



User Interface for an Immersive Virtual Reality Greenhouse for Training Precision Agriculture

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The Project

- USDA NIFA FACT project to build a virtual greenhouse application for greenhouse production courses
 - Objective 1: Prototype VR greenhouse interface with integrated electronic control system
 - Objective 2: Develop a VR greenhouse curriculum for immersive, episodic classroom education
 - Objective 3: Assess VR-based training and document best practices
- University and Industry Partnership



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Greenhouse Precision Agriculture

- Modern greenhouses contain a multitude of systems for environment control, irrigation, feeding, pest control, etc.
- Students may see such a system but rarely have access to experiment with settings and observe outcomes

Seed



Electronic Control System

User interface for controlling environmental systems

- Inputs: time of day, sunrise, sunset, indoor conditions (vapor pressure deficit, solar intensity, soil moisture, temperature, relative humidity, CO₂), outdoor conditions (solar intensity, temperature, relative humidity, wind speed and direction, barometric pressure)
- Outputs: equipment state (irrigation, foggers, screen, curtain, vents, fans, cooling/heating, and lighting)

Greenhouse Conceptual Prototype

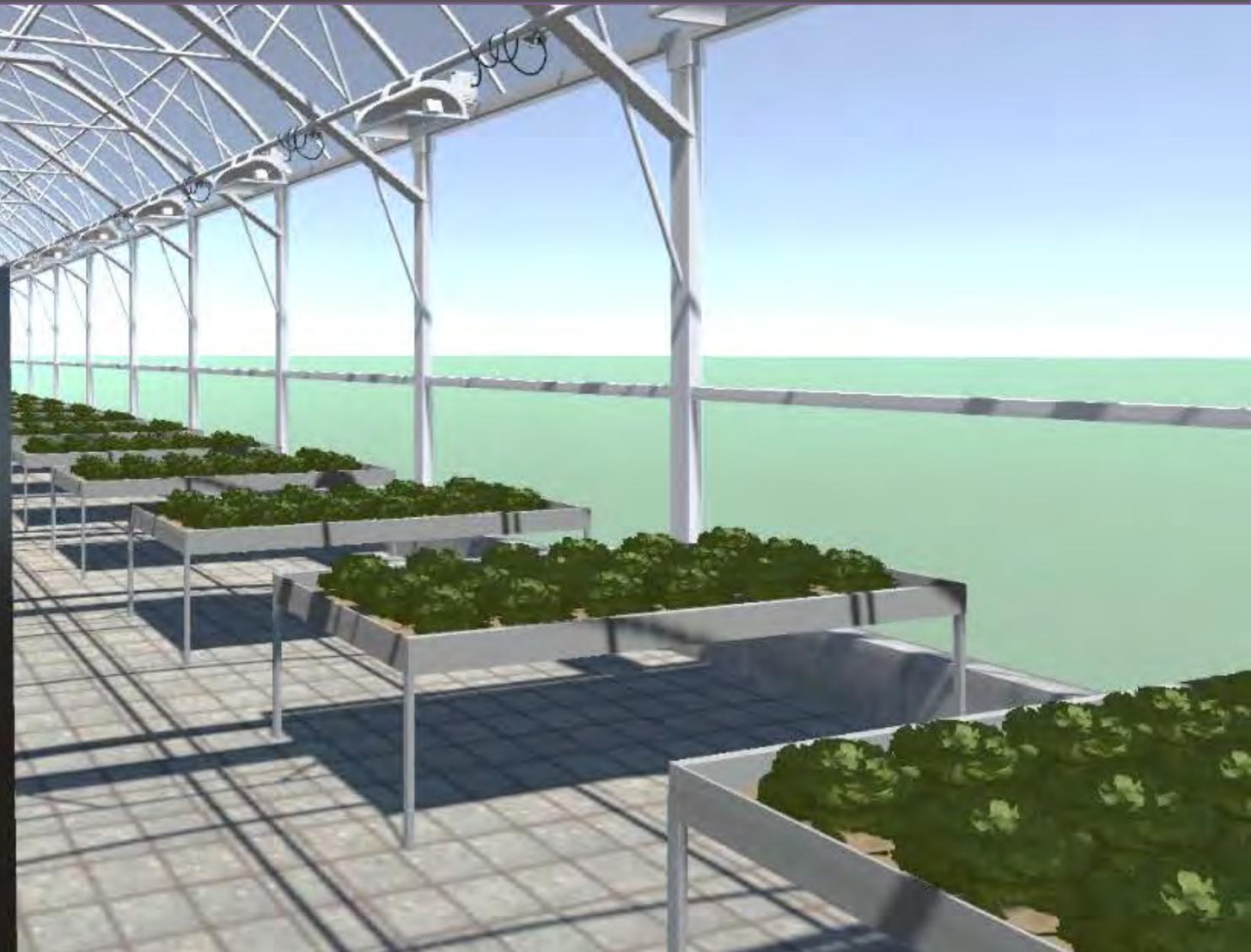
77°F 34%
2.09 kPa
6 mph W
639 PAR

Zone 1 Climate

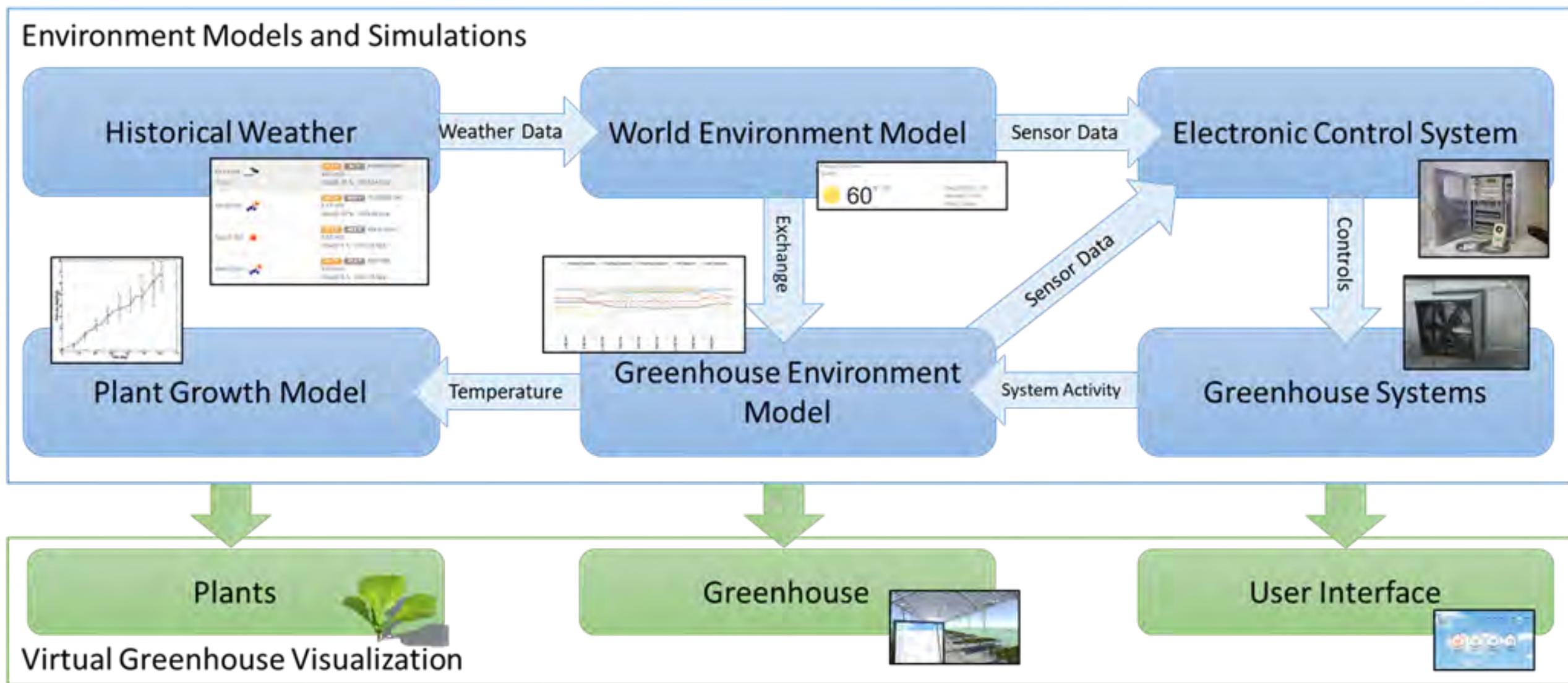
Day
7:30a - 5:00p

6:04a 7:50p 2:14p Tue, Apr 26

77	76	75	74	74	73	72	66	64
Pad Pump	Current temperature	Exhaust Fan	Variable Exhaust Fan	Curtain	Roof Vent	Target temperature range	Unit Heater	
Off		On	100% On	90% Covered	10% Opened	Off		
		Turns off at: 72°F	Turns off at: 70°F	Covers until: 73°F	Closes at: 72°F Vent limited to (fan on) setting			



