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United States Department of Agriculture
Project Initiation

Project Data for Accession Number 1024178

Project Title

AI Institute: Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability (AIFARMS)

Project Details

Sponsoring Institution National Institute of Food and Agriculture	**Project Status** ACTIVE
Funding Source NIFA Non Formula	**Grant Year** 2020
Grant No. 2020-67021-32799	**Cumulative Award Amt.** $19,998,042.00
Proposal No. 2020-09148	**Multistate No.** (N/A)
Project Start Date Sep 01, 2020	**Project End Date** Aug 31, 2027
Program Code [A7303] AI Institutes	

Project Director

Adve, V.

Recipient Organization

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Performing Department

(N/A)

Non Technical Summary

In the recent past, especially the last half of the twentieth century, advances in irrigation, fertilization, mechanization, and breeding have helped agriculture keep pace with the growth in world population. This success, however, has come at significant costs: due to pressures for increased production, farms have been damaged by chemicals, soil degradation and erosion, increased herbicide resistant weeds, and other challenges that reduce long-term farm productivity and profitability. Today, we are faced with the challenge of feeding more people on less land, despite reduced labor availability and increasing production constraints. Conventional, as-practiced technologies cannot solve these looming fundamental challenges in a sustainable manner for farmers and rural communities.Advances in the theory and practice of Artificial Intelligence (AI) play an important role in addressing these challenges in two key ways. First, improvements in autonomy and human-augmented systems can increase agricultural output while also reducing input cost and improving profit margins, with fixed or even slightly reduced labor requirements, e.g., by allowing far

more detailed monitoring and decision-making in large-scale production of both crops and livestock. Second, AI research can yield new techniques for decision-making based on agricultural data, which comes from highly varied sources, and which spans increasingly wide spatial scales from individual plants to whole regions and widely varying time scales from seconds to entire seasons.The AIFARMS Institute will develop and demonstrate the advances in AI necessary to address the major challenges facing world agriculture, by combining basic research, novel experimental facilities, state-of-the-art data analytics, and eventually evaluation in production settings. Farmers will be involved in all stages of the work, from identifying practical constraints on technological solutions to evaluating them in the field and providing feedback on the incentives and barriers to their adoption. The Institute will work with technology and agriculture companies to transfer the outcomes of the research into production use. Multidisciplinary educational programs spanning Computer Science and Agriculture, with increased AI content, will develop the skilled workforce needed to develop, deploy and support these advanced technologies in complex, modern agricultural operations. Education and farmer training programs will be carefully designed to increase participation from rural communities and expand opportunities in both agriculture and relevant STEM disciplines.If AIFARMS is successful, it will lead to technological advances that enable farmers to increase food production and profitability in the long term, to do so while maintaining productive farmland for future generations, to be more resilient to weather variability and market fluctuations, and to adapt to steadily declining agricultural labor. It will lead to foundational advances in AI that will have broad benefits in many other areas. It will also lead to a more diverse agriculture and technology workforce.

Animal Health Component

Animal Health Component: 15%

Research Effort Categories

Basic	60%
Applied	30%
Developmental	10%

Classification

Knowledge Area (KA)	Subject of Investigation (SOI)	Field of Science (FOS)	Percent
404	7410	2080	20%
402	7410	2080	20%
601	1510	3010	15%
203	1510	1060	15%
307	3510	2080	15%
102	0110	1000	15%

Knowledge Area

[404] Instrumentation and Control Systems

[402] Engineering Systems and Equipment

[601] Economics of Agricultural Production and Farm Management

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[203] Plant Biological Efficiency and Abiotic Stresses Affecting Plants

[307] Animal Management Systems

[102] Soil, Plant, Water, Nutrient Relationships

Subject Of Investigation

[7410] General technology

[1510] Corn (for sweetcorn use 1480)

[3510] Swine, live animal

[0110] Soil

Field Of Science

[2080] Mathematics and computer sciences

[3010] Economics

[1060] Biology (whole systems)

[1000] Biochemistry and biophysics

Keywords

Agricultural Sustainability, Artificial Intelligence

Goals / Objectives

The broad goals of this project are to achieve foundational advances in AI by developing innovative techniques and use them to address pressing challenges in agriculture. The project will tackle four key agricultural challenges: (1) using low-cost autonomous systems for greater efficiency (increased productivity and reduced impact cost) and labor optimization. (2) improving livestock management through AI-driven monitoring, recognition, and behavioral analysis; (3) designing resilient and profitable agricultural systems through the application of new AI techniques capable of forecasting best management practices under varying conditions across scales; and (4) reducing the risk and uncertainty of crop production using an AI-based predictive framework to target and tailor input with variable rate applications.The specific objectives required to achieve these goals are as follows:Develop new approaches for six foundational AI research goals: learning from limited data, heterogeneous information fusion, integrating domain knowledge into machine learning (ML), federated learning at the edge, learning for control, human-in- the-loop intelligence and generative AI.Develop AI-based techniques to enable autonomous teams of low-cost, mobile robots to perform a variety of agricultural tasks.Enable semi-autonomous monitoring of livestock behavior, using sensors together with novel AI techniques.Use novel learning and heterogeneous data-driven prediction for more effective high-throughput phenotyping and predictive statistical and process-based models.Develop novel machine learning algorithms trained on extensive experimental data and on validated crop simulation models to enable detailed predictions of crop yield, soil water, carbon, and nutrient fluxes across spatial scales in the US Midwest, helping farmers optimize resource usage and maximize returns on investment.

Project Methods

The project is designed around tackling key agricultural challenges using novel AI-based techniques, and carrying out the foundational AI research needed to make those techniques successful. The foundational AI research goals include learning from limited data, heterogeneous information fusion, integrating domain knowledge into machine learning (ML), federated learning at the edge, learning for control, human-in-the-loop intelligence, and generative AI.The agricultural challenges and the AI techniques required for them are divided into four synergistic thrusts. Thrust 1

concerns advancing AI for enabling autonomous farming. This includes advancing learning for navigation and perception with low-cost sensors, reinforcement learning for plant manipulation, federated learning across robots and fields, adaptive communication networks in bandwidth limited agricultural fields, and human-robot interaction methods for intuitive farmer-robot interaction. Thrust 2 concerns advancing AI for optimizing labor in livestock and to enable more autonomy in livestock management. The tasks here include AI for objective and activity recognition from dense video data, processing large volumes of video data on the farm to identify key events and trigger human involvement as needed, and advancing AI to get reliable outputs with low-cost sensors. Thrust 3 is focused on advancing AI for crop operational resilience and adaptability. Tasks here include advancing AI for obtaining reliable predictions from multi-modal, partially labeled, and noise data; identification of critical phenotypes and variables from data from mobile and stationary sensors. Thrust 4 is focused on advancing AI for improving soil health in agriculture. The key tasks here include accurate modeling from sparse geospatial training data, and advancing transfer learning to fill in data gaps.The project will expand and use several innovative and unique experimental facilities to develop and evaluate proposed solutions. These include an autonomous "farm of the future," the SoyFACE facility for evaluating production impacts under open-air production conditions, the Piglet Nutritional and Cognitive Lab, and new experimental microsites at Tuskegee University.The project will also assemble substantial datasets for key challenge problems for agriculture. Investigators will work together to combine data from experiments in autonomous agricultural systems, AI-augmented livestock monitoring, genomics and breeding for crop operational resilience, and soil health monitoring. This project will create comprehensive tools that benefit farm operations, industry partners, and rural economic development.