National Ag Producers Data Cooperative (NAPDC) Webinar

SEPT 19, 2022

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Kang Xia

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Center for Advanced Innovation in Agriculture (CAIA)
College of Agriculture and Life Sciences
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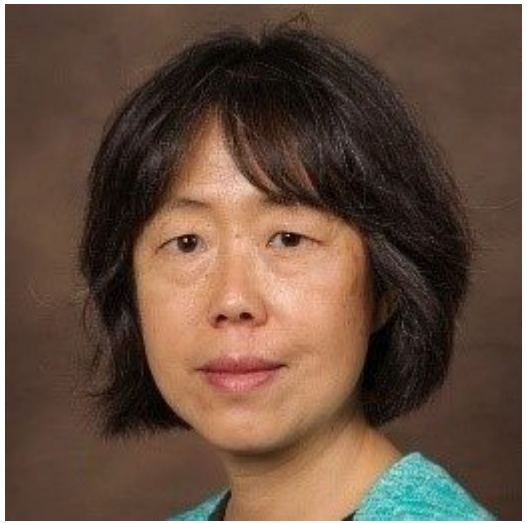
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
CENTER FOR ADVANCED INNOVATION IN AGRICULTURE
VIRGINIA TECH



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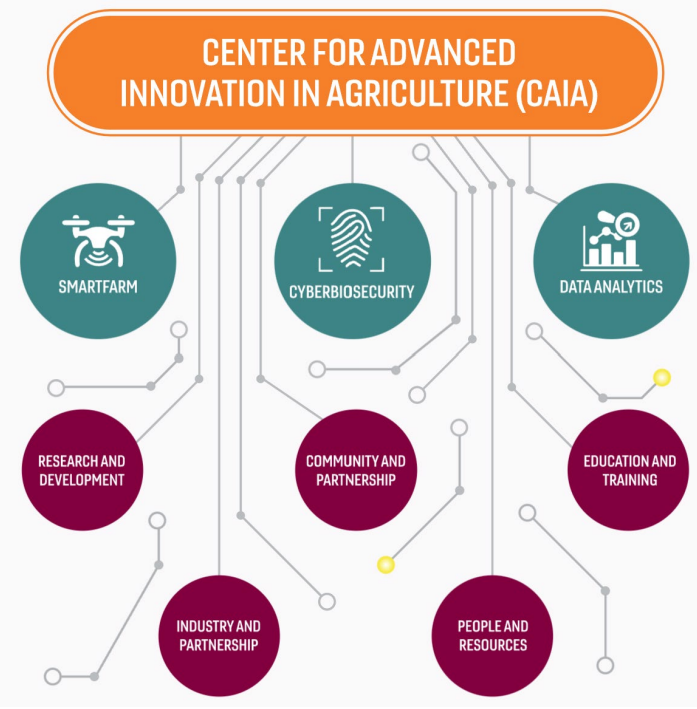
What is CAIA?

- A center within the College of Agriculture and Life Sciences at Virginia Tech.
- Designed to drive innovation and advance agriculture and food systems in the era of digital agriculture.
- CAIA develops partnerships, creates synergies, and evaluates technological efficiencies for economic growth.

We do this by translating research innovation into application and facilitating adoption, workforce development, and awareness.

CAIA's strength is in the vast diversity of knowledge and expertise of our affiliated faculty and our partnerships.



https://caia.cals.vt.edu/

Director: **Susan E. Duncan**
Associate Director of Virginia Agricultural Experiment Station

Associate Director: **Kang Xia**
Professor, School of Plant and Environmental Sciences

SmartFarm Innovation Network

- Outcome of 2018 summit on Agricultural and Natural Resources (ANR):
  - Rapid digitization of agriculture
  - Need for security
  - Need for increased productivity to meet the demand of increasing population & climate change
- Precursor to CAIA and one that is based on VT's strength

Cyrus McCormick's reaping machine (1831) (https://www.thoughtco.com/mccormick-reaper-1773393)

VT Shenandoah Valley Agricultural Research and Extension Center

10,000 BCE **1800**

Agriculture Revolution

Birth of Agriculture: 10,000 BCE

1st Revolution: mechanization, steam, water power

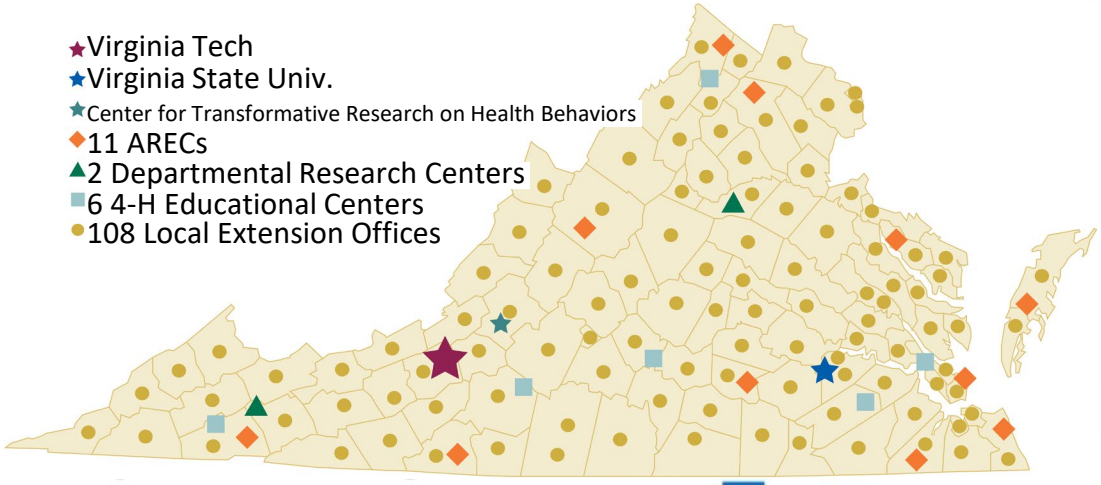
2nd Revolution: mass production and electricity

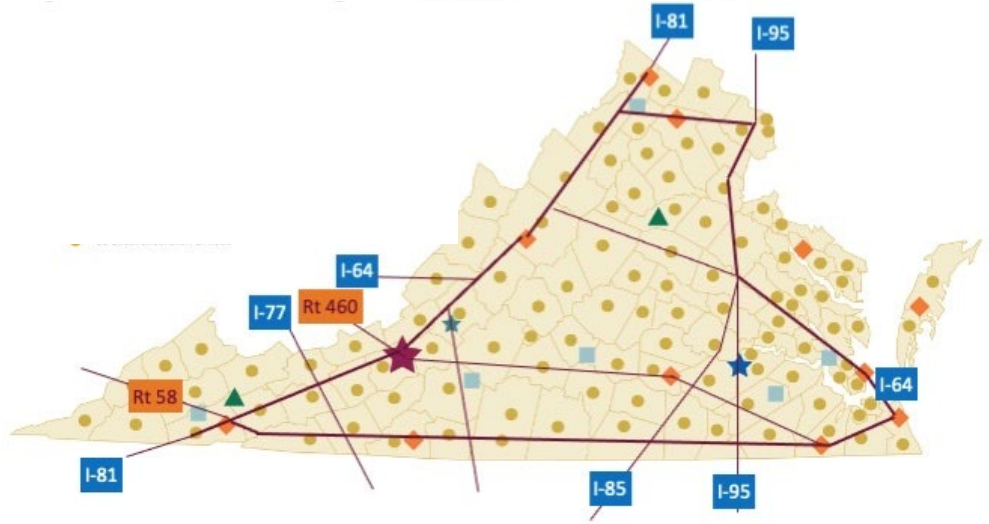
3rd Revolution: Electronic and IT systems, automation

4th Revolution: Cyber+physical+ biological systems

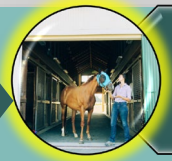
SmartFarm Innovation Network

- Virginia Tech
- Virginia State Univ.
- Center for Transformative Research on Health Behaviors
- 11 ARECs
- 2 Departmental Research Centers
- 6 4-H Educational Centers
- 108 Local Extension Offices





SmartFarm Innovation Network®



Sustainable Precision Animal Agriculture

Controlled Environment Agriculture Innovation Center

Smart Technologies for Crop and Green Industries

→ CENTER FOR ADVANCED INNOVATION IN AGRICULTURE (CAIA)

Building a network of interconnected technology centers to spark a new economy

SmartFarm INTEGRATIONS

- Cyberbiosecurity
- Cloud computing
- Data science
- Systems modeling
- Robotics
- Artificial intelligence
- Sensors and biosensors
- Precision agriculture
- Geospatial technologies