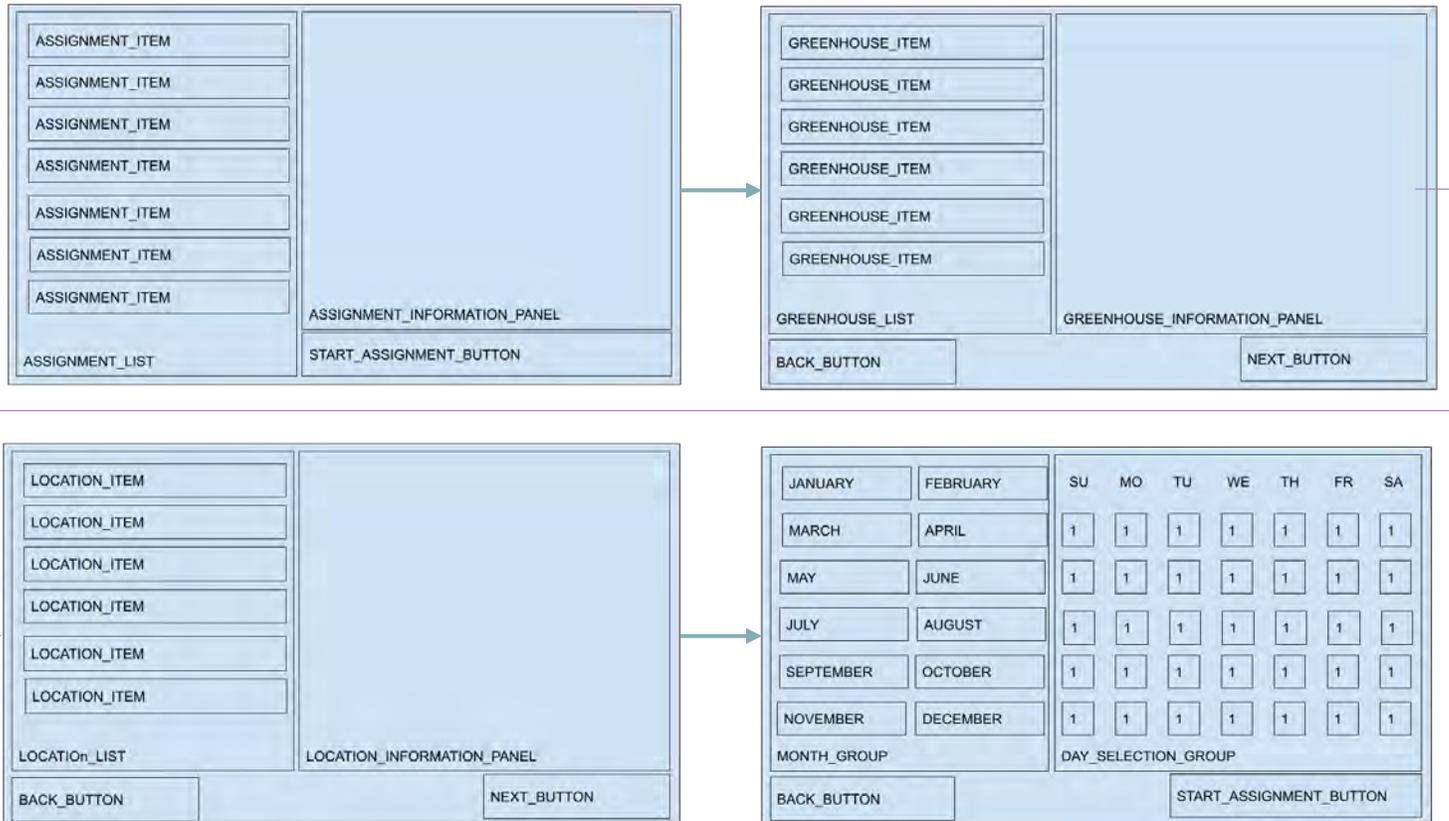
Virtual Greenhouse Systems



User Actions

Two Basic Domains	
Lobby	System
Greenhouse	--
Three Types of Actions within the Greenhouse	
Interaction with Greenhouse	Physical or System
Interaction with the ECS	System within the Simulation - Access could be Physical or System
Interaction with the VR System	System

Lobby Actions



- Login to LMS Profile
- View LMS Profile information
- View Available Assignments
- Review Past Assignments
- Load In-Progress Assignment
- Replay an Assignment
- Start a New Assignment
 - Select a Greenhouse
 - Select a Location
 - Select a Start Date
- View System Settings
- Quit the Application

Greenhouse Actions

Interact with the Greenhouse

- View the Greenhouse
- Move around the Greenhouse
