


Research Outline

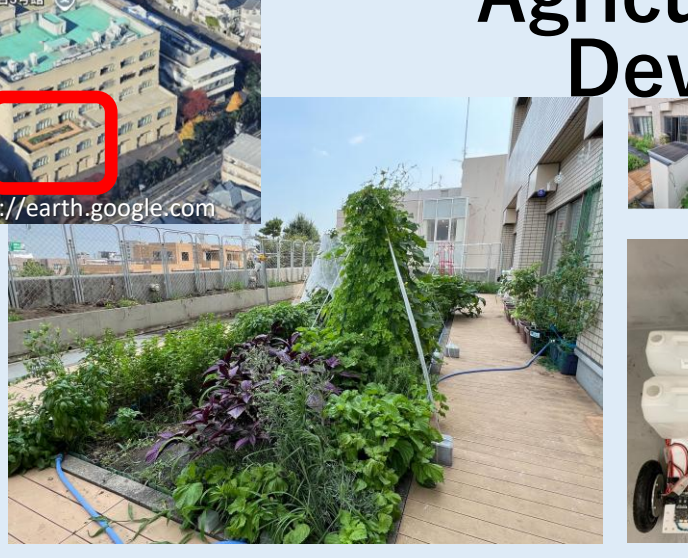
Our laboratory promotes **Smart Agriculture** through a comprehensive framework integrating **mechanical systems**, **robotics**, **sensing**, and **AI**:

- **Off-grid Energy & Communication**: Providing stable power, water supply, and telecommunications to remote agricultural sites.
- **Sensing**: Monitoring temperature, humidity, light intensity, pH, plant growth, and other key variables.
- **Actuation**: Automating soil and crop management (e.g., pruning and harvesting), including **automated robotic systems for tomato lower-leaf processing** and **wildlife-damage prevention device** development.
- **Ecosystem-based Organic Agriculture**: Advancing sustainable, organic farming that leverages biodiversity.

Digital Twin: The core platform integrating these technologies—visualizing field data from robots, sensor networks, and **smart agricultural boots** for environmental mapping—and delivering real-time predictions for optimal cultivation strategies. Through integrated **research and education**, we shape the future of socially implemented, inclusive agriculture and help realize a **sustainable, productive, and inclusive Super Smart Society**.



Smart Agriculture Research & Education Field
@ Suzukakedai Campus



Urban Rooftop Farm
@ Ookayama Campus

Development of an Automated Robot System for Lower Leaf Processing Operations

- We are collaborating with Fukatsu et al. at the National Agriculture and Food Research Organization (NARO) to **develop a robotic system that automates lower leaf removal - a task requiring significant labor after harvesting in tomato cultivation.**
- **2025–2027 Grant-in-Aid for Scientific Research (B) “Realization of a Cultivation Support Robot System Capable of Handling Work Targets Obstructed by Branches and Leaves” (Collaborator).**

Conventional Method

Proposed Method



Rotary Cutting Mechanism with Opening and Closing Function

Main stem camera recognition, Robot arm tracking control for the main stem [1]

Main Stem Holding and Moving Mechanism [2]

[1] Kashino, Fukatsu, et al, Geen Sys 2023, P502-05, [2] 深津、他, JSAI2023

Technology under development

Creating New Value with Remote Agricultural Support Systems

- Focusing on the “severe labor shortage” in Japan's agriculture and the “potential workforce of people with disabilities who face physical barriers to participation.” This initiative leverages agricultural activities themselves as rehabilitative training, reconstructing a new relationship between people with disabilities and farm work.
- A novel approach to enhance the well-being of people with disabilities—specifically their physical and mental health, social participation, and self-actualization—through **tactile feedback-based remote agricultural support**.
- Funded by the University's Basic Research Organization New Research Development Grant, this collaborative project is underway (2025–) between the Medical and Dental Sciences Program, Aging Control Science Course (Tohara, Yamaguchi et al.) and the School of Environment and Society, Innovation Science Division / Professional Degree Program in Technology Management (Kimura et al.).

Persons with disabilities (operating side)

Design and prototyping of haptic (tactile) control devices, development of remote control interfaces

Development of Evaluation and Verification Test Methods for Work Adaptation Based on Disability Characteristics, Evaluation and Verification Testing, Assessment of Work Efficiency and Psychological Effects

Formulation of guidelines for implementing well-being design of social implementation plans and policy development considering multiplier effects for healthy individuals from R&D strategy and technology management perspectives

Agricultural work (remote area)

Operator Side

Person with disabilities

Haptic Control Device

Internet (Web, etc.)

Remote Area

Operator Area

Monitor

Haptic Control Device

Operator

Research Outline Concept Illustration

Prototype System

(Putri and Takahashi, et al, IWAEM2024.)

Development of a Remote Control System Utilizing Haptic Devices to Accelerate Agricultural Support for Persons with Disabilities and Its Implementation in a Well-being Society

Smart Agriculture Boot Development and Digital Twin

- Using **agricultural work boots equipped with wearable sensors (smart agriculture boots)** to measure field environment data on the move, then **integrating that data to build an agricultural digital twin with farm sensor network and other robots.**
- Conceived an original approach: **“Transforming the worker themselves into a sensor platform.”**
- Achieves high-resolution, time-series environmental information mapping that complements conventional fixed sensors and remote sensing with robots, enabling labor-saving and advanced agricultural production management.
- Collaboration with Univ. Virginia, Furukawa et al. ongoing (2025–).