SYSTEMS
TECHNOLOGY
SUSTAINABILITY
SOCIO-ECONOMICS
HUMAN BEHAVIOR
POLICY

- Biodesign and genetics
- Vertical farming
- Food security
- Renewable resources
- Systems biology
- Synthetic biology
- Social and environmental issues

10,000 BCE — **1800** — **Agriculture Revolution**

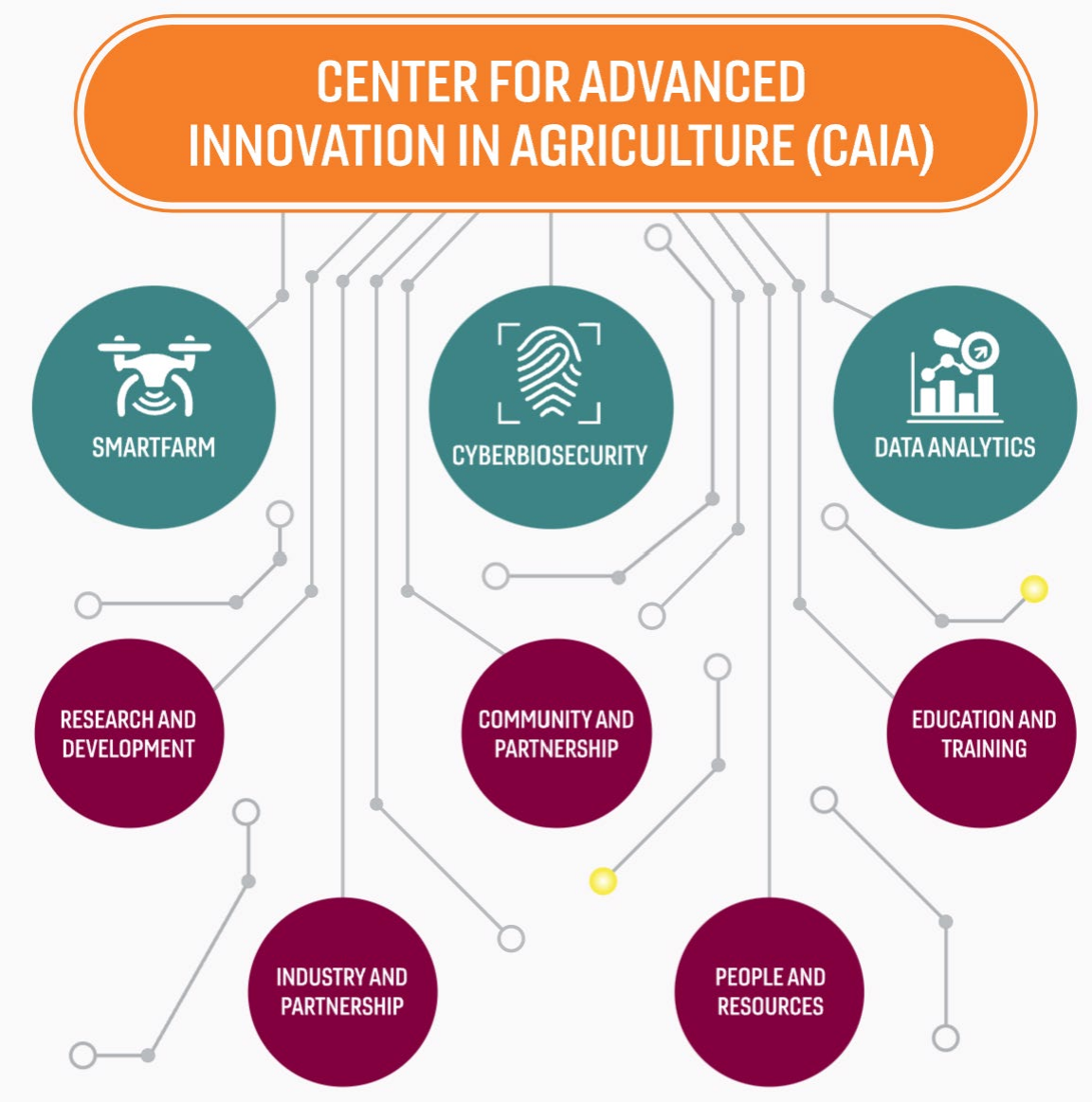
- Birth of Agriculture: 10,000 BCE
- 1st Revolution: mechanization, steam, water power
- 2nd Revolution: mass production and electricity
- 3rd Revolution: Electronic and IT systems, automation
- 4th Revolution: Cyber+physical+ biological systems

CAIA's overarching GOAL is to:

Establish Virginia Tech as a comprehensive & innovative ***global*** research leader in smart and secure agriculture technologies and data analytics for informed decisions.

Vision is to foster **informed decisions** using agricultural technologies and analytics for growth and research opportunities

Mission is to leverage science and technology to create **transformative solutions** to support agriculture and food systems, the environment, and communities in the Commonwealth and beyond



How will the CAIA achieve its vision and mission?

- Rely on scientific **discovery** and **application**
- Focus on **intersection/integration** of platforms: SmartFarm and agricultural technology, cyberbiosecurity, data analytics and decisions
- Derive **technology-driven** innovative solutions
- Address **challenges** and **security** in the domains of plants, animals, and food systems connecting the natural world and human society
- **140 CAIA-affiliated faculty + growing external partnerships**
- **Graduate student affiliated group**

COLLEGE OF AGRICULTURE AND LIFE SCIENCES
VIRGINIA TECH

A COLLABORATIVE NETWORK OF FACULTY…

CAIA success is based on the convergence of faculty from different disciplines, domains and skills to inspire innovation.

VIRGINIA AGRICULTURAL EXPERIMENT STATION
VIRGINIA TECH

NEW FACULTY SINCE JANUARY 2022

SMARTFARM INNOVATION NETWORK® CLUSTER GROUP

CAIA GRADUATE STUDENT AFFILIATES GROUP

COLLEGE OF SCIENCE
VIRGINIA TECH

VIRGINIA TECH TRANSPORTATION INSTITUTE

ENGINEERING
VIRGINIA TECH

Commonwealth Cyber Initiative

Commonwealth Cyber Initiative
SOUTHWEST VIRGINIA

GO VIRGINIA

VA Innovation CENTER (VIC)

FRALIN LIFE SCIENCES INSTITUTE
VIRGINIA TECH

COLLEGE OF NATURAL RESOURCES AND ENVIRONMENT
VIRGINIA TECH

PAMPLIN COLLEGE OF BUSINESS
VIRGINIA TECH

Governance

Administrator: Dr. Alan Grant, Dean, College of Agriculture and Life Sciences

Director: Dr. Susan Duncan, Associate Director of Virginia Agricultural Experiment Station

Associate Director: Dr. Kang Xia, Professor, School of Plant and Environmental Sciences

Internal Faculty Leadership Group: VCE: Dan Goerlich, Kim Niewolny; **AREC:** Michael Schwarz; **CALS Comm:** Zeke Barlow; **CALS Advancement:** Vernon Meacham; **Platform Leaders:** Robin White, Mike Evans, Michael Schwarz, Joseph Oakes, Ford Ramsey, Tiffany Drape; **Faculty Fellows:** Maria Balota, Eric Kaufman, Biswarup Mukhopadhyay

Internal Stakeholders Committee: CALS Dean, Associate Deans, Asst. Dean of Finance, and representative (3) Department Heads

Administrative Support: Becca Emery

Proposal Development Support: Kira Gantt

External Partnerships

Internal Faculty Leadership Group: VCE: Dan Goerlich, Kim Niewolny; AREC: Michael Schwarz; CALS Comm.: Zeke Barlow; CALS Advancement: Vernon Meacham; Platform Leaders: Robin White, Mike Evans, Joseph Oakes, Tiffany Drape, Ford Ramsey

External Advisory Committee

- Representation
- Partnership
- Motivation

Industry-University Partnerships

- Representation
- Return
- Re-investment

Community-University Partnerships

- Growth
- Development
- Training

SHORT TERM MILESTONES
(within the first 5-years)

July 2021-May 2022 : >$53.5M in proposals identified CAIA

- **Leadership** and **administrative** structure
- Competitive **seed funding** RFA
- Ongoing affiliate faculty seminars, workshops, team building

- **Platform** Teams
- Interdisciplinary **graduate education program**
- Annual **seminar** and **training** series
- External Advisory Council

- Partnerships between CAIA, CCI-affiliated universities, industry
- External Communications **network**
- Workforce training

- **Pursue large Center** and **Research Grants**
- **Increase overall funding and technology capacity**
- **Partnerships and Impacts**

LONG TERM MILESTONES
(10 years)

- PhD students receiving CAIA affiliated transdisciplinary **graduate education certificate**

- Major **federal** and **industry funding** support of CAIA platforms
- Intellectual property **disclosures** and company **start-ups**

- **National** and **global** recognition and impacts

- VT CALS as a **workforce** training center **destination**
- **Community engagement and Ut Prosim service**

Chreston Miller

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Assistant Professor
Data and Informatics consultant, Engineering
Data Services, University Libraries
Virginia Tech

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Why The Libraries?