- Select Seeds
- Select Planters
- Select Soil Medium
- Plant seeds in soil-filled planters
- Place plants on greenhouse tables
- Inspect the plants
- Manually water the plants
- Manually feed the plants
- Apply insecticide to the plants
- Apply fungicide to the plants
- Discard plants
- Harvest plants

Interact with the ECS

- Access the ECS
- View ECS Main Status Screen
- Schedule watering the plants
- Schedule feeding the plants
- View data logs and graphs
- View equipment status
- Review periods and setpoints for controls

Interact with the Training System

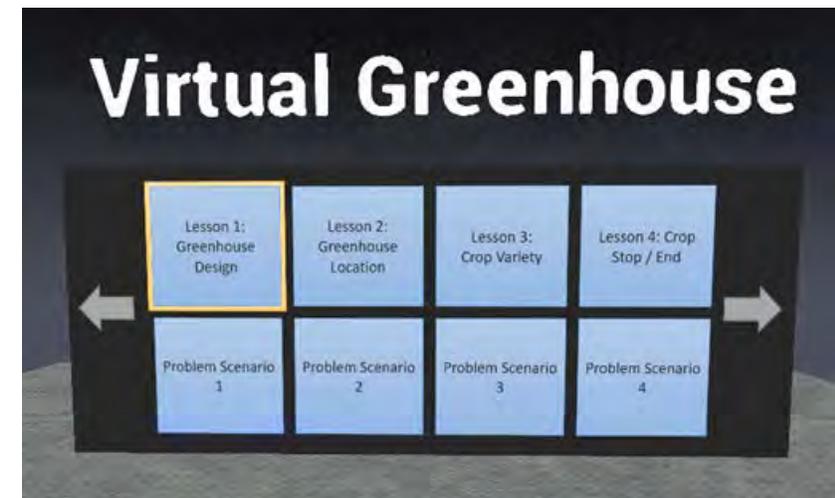
- Advance the calendar
- Review the outcomes of the assignment
- Submit an assignment for review
- View and modify system settings
- Exit the assignment
- Quit the application