Farm worker

Potential Communication Base Station in Mountainous Areas (Lora, LPWA, Starlink, etc., Mobile Type)

Power: Utilizing off-grid power sources such as solar power generation

Mapping of Field Environment Information

Sensing + Farming Operations + Feedback to Automated Cultivation Systems, etc.

Smart Agriculture Boots (Agricultural work boots equipped with wearable sensors)

Upper: Equipped with IMU

Sole: Equipped with soil sensor

Side: Equipped with optical sensor

Smart Agriculture Boots (Prototype)

Invasiveness into narrow passages and dense plant environments

Foot sole inclination, Speed, Walking distance tracking (Ex. Right foot)

Field Worker Position Estimation Results

Cloud

ENVIRONMENTAL & GROWTH

Digital Twin

Base image for overlaying digital twins (e.g., 3D laser scanner image)

Environmental Information Mapping Using Smart Farming Boots for Realizing Agricultural Digital Twins

Smart Agriculture Education and Research for Realization of Super-smart Society and Creation of New Industries

Off-grid Energy & Communication System

Off-grid Power and Communications to Support Smart Agriculture

Constructed a field (Smart Agriculture Education and Research Field) at Suzukakedai Campus, where soybeans, cabbage, broccoli, radish, komatsuna, etc. are grown organically. Supporting sustainable social implementation of smart agriculture in rural & mountainous regions through off-grid technologies for electricity, communications, and water using solar tracking power generator panels, LED satellite communications, and rainwater.

Smart Agriculture using Digital-twin (for Visualization and Future Prediction/Cultivation Strategy Determination)

“Agriculture” x “Robot, AI, IoT etc.” = “Smart Agriculture”

Sensing of Cultivation Environment (Temp, Humidity, Illuminance, pH, and etc.) and Plants

Sensing

Environmental and Soil Sensing by Sensor Network

3D model

Color camera image by drone

Chlorophyll analysis

Soil analysis robot system

Actuation (Robots and Field Cultivation System)

Actuation

Cultivation policy is determined based on the growth condition estimated from the sensing data, and the robot system is controlled remotely and automatically

Compact automatic robot farm machine (weeding/harvesting, etc.) that utilizes 3D structural information of the field

Compact size automatic robot

Ecosystem-Based Organic Agriculture

Toward New Smart Organic Agriculture with Ecosystem

January 2020: Start of smart agriculture education and research field construction: Changing Top-layer soil in Suzukakedai campus residual soil yard using mountain soil as covering soil.

In the first year, productivity was low due to lack of organic matter and soil microorganisms. ~Productivity improved in the second year through soil improvement by using organic matter.

Greenhouse experiment (May 2021)

Plant (Soy Beans)

Realization of a Super-Smart Society and Create New Industries by Consortium Co-Creation (Creation New Industries)

With SSS Consortium Smart Agriculture Initiative Members

SCIENCE TOKYO, MEXT, NARO, JICA, etc.

Research Theme Overview (Takahashi Laboratory)

Research on Reducing Wildlife Damage

- Development of an **animal detection device utilizing directional ultrasound** and an **ultrasonic field generator (intimidation device)** that delivers aversive stimuli to animals.
- Demonstrated the potential for image detection and 3D object shape imaging, while confirming a certain level of intimidating effect on monkeys.
- 2024-2025 F-REI Agriculture, Forestry, and Fisheries Sector Commissioned Project Theme (3) “Construction and Demonstration of a Bird Damage Prevention System Utilizing Advanced Technologies” (Promotion of Agriculture, Forestry, and Fisheries Research at the Fukushima International Research and Education Organization). Collaborative project with Yamaguchi et al. at the National Agriculture and Food Research Organization (NARO), currently in progress.

研究開発の背景と研究の目標

「鳥獣被害対策」は被災12市町村喫緊の課題。福島国際研究教育機構の基本構想、基本計画において、取り組むべき農林水産研究開発業務の短期的かつ更なる発展に向けた研究を推進するため、農業被害、野生動物被害の軽減および農分野（工）との連携による、営農再開の課題解決に貢献する。

被災地域の対策対象は、被災しない農家の捕獲効率化と人に慣れたサルの管理手法の開発・実証を実施。労働力不足に対応する鳥獣被害対策システムで営農再開、そして「福島から」国内課題解決に貢献

課題解決に向けた取り組み研究

課題 (1) イノシシ被害を発生環境を高度化する被害対策の推進

課題 (2) 起病性超音波による野生動物の検知・サル課題

1) 検知・超音波による被害対策の推進

2) 検知・超音波による被害対策の推進

3) 検知・超音波による被害対策の推進

4) 検知・超音波による被害対策の推進

3D object shape imaging is possible using airborne ultrasound

Animal Experiment: Tracking Parametric Speaker (Experiments of Monkey's Search and Avoidance Behavior in Response to the Sounds)

Intimidation Device

Research Outline on Reducing Wildlife Damage Caused by Monkeys