UNIVERSITY LIBRARIES
VIRGINIA TECH

- Data Services of the University Libraries have been developing and growing within the last few years
- Specifically, support for data analytics and machine learning
- Application of this support for CAIA began with one project in Food Science and Technology…

https://lib.vt.edu/research-teaching/data-services.html

Seeing Flavors

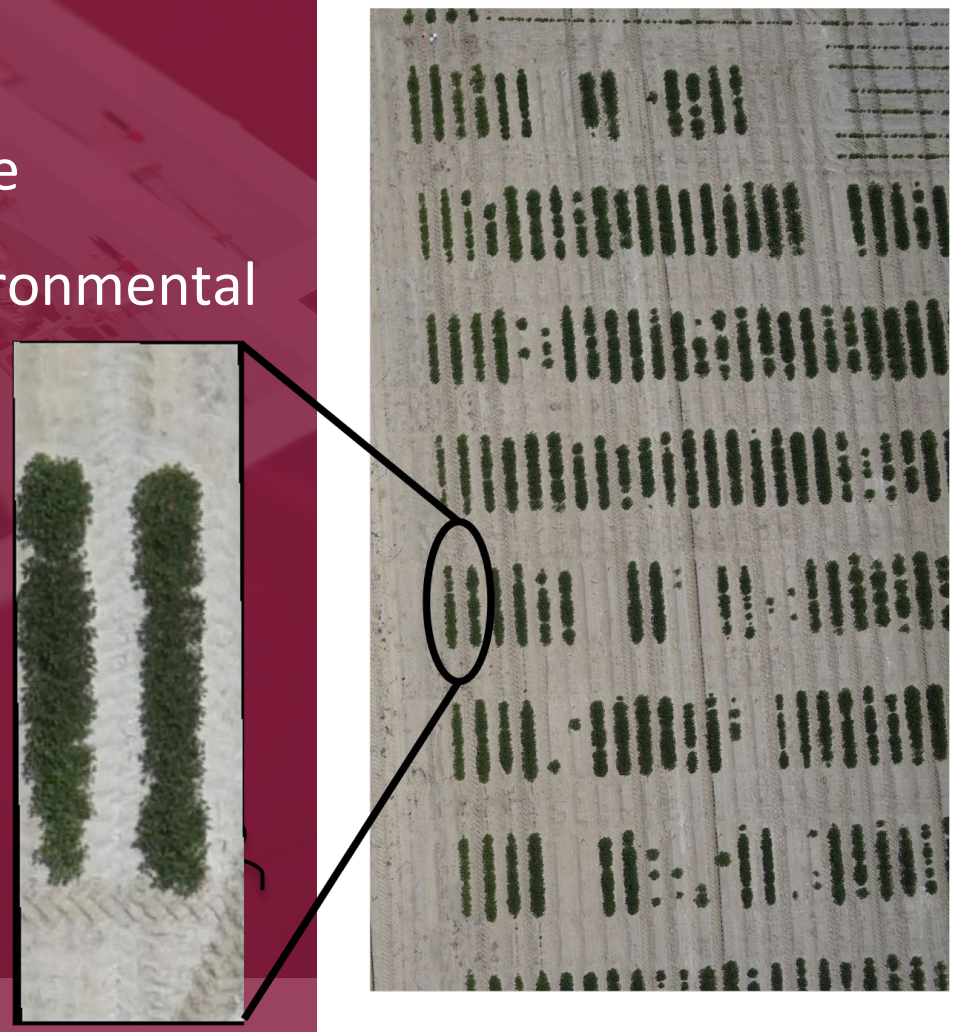
- Application of machine learning to identifying unique language descriptors within whiskey descriptions
- Work with Dr. Jacob Lahne and Dr. Leah Hamilton

Started a Partnership

- This started a partnership between the University Libraries and CAIA with current and future projects…

Wilting Detection

- Resulted from Demystifying Machine Learning course
- Grant Proposal with CALS' s School of Plant and Environmental Sciences (located at the Tidewater AREC).
  - Informatics Lab (within Data Services) is Co-PI
- Help Peanut breeders
  - Aerial images taken by drones
  - Predict wilting scale of plots

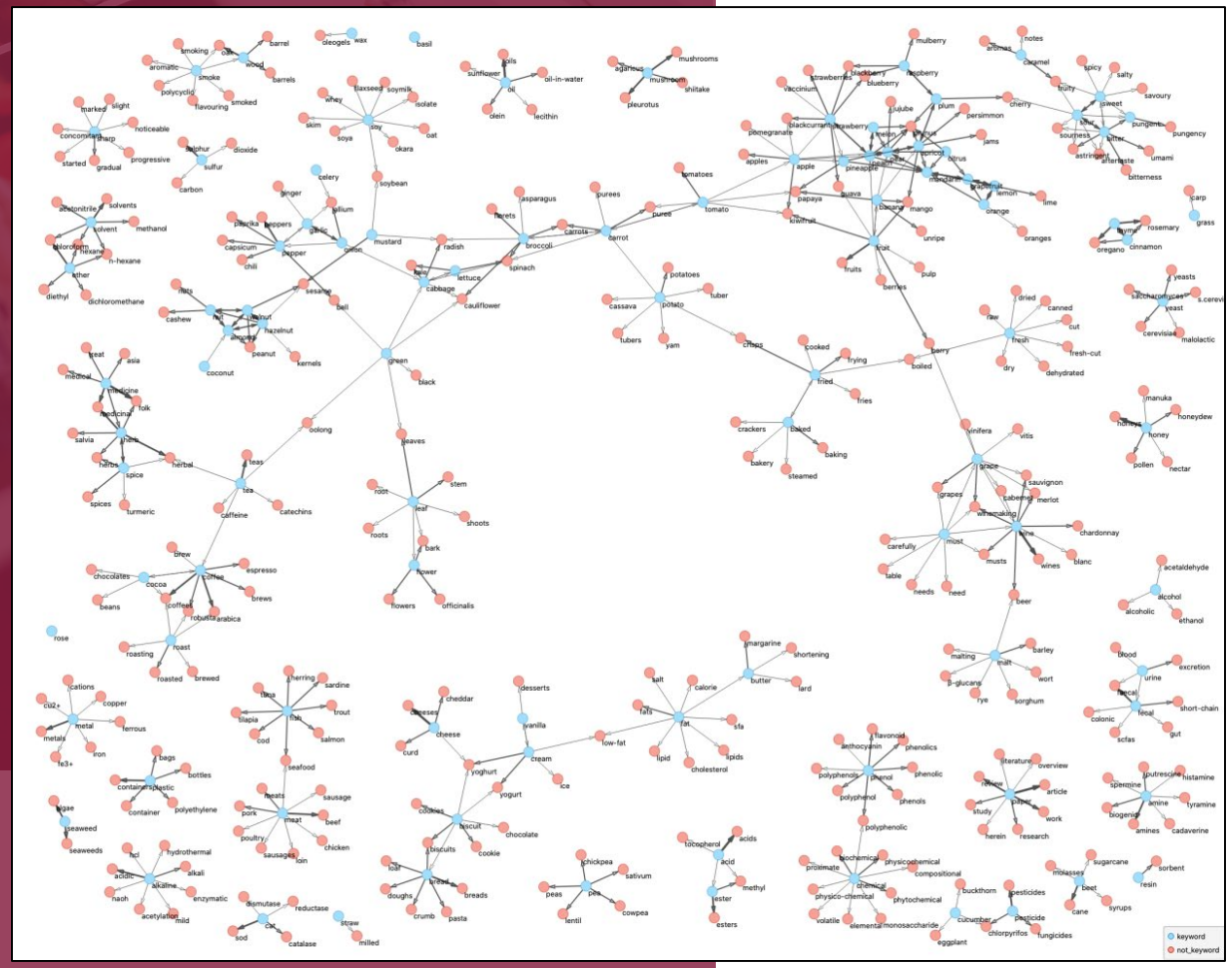


NLP for Food Science and Food Chemistry

Identification of new knowledge and research directions through the analysis of Food Science and Food Chemistry journal abstracts

Food Science Journals

Food Chemistry Journals



Identifying Turf Grass Diseases

- Identification of “bare spots” caused by disease in turf grass
- This identifies where to focus treatment