User Interface Style



Physical Interaction

System Menu



ECS User Interface

- Two-step process
 - Access the ECS
 - Use the ECS



Physical Interaction

- ECS is a small tablet-size touchscreen interface
- User must walk to the ECS location
- User must physically tap the touchscreen to activate ECS functions

ECS User Interface

- Two-step process
 - Access the ECS
 - Use the ECS

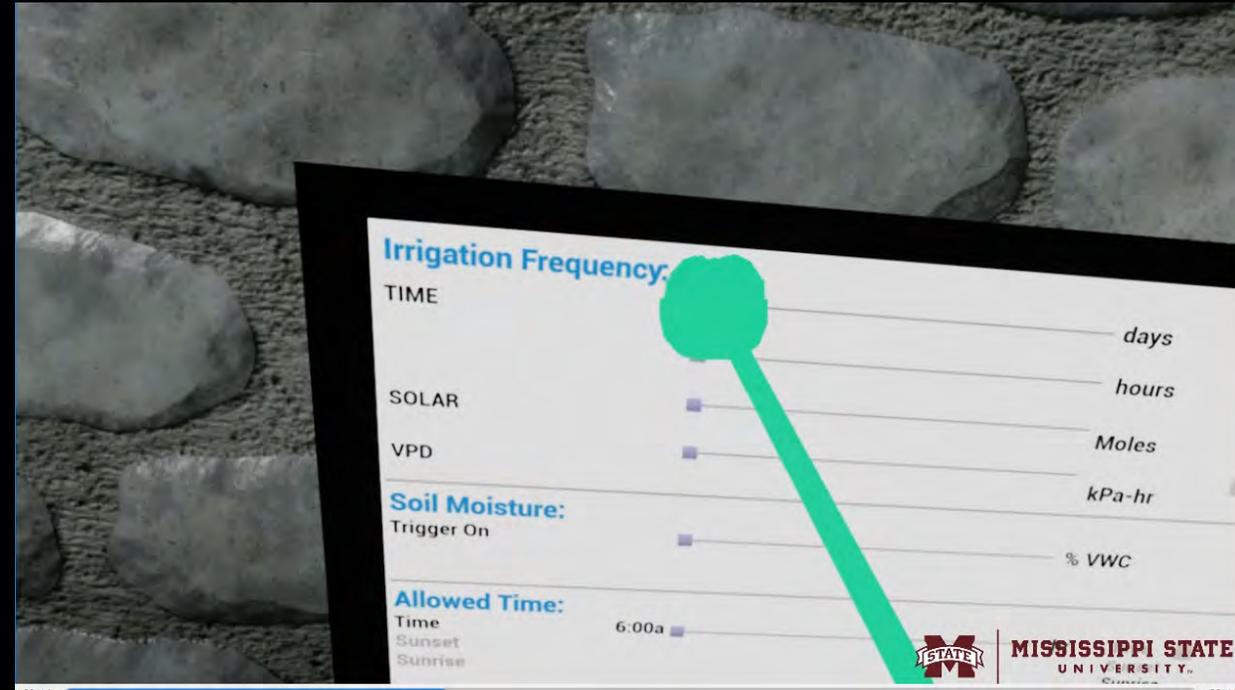
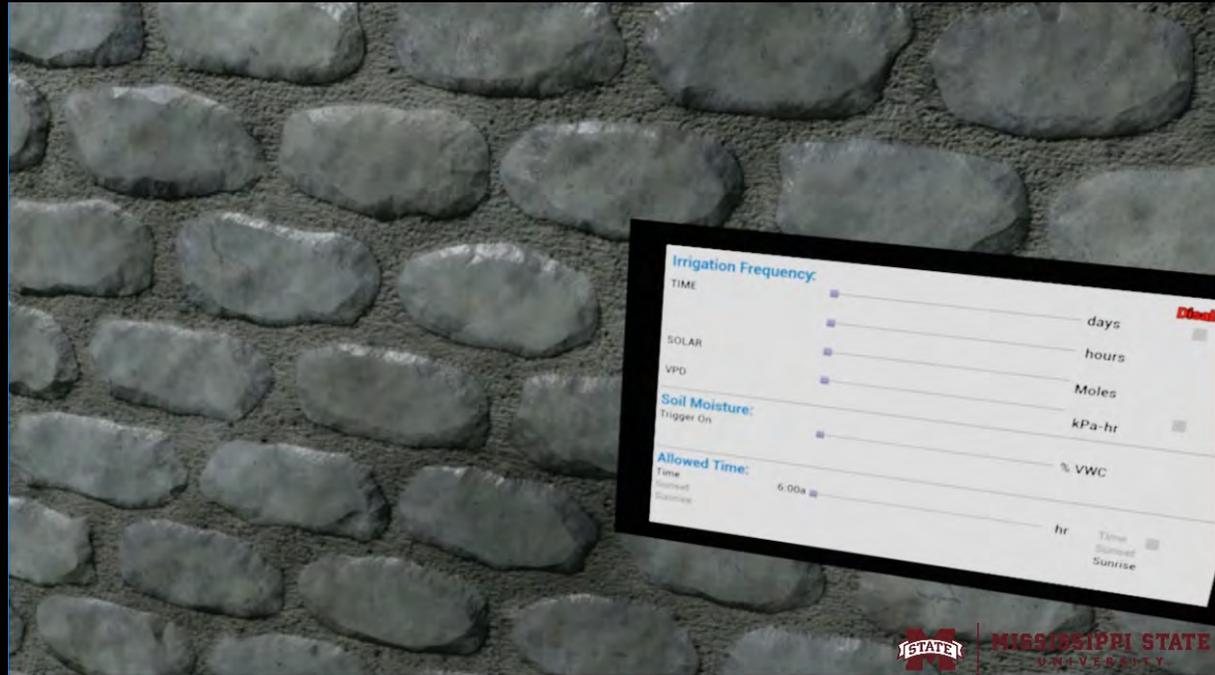


