**Awards issued prior to January 20, 2025, were funded under previous Administrations and may not reflect the priorities and policies of the current Administration.**

**United States Department of Agriculture**
**Project Initiation**

# Project Data for Accession Number 1027030

## Project Title

AI Institute: AIIRA: AI Institute for Resilient Agriculture

## Project Details

| | |
|---|---|
| **Sponsoring Institution**<br>National Institute of Food and Agriculture | **Project Status**<br>ACTIVE |
| **Funding Source**<br>NIFA Non Formula | **Grant Year**<br>2021 |
| **Grant No.**<br>2021-67021-35329 | **Cumulative Award Amt.**<br>$20,000,000.00 |
| **Proposal No.**<br>2021-07266 | **Multistate No.**<br>(N/A) |
| **Project Start Date**<br>Sep 01, 2021 | **Project End Date**<br>Aug 31, 2028 |
| **Program Code**<br>[A7303] AI Institutes | |

## Project Director

Ganapathysubramanian, B.

## Recipient Organization

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY

515 MORRILL RD, 1350 BEARDSHEAR HALL

Ames, IOWA 500112105

## Performing Department

MECHANICAL ENGINEERING - ENG

## Non Technical Summary

Our planet faces a daunting challenge: By the end of the century, world population will increase by 45%, cropland will decrease by 20% and our climate will become increasingly variable, threatening crops and putting communities at risk. We need to increase agricultural productivity by 70% to meet our growing food security needs - a challenge we are not able to meet under our current rate of progress.Now imagine a truly game-changing technology that can greatly accelerate this progress. It already exists in the form of artificial intelligence (AI). Using advanced sensor technology, scientists can create digital twins - virtual simulations that mimic real-world plants, crops and farms. For every year of biological data, digital twin-based AI systems can create hundreds of reality-based simulations that can:Streamline and revolutionize plant breeding to help scientists develop improved crop varieties that can better withstand environmental, pest and disease challenges while delivering higher yields and quality.Help farmers and their advisors adopt improved farming techniques and technologies that can boost their profits and help improve the long-term care

of their critical land and soil resources.Provide governments with the insight they need to encourage and incentivize adoption of policies and practices that deliver the most benefit with the least environmental cost.Give agricultural companies the data and knowledge needed to develop more effective precision management systems and improved plant varieties that thrive with less water, fertilizer and pesticides.Drive economic development across the rural landscape through AI-inspired ventures.The leaders of the AI Institute for Resilient Agriculture (AIIRA) believe these breakthroughs - and more - can be a reality in the very near future. The Institute is bringing together AI experts with plant breeders, agronomists, geneticists and social scientists to accelerate the adaptation and use of AI-based technologies to transform agriculture to meet the needs of our world's growing population and increasingly climate-challenged food systems.

## Animal Health Component

Animal Health Component: 0%

## Research Effort Categories

| | |
|---|---|
| Basic | 50% |
| Applied | 40% |
| Developmental | 10% |

## Classification

| Knowledge Area (KA) | Subject of Investigation (SOI) | Field of Science (FOS) | Percent |
|---|---|---|---|
| 212 | 1820 | 2080 | 10% |
| 206 | 2499 | 2080 | 10% |
| 212 | 1820 | 1081 | 10% |
| 205 | 1820 | 2080 | 10% |
| 903 | 2499 | 2080 | 10% |
| 203 | 1510 | 2080 | 10% |
| 205 | 1510 | 2080 | 10% |
| 201 | 1510 | 2080 | 10% |
| 201 | 1510 | 1081 | 10% |
| 203 | 1820 | 2080 | 10% |

## Knowledge Area

[212] Diseases and Nematodes Affecting Plants

[206] Basic Plant Biology

[205] Plant Management Systems

[903] Communication, Education, and Information Delivery

**United States Department of Agriculture**
**Project Initiation**

[203] Plant Biological Efficiency and Abiotic Stresses Affecting Plants

[201] Plant Genome, Genetics, and Genetic Mechanisms

## Subject Of Investigation

[1820] Soybean

[2499] Plant research, general

[1510] Corn (for sweetcorn use 1480)

## Field Of Science

[2080] Mathematics and computer sciences

[1081] Breeding

## Keywords

Crop breeding, Sustainable production, AI-Ag informal learning for breeders and producers, AI-Ag literate workforce, AI-Ag nexus for NIFA stakeholders, Accomodation of expert judgement in machine learning, Adoption of AI for Ag, Ag Digital twin, Context-aware machine learning, Data-efficient inference and reasoning, Democratization of AI for Ag, Multimodal data fusion, Robotic perception and decision-making

