CPS: Medium: CPS-Enabled Variable Rate Technology

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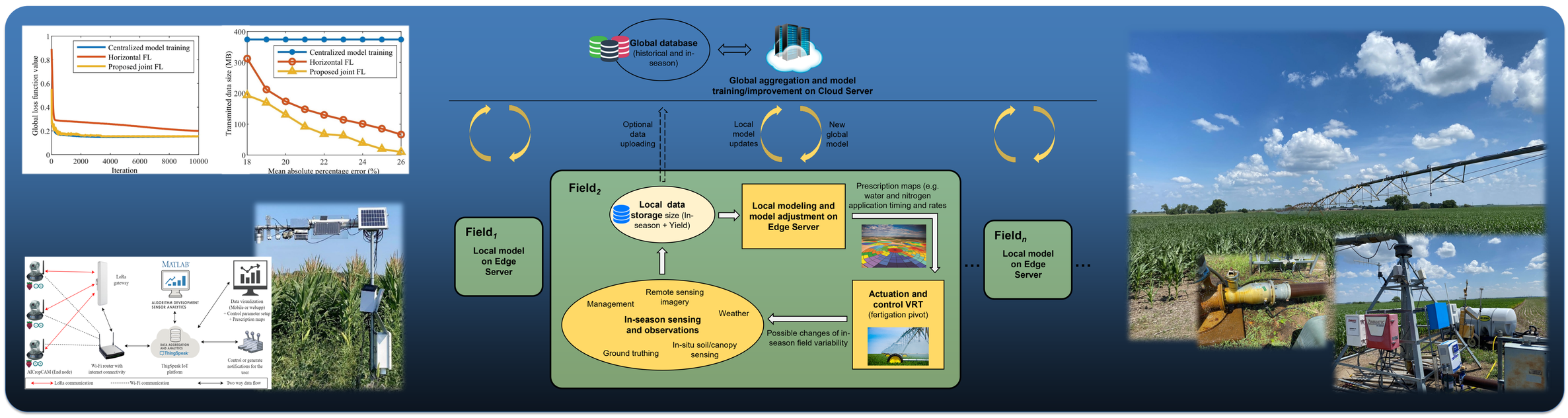
- Variable rate technology (VRT) is one of the backbone technologies in Precision Agriculture. It is infiltrated into almost all agricultural operations, such as a center pivot or linear move system based irrigations and fertigations.
- **Challenges –** Existing VRTs face the following interconnected limitations:
  1. Limited source of inputs for decision making;
  2. Only addresses one crop stress or management operation at a time (e.g., water, nitrogen);
  3. Farmers generate huge amounts of data everyday that can be used for modeling; but it is too complex and expensive for them to upload the data to cloud. Some of them also have data privacy and security concerns.
- **Overall Goal & Scientific Impact –** This project develops a generalizable and scalable framework for the next-generation VRT in agriculture enabled by Cyber-Physical Systems (CPS).



- **Approach & Innovations –** This framework is featured with the following key innovations (aims):
  1. An IoT based multimodal sensing network;
  2. A hybrid of AI and process based irrigation and nitrogen stress detections and management decision making algorithm;
  3. A continuous model update strategy based on hybrid federated learning that can enable the utilization of the massive amount of real-world training data and a more feasible and optimized networking and computational resource allocation and data privacy.
- **Field Validation –** The group has been implementing and validating the first version framework in a center-pivot fertigation system equipped field in eastern Nebraska since the growing season of 2023.
- **Boarder Impact –** Here are some highlights:
  - The group has been making contacts with major pivot manufacturers and brought their attentions to this work and potential future collaborations;
  - The "CPS-enabled VRT" concept and some of the project basic approaches such as sensing, IoT, modeling for irrigation scheduling have been converted into a new junior-standing digital agriculture course which has been officially approved and offered twice at UNL;
  - A YouTube video series has been created to introduce the project to publics;
  - A web portal has been under development by the project group to showcase the project and also make the project outcome – the developed framework – freely available to growers and industry.

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