Virtual Greenhouse Option 1: Physical Screen - Small

- ECS is a small tablet-size touchscreen interface
- User must walk/teleport to the ECS location
- User uses point-and-click to interact with the screen

- Realistic implementation
- Poor user experience – have to get quite close to read, hard to interact

<TabletsliderDemo.mp4>



ECS User Interface

- Two-step process
 - Access the ECS
 - Use the ECS

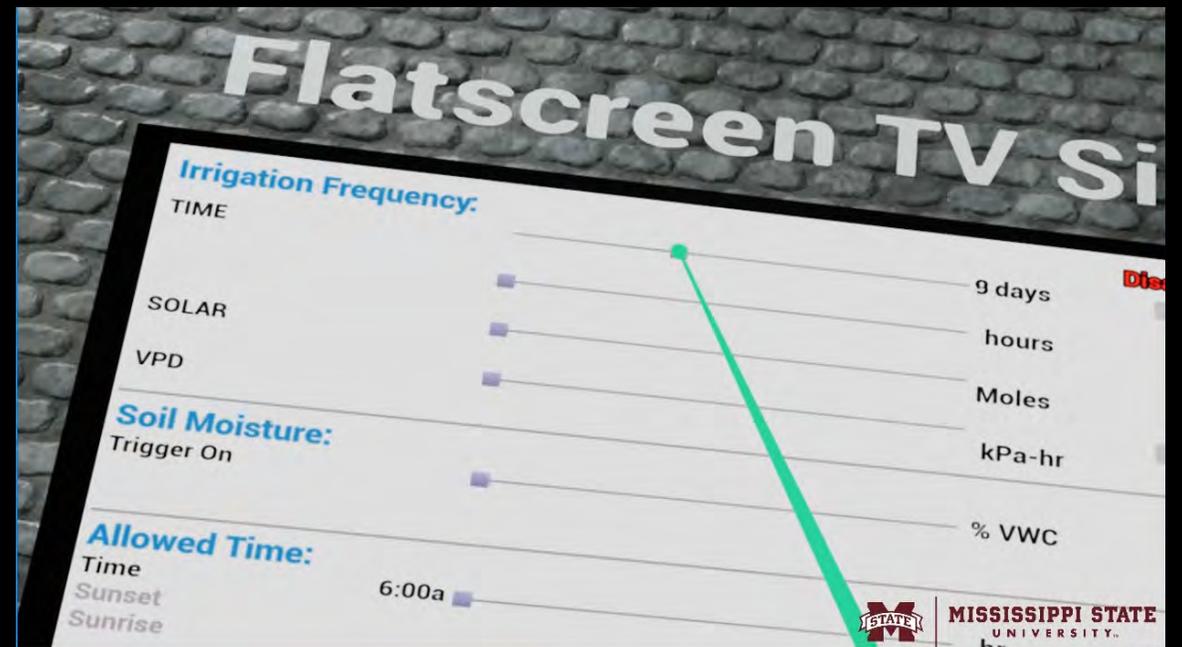


Virtual Greenhouse Option 2: Physical Screen - Large

- ECS is a large TV interface
- User must walk/teleport close to the ECS location
- User uses point-and-click to interact with the screen

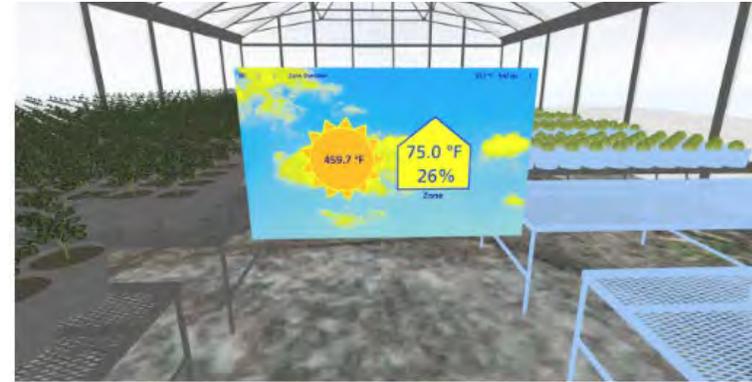
- Improved user experience – easier to read, easier to target
- Reduced realism