Support for Researchers

UNIVERSITY LIBRARIES
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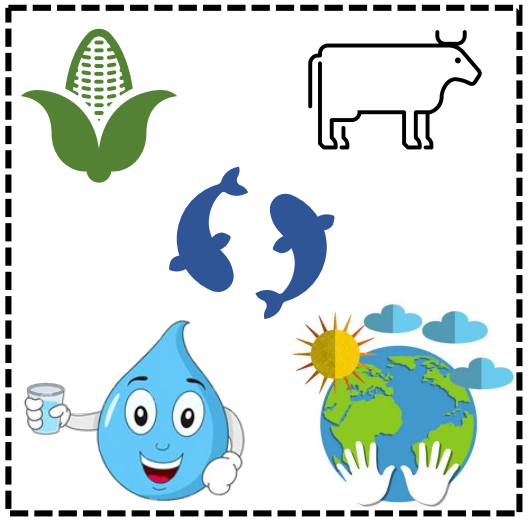
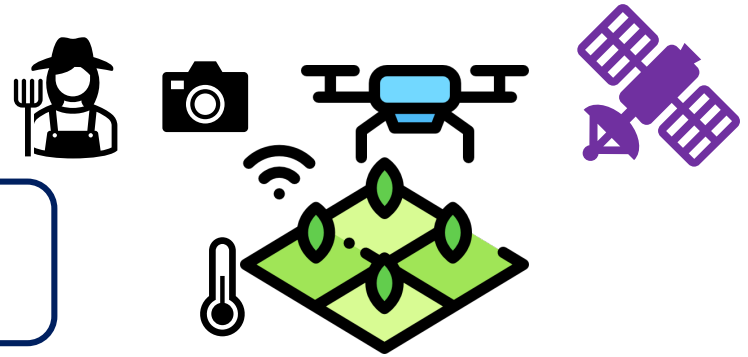
Program Focus: “farms of the future”

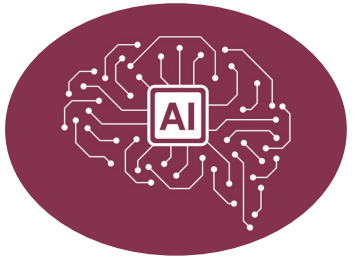
Semi-autonomous to autonomous agricultural practices



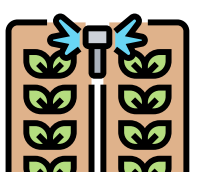


Monitoring

Data analytics

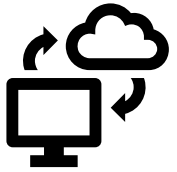


Autonomous management

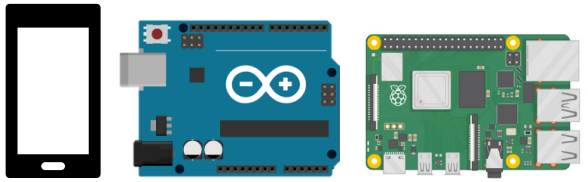


Local

Cloud

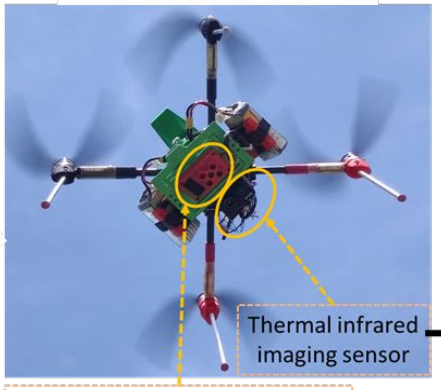


Edge

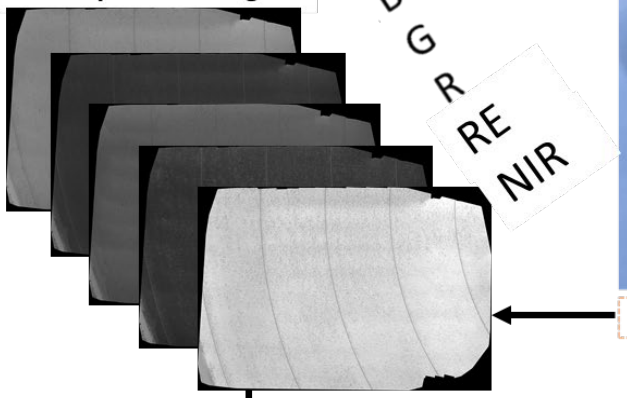


Field/regional scale crop water use mapping

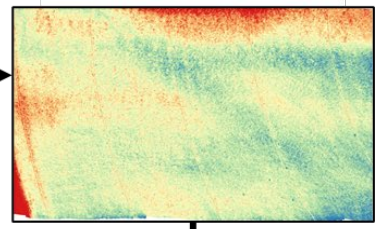
Small UAS aka drone



Multispectral images



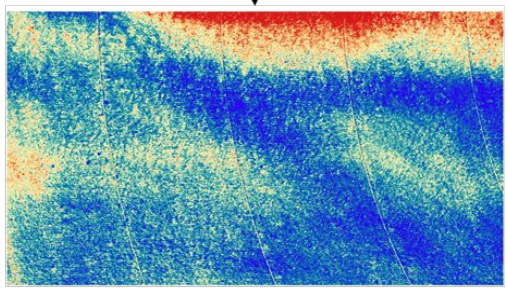
Temperature image



Weather data

Source: WSU AgWeathernet

Energy balance model



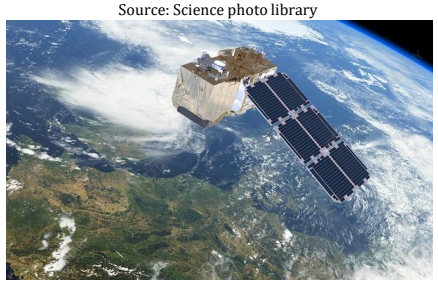
Crop evapotranspiration map

MODIS satellite (1 km/pixel)

Source: NASA

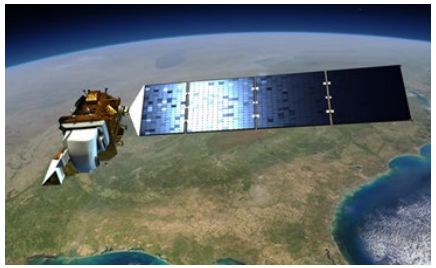
Sentinel 2A satellite (11 m/pixel)

Source: Science photo library



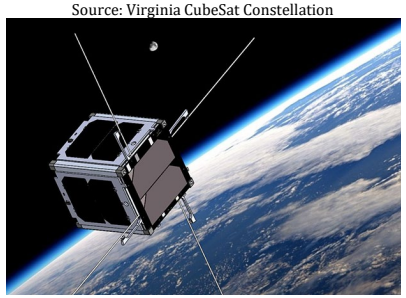
Landsat 8 satellite (30 m/pixel)

Source: NASA



CubeSat 3U satellite (3 m/pixel)

Source: Virginia CubeSat Constellation

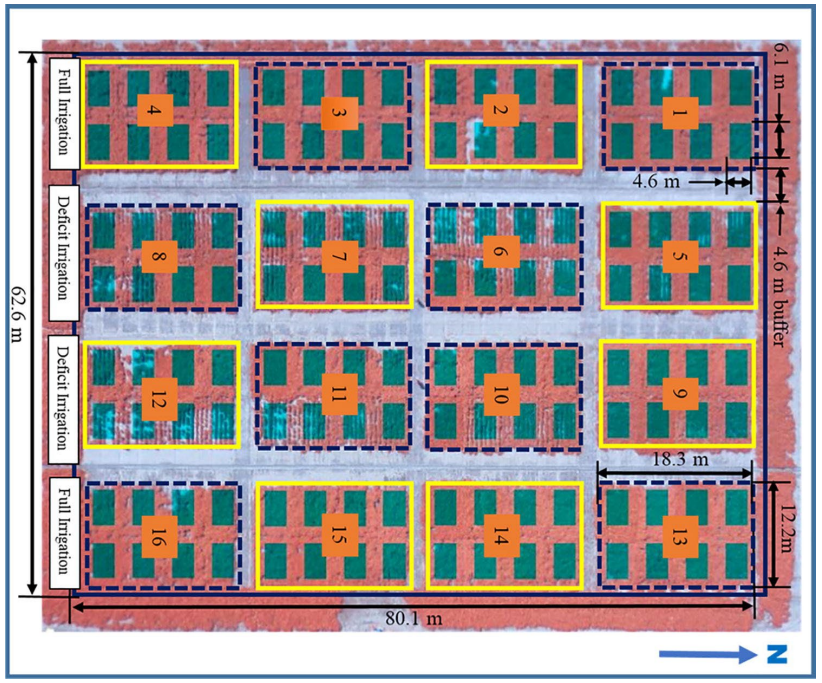


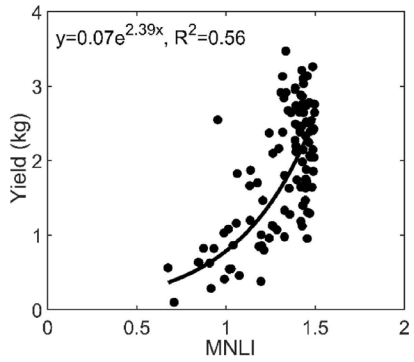
Kompsat satellite (1 m/pixel)