## Goals / Objectives

The project has the following goals and associated objectives:Goal 1: Build plant and field scale predictive models through foundational AI advances. The specific objectives related to this project are:Objective 1: Build AI algorithms and perform associated theoretical analyses for (a) optimal sensor placement, (b) remote and proximal perception, and (c) programmable sensing for ag applications.Objective 2: AI theory and algorithms that encode contextual /domain knowledge into AI constructs. These context-aware models fuse multi-scale, multimodal data that will result in accurate predictive models for biological entities.Objective 3: Develop and deploy novel AI planning and control capabilities so robots can intelligently execute in-field actions like data collection and dexterous manipulation of plants and their environment. Goal 2: Deploy plant and field scale predictive models for breeding and crop production applications. The specific objectives related to this goal are:Objective 4: AI theory and algorithms that enable in silico breeding, and AI-enabled decision-support tools that reduce resource utilization while managing risk. This includes AI-enabled optimization in high-dimensional spaces for ideotype design, partial data-based optimization with guarantees, reinforcement learning for coupled in silico and conventional breeding.Objective 5: Extend predictive model based decision-making to field-level optimization of production tasks and develop distributed AI approaches to enable multiple mobile agents to collect data, take action, and improve models under dynamic conditions at different spatiotemporal scales.Goal 3: Understanding and resolving social barriers to, and AI innovations for adoption of the AI technology in the agricultural ecosystemObjective 6: Identify social, behavioral, and business catalysts and barriers to acceptance and adoption of AI technology by various stakeholders in the ag ecosystem.Objective 7: Develop foundational algorithms and theory to increase trustworthiness of AI tools, specifically to enhance the acceptance and adoption of AI-enabled technologies by the ag community. Goal 4: Create a diverse, AI-aware agricultural workforce and serve as a nexus for AI-in-Ag developmentsObjective 8: Develop talent and skills for a highly competent next generation AI workforce, including activities for graduate students; undergraduate students; and continual learners with diverse backgrounds,learning levels, and fields of expertiseObjective 9: Broadening participation of women, Hispanics, and Native Americans in AI using evidence based strategies across multiple age groups.Objective 9: Team science based collaboration and sustained knowledge transfer activities.

## Project Methods

**United States Department of Agriculture**
**Project Initiation**

Effort: Our efforts will include:Principled approaches for sensor allocation and placement, along with advances in context-aware 3D sensing, will provide layered data to feed the digital twinBuild, train, and validate a new family of deep generative models that are explicitly physics aware and that encode biophysical and phenomenological constraints, physiological crop models, bio-eco-hydrological process models, and network associations within the training processExplore the use of forceful interaction to inform the digital twin, model-based strategies for manipulation of flexible and granular material with soft manipulators, and AI-driven design of robotic mechanisms well suited to a given dexterous task. A systems integration component will support in-field testing and application of developed AI advancesAI-enabled optimization in high-dimensional spaces for ideotype design, partial data-based optimization with guarantees, reinforcement learning for coupled in silico and conventional breeding.New algorithms and theory for distributed optimization and learning to solve various multi-agent reasoning problems. Important practical constraints, such as limited communication and privacy awareness, will drive the AI innovationsIdentify social, behavioral, and business catalysts and barriers to acceptance and adoption of AI technology by various stakeholders in the ag ecosystem. Use a combination of quantitative and qualitative approaches: community of practice, focus groups, online surveys, participatory workshops and economic experiments, semi-structured interviews, and the Delphi method.Define, formulate, and develop algorithms and metrics of interpretability and robustness for AI frameworks; develop principled approaches to incorporate knowledge of domain expertsEvaluation: AI research will be evaluated via metrics including computational efficiency, sample efficiency, generalization to model fidelity, and effectiveness of data collection. Application-oriented impacts to genetics, breeding, and production will be evaluated through cross-cutting field trials that integrate and deploy AI advances and measure their efficacy for multiple crops and growing regions. Social impact will be measured by a community of practice, regional and national surveys, focus groups, and field experiments, and the evaluation will examine the dissemination of findings on catalysts and barriers to AI adoption to stakeholders. Formal and informal education and workforce development modules will be formatively and summatively accessed. Outreach will be assessed by the number of stakeholders engaged and changes in their AI-ag knowledge and attitudes