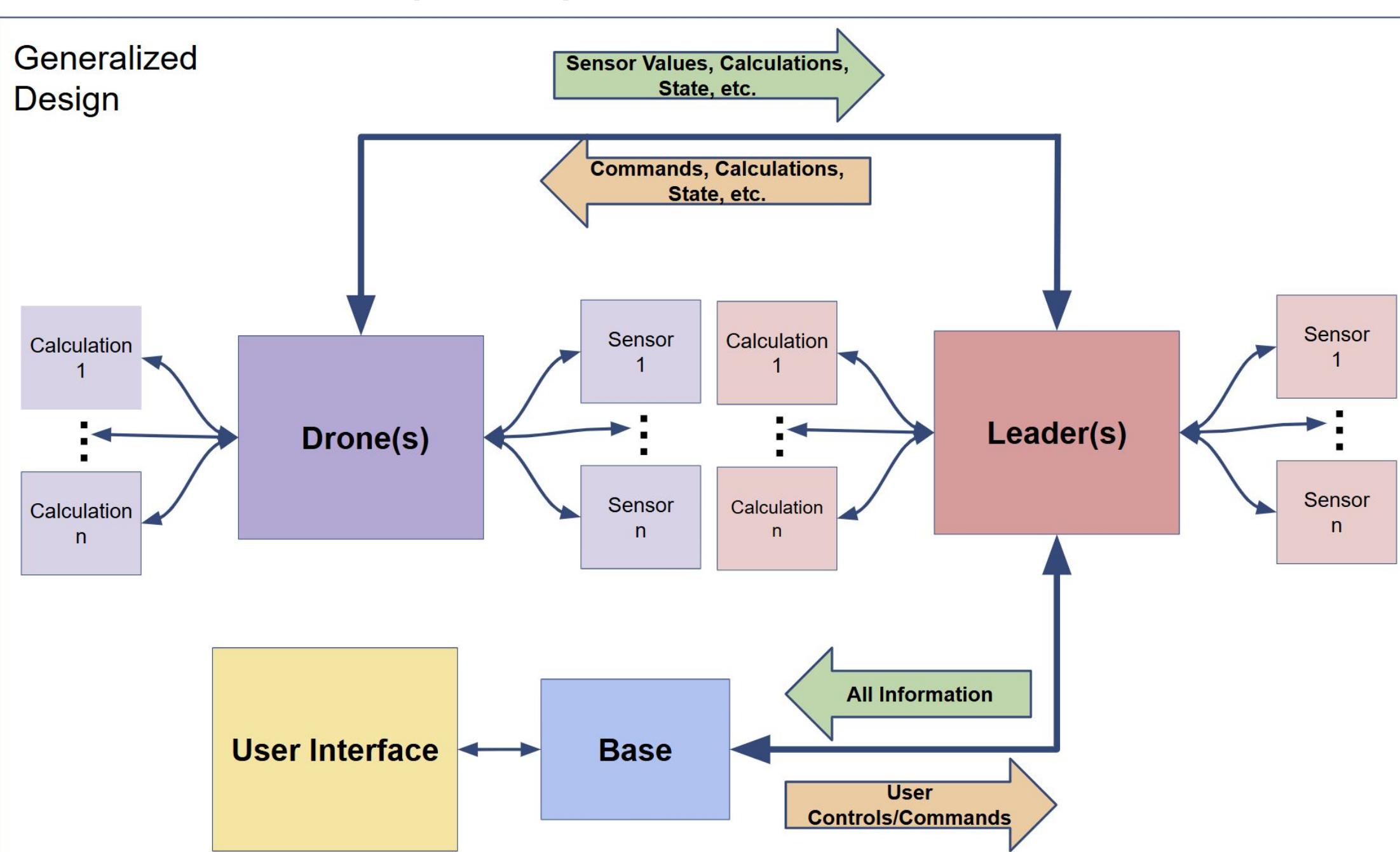


Autonomous Unmanned Ground System Swarm Collaboration: A Customizable Testbed

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Overview

This work presents the design and development of a **highly customizable and Modular Unmanned Ground System (UGS) Swarm Testbed** with an emphasis on human interpretation of ongoing data and control of the experiment. Utilizing Robot Operating System 2 (**ROS2**), the testbed provides not only **seamless modular development platform**, but it also provides a **web-based interface** for simpler researcher observation and participation.



Design Approach

The testbed consists of four primary components: UGS(s), Leader(s), Base, and User Interface. UGS(s) are sensor platforms with limited computational power who pass and receive information from the Leader(s). Their primary goal is to gather, preprocess, and transmit information. The Leader(s) are more computationally powerful and perform expensive calculations (swarm behavior, object detection, etc). The Leader(s) also serve as the communication bridge between the UGS(s) and the Base. The Base receives data from the Leader(s) and relays commands from the User Interface back to the Leader(s) that distributes the same info to all units in the UGS swarm. The User Interface is a web-based dashboard implemented using HTML and roslibjs, and hosted on a web server connected to the Base. The UGS(s), Leader(s), and Base are implemented as Python ROS2 nodes, ensuring seamless, real-time communication across all system components.



Current Configuration

In the current configuration, the Testbed consists of one Leader UGS, a variable number of Follower UGGs, a Base Station, and a web-based User Interface. Each Follower UGS transmits its indoor GPS data and live image stream to the Leader. The Leader processes the incoming image stream using a Convolution Neural Network (CNN) to detect the presence of the target. When found, the Leader broadcasts this target location to all other UGSs, triggering them to navigate toward the detected goal. The Base Station provides centralized data logging and acts as a relay between the User Interface and the Leader, allowing the researcher to observe data streams and issue commands in real time.

The screenshot shows the User Interface with several panels:

- Basic Triggers:** Buttons for "Start ROS2" and "Stop ROS2", and checkboxes for "Indoor GPS System", "GPS System", "Automated Movement", and "Collect Data".
- Control:** A large empty text input field.
- Choose Rover for Commands:** Checkboxes for "All", "Sentinel", "Jupiter", "R2", and "R3".
- ROS Bridge:** Fields for "ROSBridge Server Address" (containing "127.0.0.1") and "ROSBridge Status" (showing "Disconnected"). A "Connect" button is at the bottom.
- Choose Data Output:** Radio buttons for "Indoor GPS Data", "GPS", and "Data".

Impact

This Testbed provides a flexible platform for performing multi-agent coordination research, enabling rapid testing of swarm methodologies, communications development, and AI-driven decision-making. Its design and real-time observation tools make it ideal for adaptive experimentation across robotics, AI, and autonomous systems research.

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