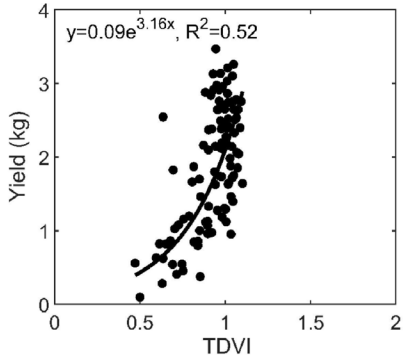
Source: eo portal

High throughput phenotyping

Pinto bean

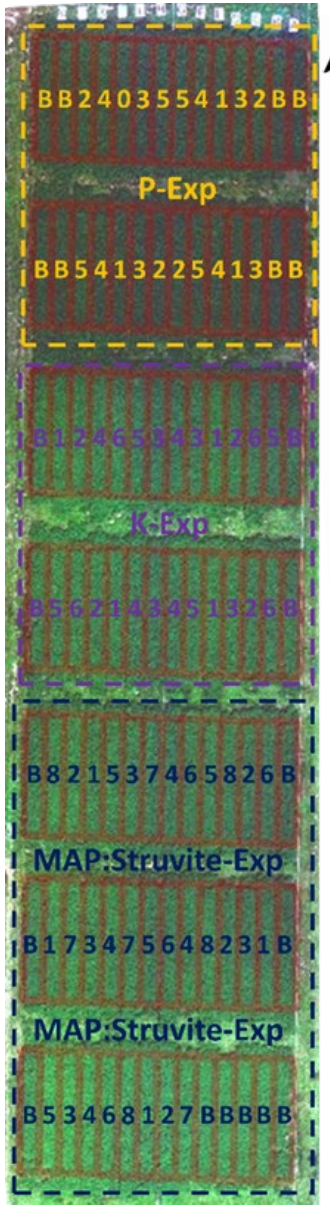




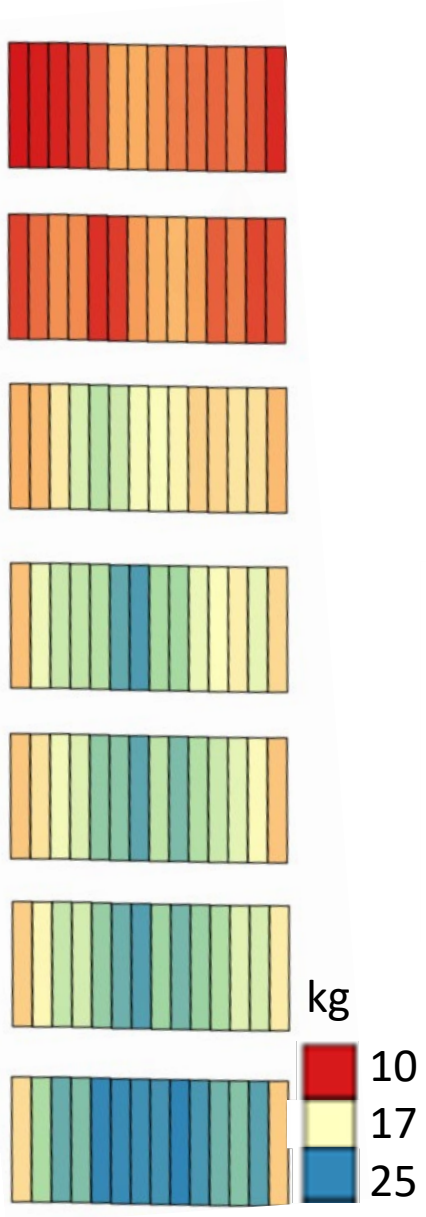


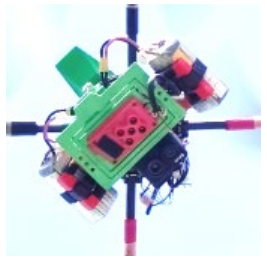
Information processing in agriculture, 2019, 6(4), 502-514
Computers and electronics in agriculture, 2021, 182, 105999

