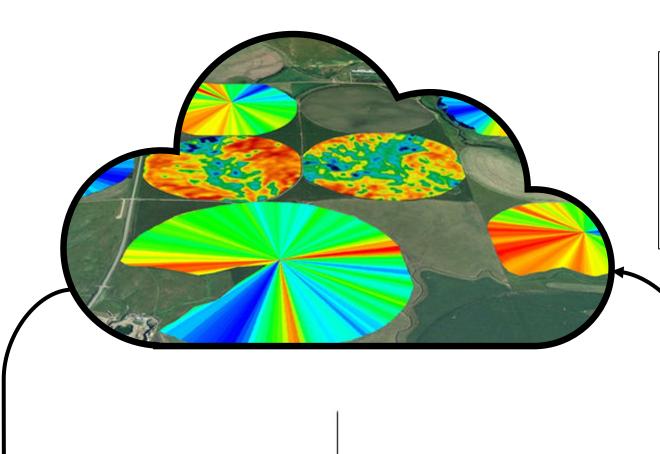
 Modern edge-cloud computing techniques can be utilized to improve the processing time and infrastructure scalability to continually adapt to grower needs and continued technology advancements

• Cloud-computed VRI prescription determined by machine learning model

### **Level Three:**

- Edge-hosted and processed machine learning model with high spatial and temporal resolution local data
- Transmits final model parameters to cloud for continued (federated) model improvement

## **Scalable Implementation**



### Cloud-Built VRI Prescription

- Inputs weather, agronomic, and field-collected data
- Capability to quickly process large amounts of data
- Hosts robust crop model to build recommendations

### systems

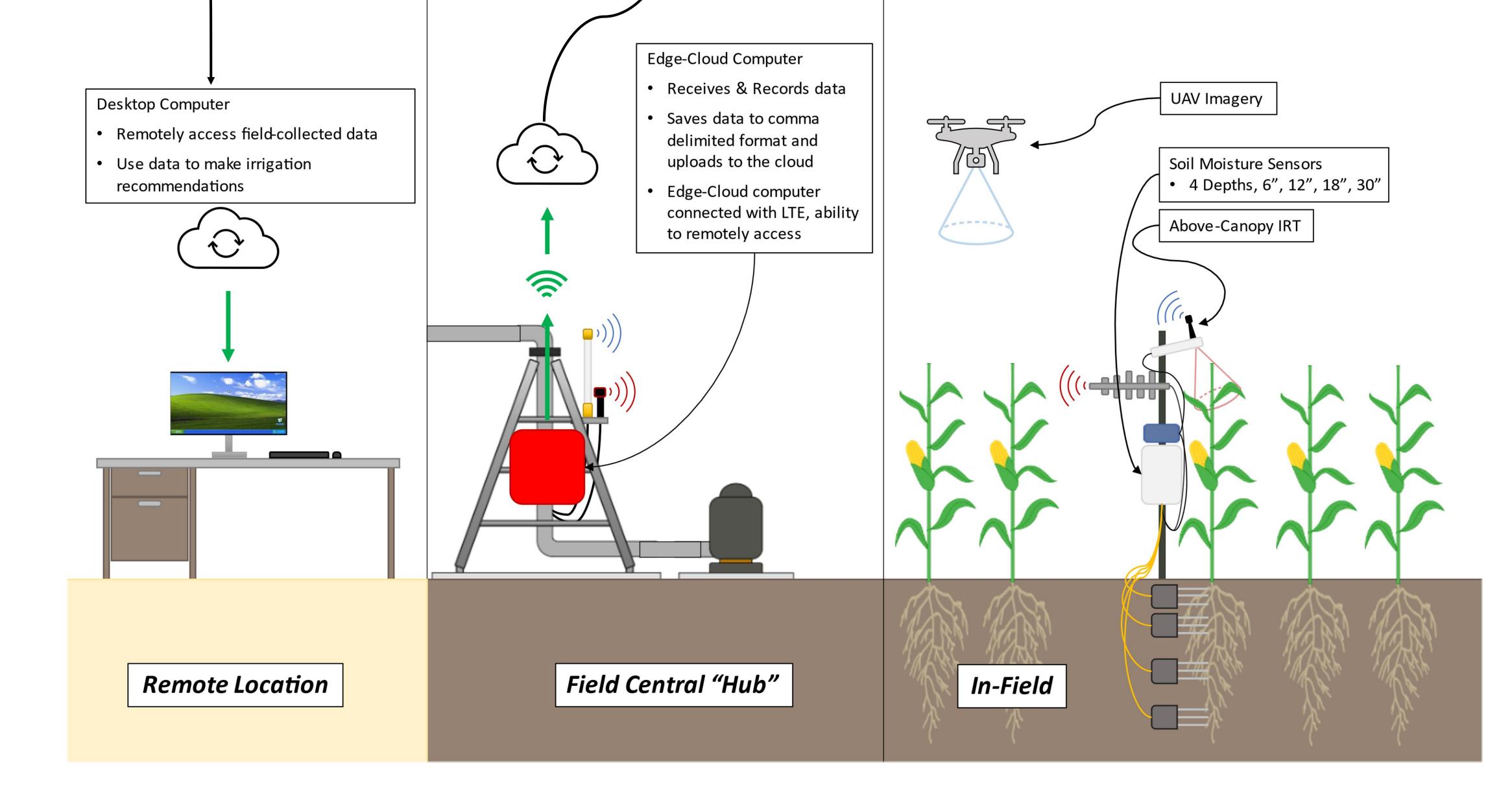
- Traditional methods (i.e., hand-feel) do not account for infield variabilities, leading to over- or under- irrigation
- Availability of existing farm data may impose restriction on model output quality, and thus model implementation

# Federated learning implementation will continually improve irrigation recommendations over time

- As more data is collected and irrigation recommendations made, federated learning will allow for continued refinement of the model
- Initial training datasets are finite, and are not good at accounting for large geographic and seasonal irrigation differences
- With larger and more varied implementations, the model will become increasingly robust with time despite any differences in a singular implementation's complexity

## **Initial Results**

• Two years of historical field data assembled from the



Eastern Nebraska Research, Extension, and Education Center as input (Agronomic, weather, satellite imagery, research plot locations as input data)

- Target dataset used was SETMI (Spatial Evapo-Transpiration Modeling Interface) Irrigation
  Recommendations as Days until Irrigation
- Initial Training Results:
  - Linear Regression: RMSE ~ 49 days
  - Random Forest: RMSE ~ 2.5 days

## Acknowledgements

The presenting author would like to express gratitude towards both this poster's co-authors and other project collaborators for their time and contributions in the development of this proposed novel irrigation scheduling regime.

This research is funded by the United States Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA)

#### UNIVERSITY of NEBRASKA-LINCOLN

The University of Nebraska does not discriminate based upon any protected status. Please see go.unl.edu/nondiscrimination. © 2020. PL2002.

IN DUR GRIT. DUR GLORY.