<LargeMonitorDemo.mp4>



ECS User Interface

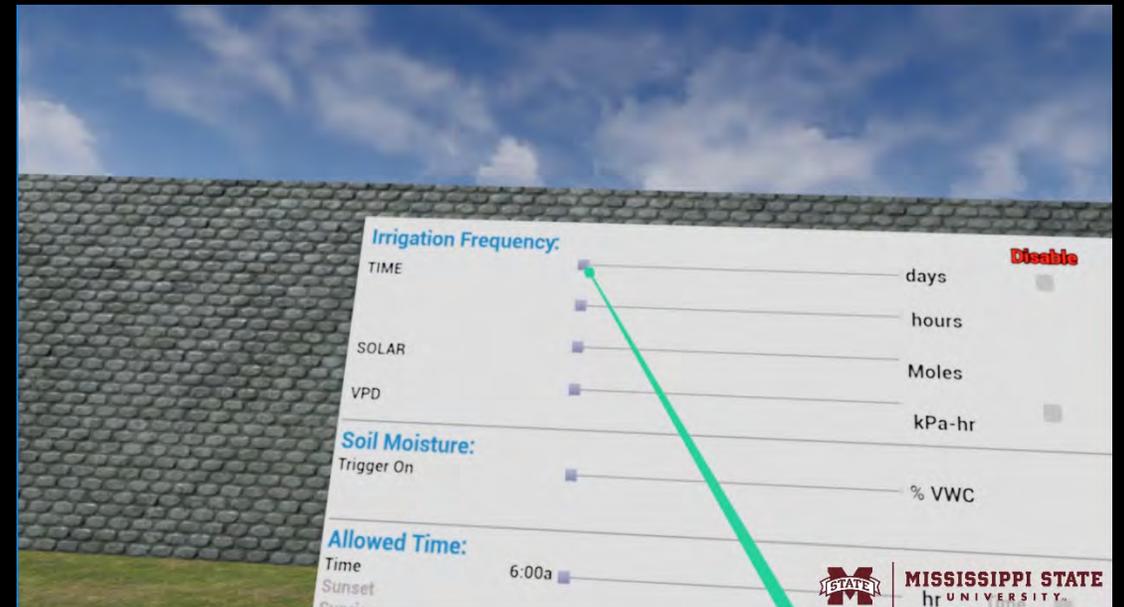
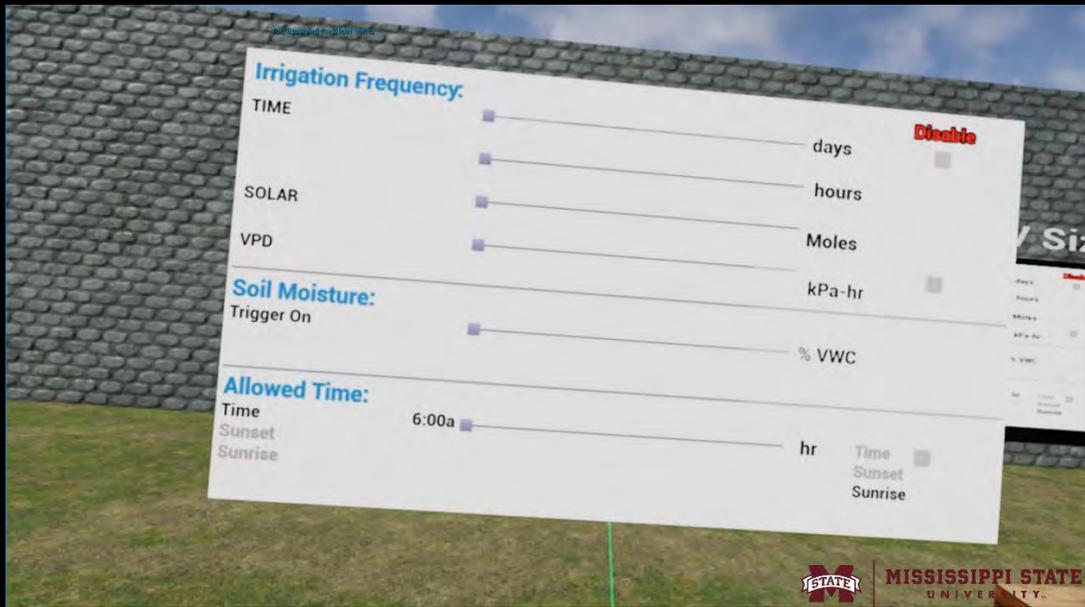
- Two-step process
 - Access the ECS
 - Use the ECS



Virtual Greenhouse Option 3: Pop-Up Screen - Large

- ECS is a pop-up floating user interface
 - Also used for System Actions
- User must walk/teleport close to the ECS location
- User uses point-and-click to interact with the screen

<PopupDemo.mp4>



Next Steps

- A little more polish on the prototype user interfaces
 - Closer match to the source user interface's look-and-feel
 - Implement touch-based controls for the Physical Small ECS interface
- User Studies
 - Previous work showed preferences for touch-screen interfaces* but in this case that preference may be offset by the fixed location and small size of the ECS display
 - Interested in potential benefits of recreating physical interactions on learning and on transfer
 - Need some user data to make recommendations for the commercial implementation

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