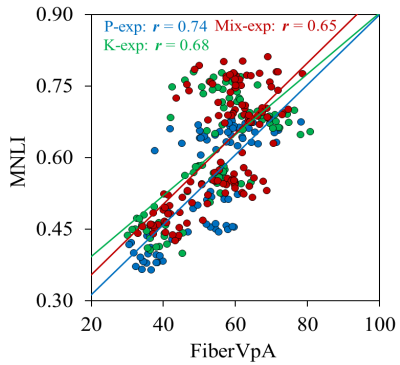
Alfalfa

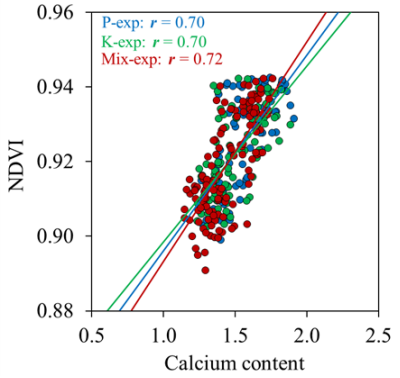


Yield map



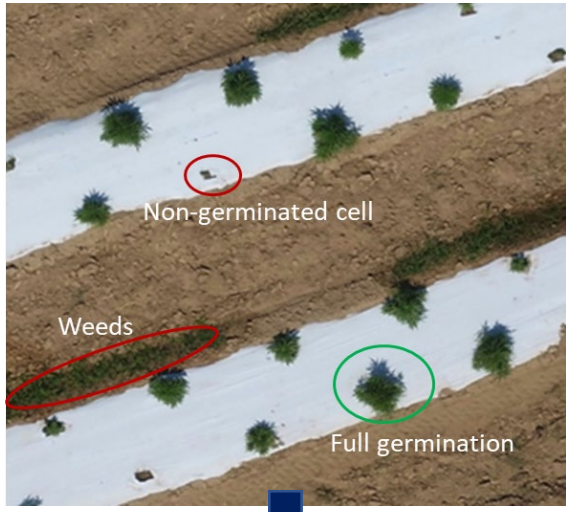




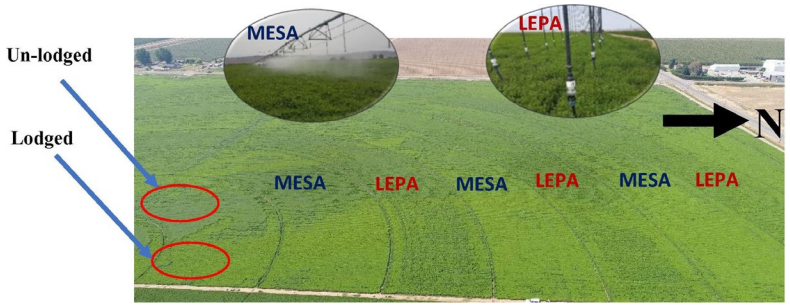


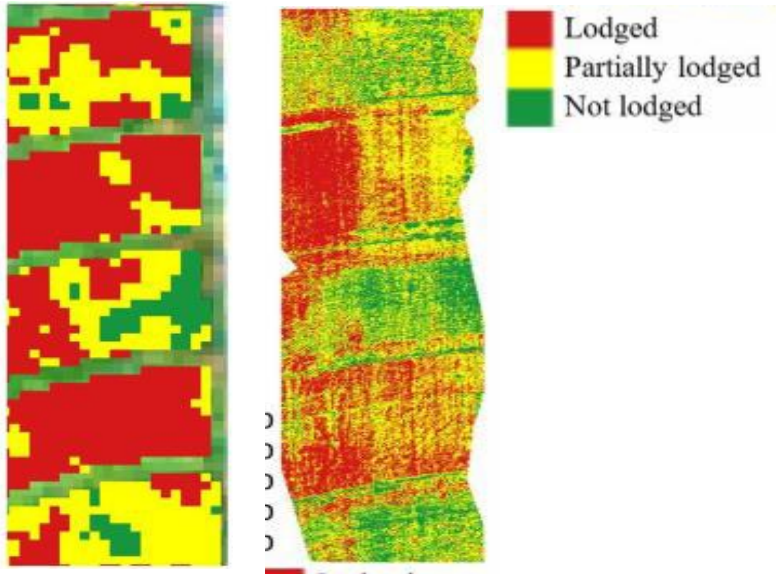
High-throughput crop status mapping

Non-germination



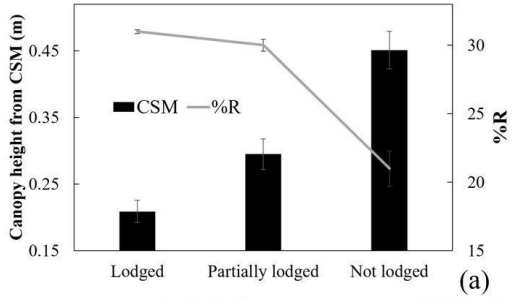
Crop lodging

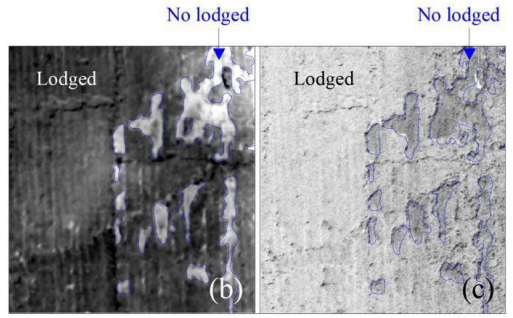


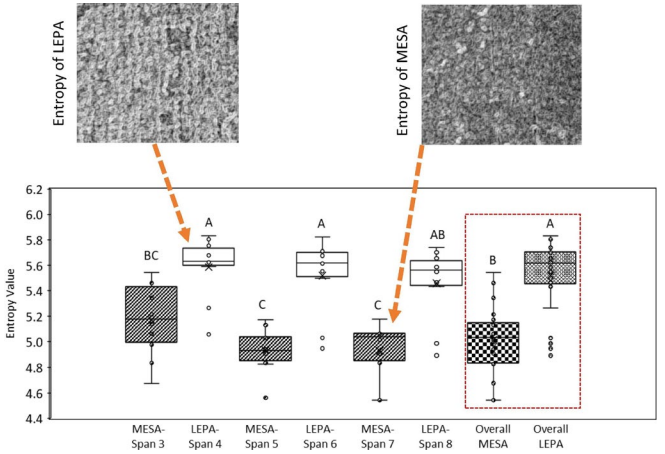


IEEE Geoscience and remote sensing letters, 2019, 17(5), 755-759

Information processing in agriculture, 2021, 8(3), 1-8



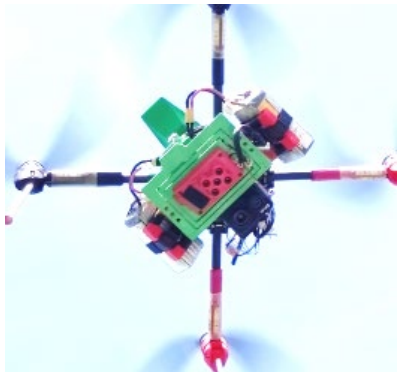


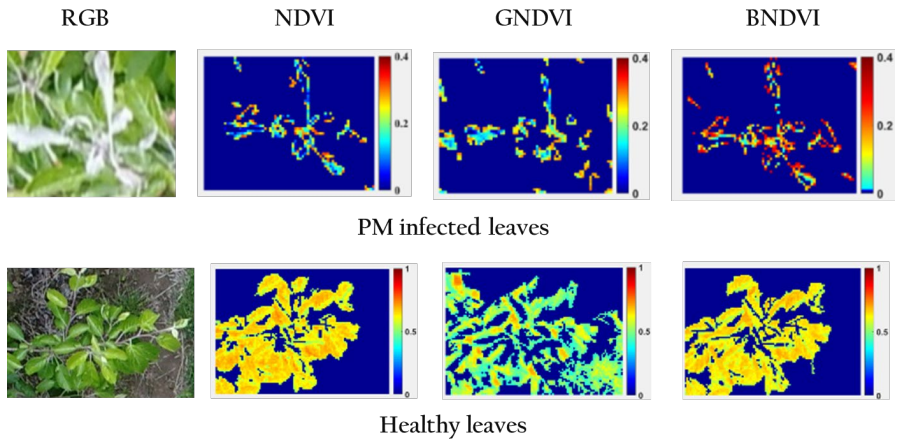


Field-scale disease infestation mapping

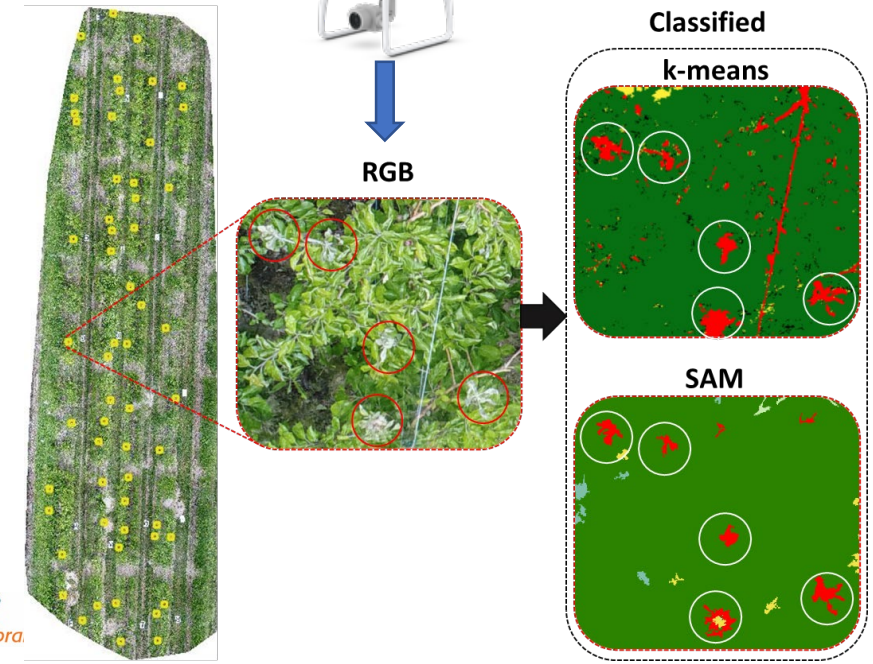
UAV-based high throughput spectral imaging and machine learning

Powdery mildew in apples

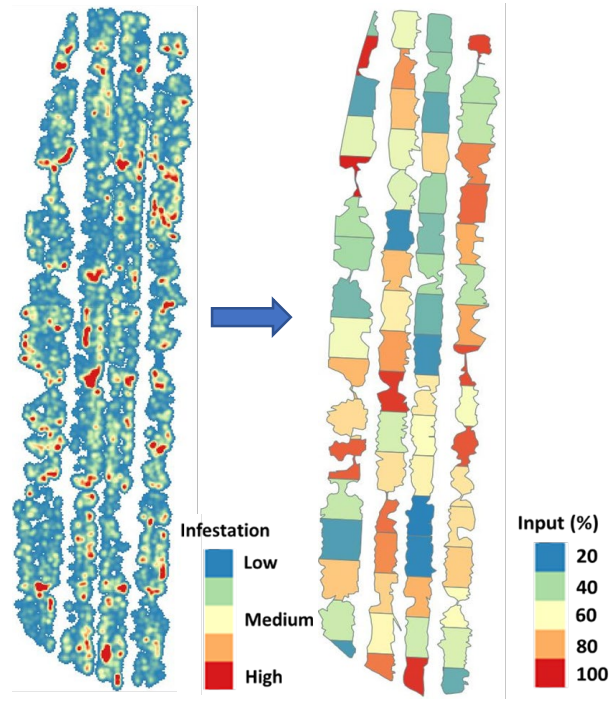




Accuracy: ~77%



Heatmaps prescription map



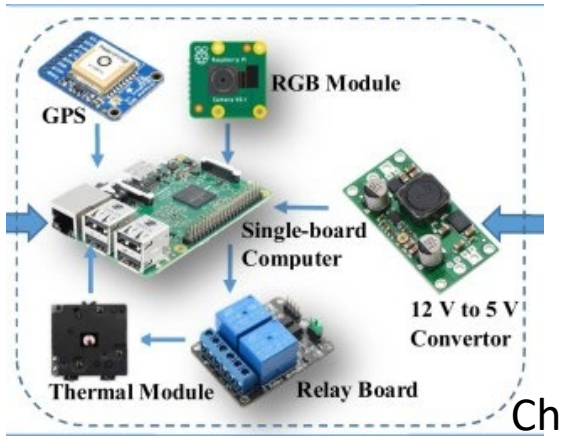
Scientia horticulturae, 2021, 287, 110228.

Edge-based solutions

Smartphone applications

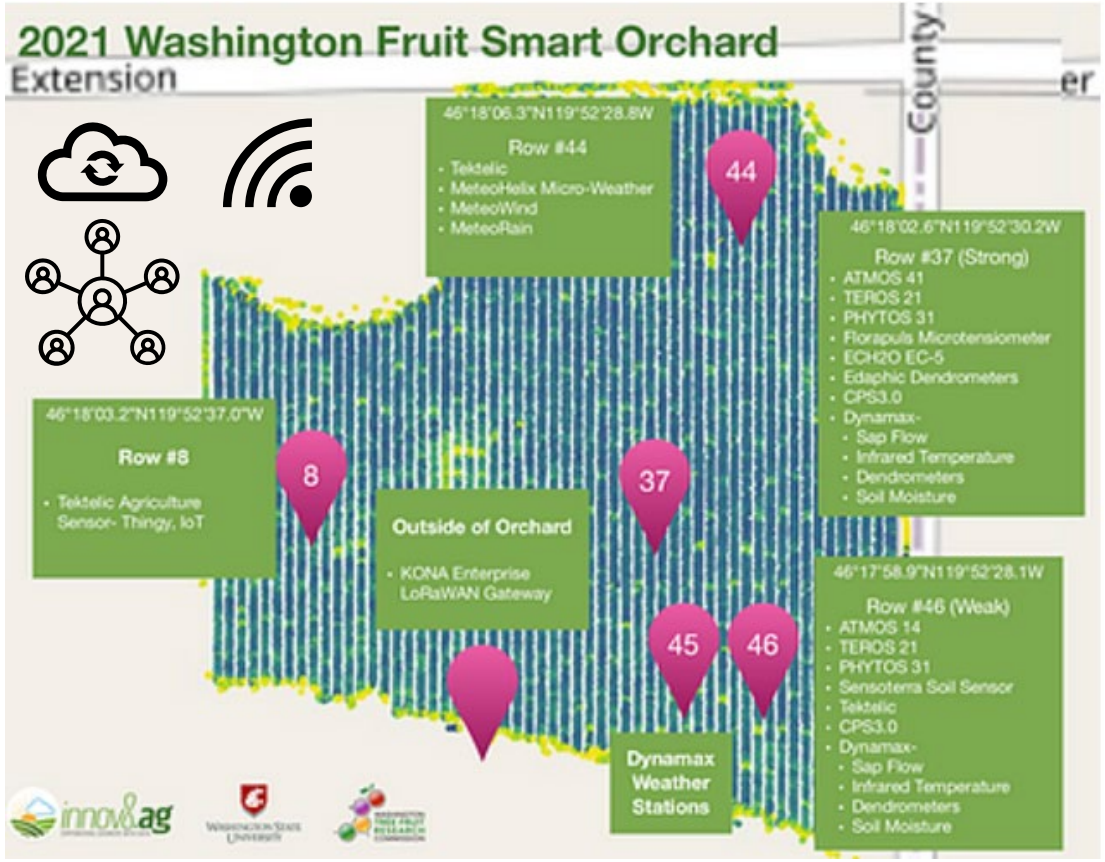
Crop ecosystem monitoring and management

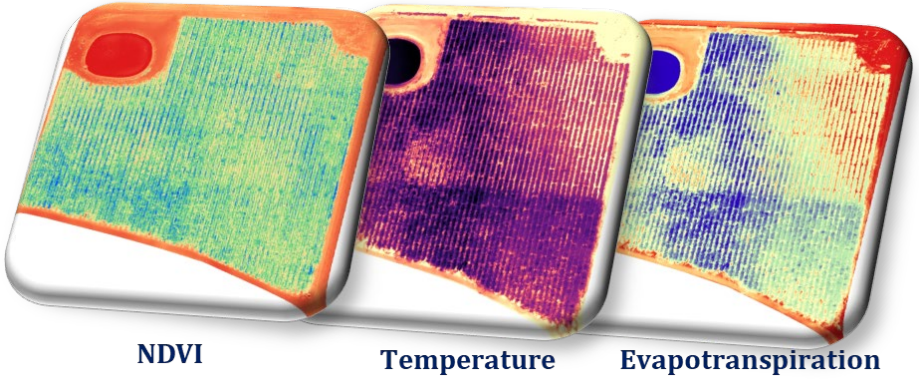
Custom sensor developments



Chandel et al., 2019

Smart farm testbeds



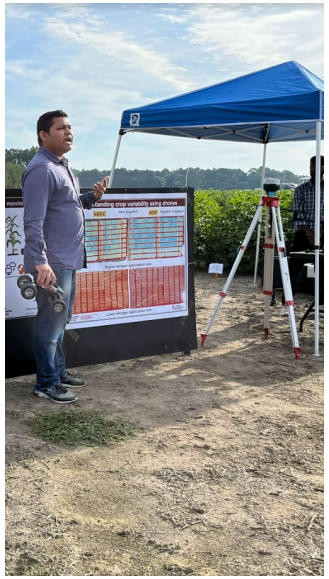


Participants

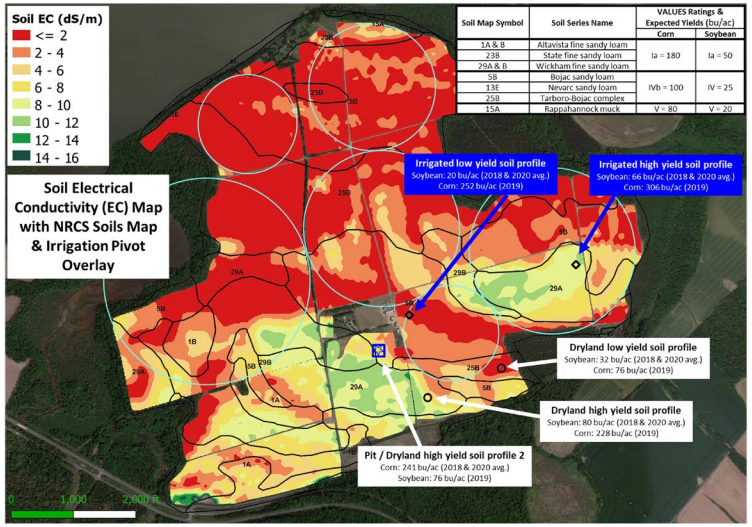
WA tree fruit research commission
Growers
Extension specialists
Government agencies
Horticulturists
Precision ag scientists
Sensor and data mgmt. companies

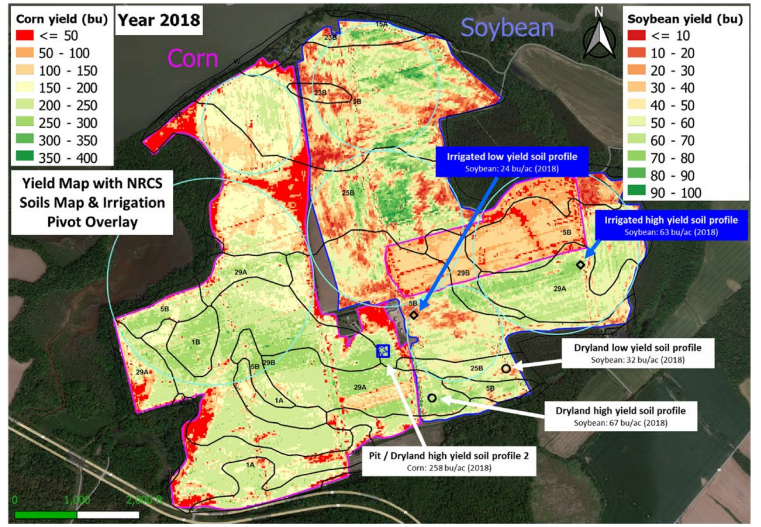
THINGY:IoT
teralytic
Aker
Microsoft
Dynamax
SmartApply
ARABLE
AquaSpy
ceres
DAVIS
AgriNET
AgWeatherNet
METER
Agricultural and Forest Meteorology
FRUIT MATTERS
IEEE Xplore Digital Library
Washington State University
Washington State Tree Fruit Association

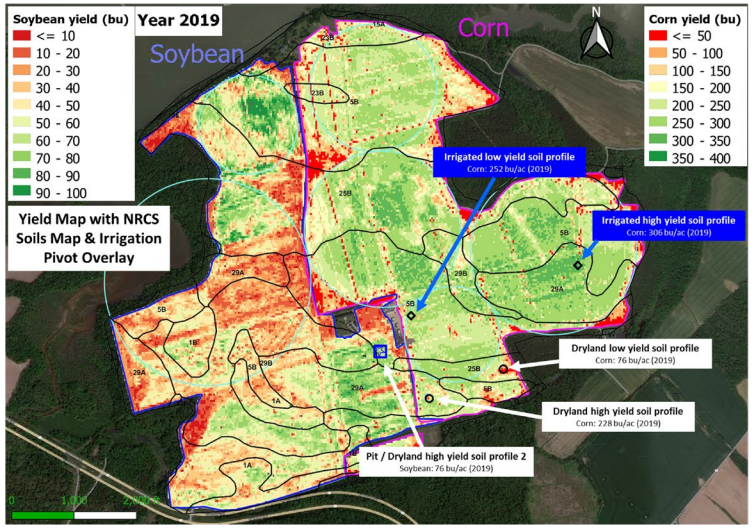
Technology and information dissemination to end users

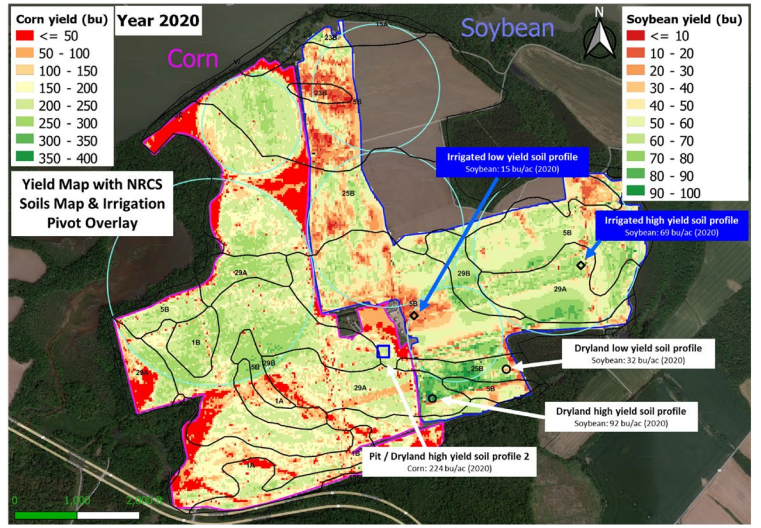


Understanding corn and soybean yield variabilities









Virginia AG EXPO
Thursday August 4, 2022

COLLEGE OF AGRICULTURE AND LIFE SCIENCES
CENTER FOR ADVANCED INNOVATION IN AGRICULTURE
VIRGINIA TECH

Virginia Cooperative Extension
Virginia Tech · Virginia State University

USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

Tiffany Drape

(tdrape@vt.edu)

Assistant Professor
CAIA cybersecurity + Biosecurity
Ag Leadership & Community Education
Virginia Tech

COLLEGE OF AGRICULTURE AND LIFE SCIENCES
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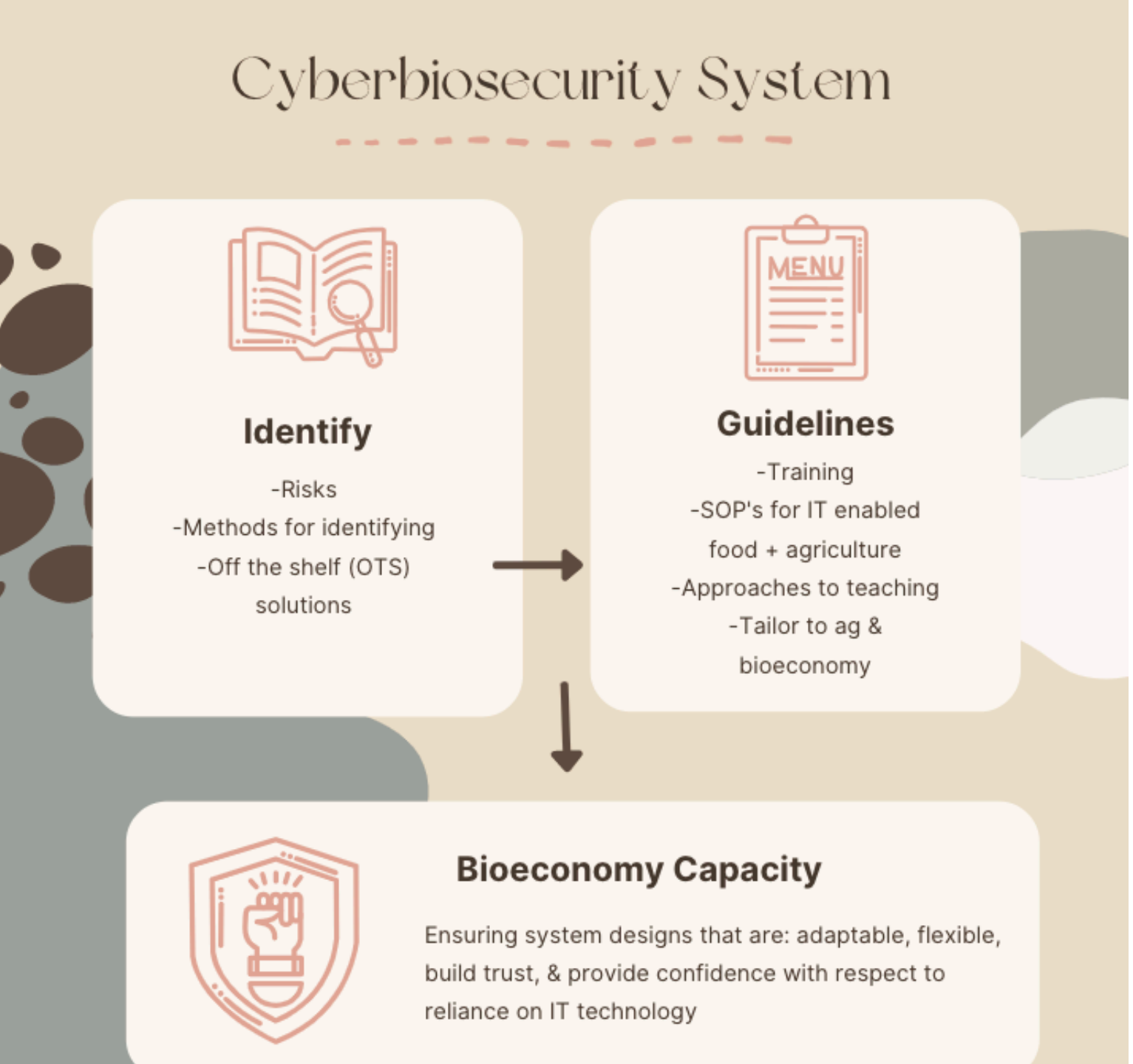
VIRGINIA TECH

National Ag Producers Data Cooperative (NAPDC) Webinar

SEPT 19, 2022

Integrating Cybersecurity and Agricultural Innovation



Cyberbiosecurity is an emerging discipline addressing the educational and workforce gap between cybersecurity, cyberphysical systems and biosecurity.

Our approach

- Cyberbiosecurity ***combined workforce development in agriculture & the life sciences (ALS)***
- ***TEACH*** data security in ALS through ***Experiential Learning class***
- Each student enrolled in the course ***is offered an internship placement***
- Practical knowledge of how to ***navigate an internship*** through workforce development training
- Students are ***exposed to the industry & partners*** through social interactions

AGRI-TRAK

Deloitte.

JOHN DEERE

What’s the impact on security?

- Why should people care?
- This EL course will ***increase capacity building of the cyberbiosecurity field &*** its partners
- The study will reinforce if there is enough interest in the program to ***expand the learning opportunities*** beyond this program
- Results should reveal if this ***work is replicable*** for other course & programs to utilize
- The course efficiently contributed to ***the training & development of the future workforce***

What are the outputs?

- Curriculum: QR Code to FREE curriculum
- Student placement in jobs/internships
- Increased efficacy in students post experience
- Across discipline collaboration

- https://vtechworks.lib.vt.edu/handle/10919/111501

Other efforts in CAIA

Agricultural Leadership for Cyberbiosecurity: A Teaching Case Study

Eric Kaufman, Agricultural, Leadership & Community Education, Virginia Tech

- Draft a **teaching case study** highlighting agricultural leadership for effective cyberbiosecurity.
- **Pilot test** the teaching case study with undergraduate agricultural science students.

Outcome: Distribute a refined version of the case study for use by Virginia Community College System faculty.

Measuring the Causal Effects of Outliers in Agricultural Supply Chains Using AI

Feras A. Batarseh, Bradley Department of Electrical and Computer Engineering (ECE), Virginia Tech

- Causality-based AI assurance framework (using Python's DoWhy Library).
- Data: county-level **yield data** (corn, soybean, & cotton) (NASS) & **climate data** over **40 years**.
- Perform causal inference by modeling **climatic variability, price, & crop yield**.
- Using AI-driven causal inference, gain insights into what **would happen to supply chains** if there are some **meteorological, cyber, or policy changes.**

Outcome: Policy makers & stakeholders understand the effect of various parameters on the overall supply chain.

Thank you!

Questions?

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