LASSI Integration with Argus

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1 LASSI

In a greenhouse, daily light integral (DLI) from sunlight is highly variable, but consistent DLI can be achieved with proper control of supplemental lights and deployable shade. LASSI (light and shade system implementation) refers to an algorithm developed at Cornell that allows consistent DLI delivered to the plants each day of the year (Albright et al., 2000). LASSI predicts remaining solar insolation based on the first few hours of the day and continually adjusts the prediction as new sensor data arrives.

LASSI can also be used to control CO_2 supplementation to achieve a consistent virtual DLI (Albright et al., 2004).

2 GLASE Pilots

GLASE (Greenhouse Lighting and Systems Engineering) is a consortium funded by NYSERDA that brings together university researchers, grower, and industry partners to further the state-of-the-art in CEA plant science, controls, and energy modeling.

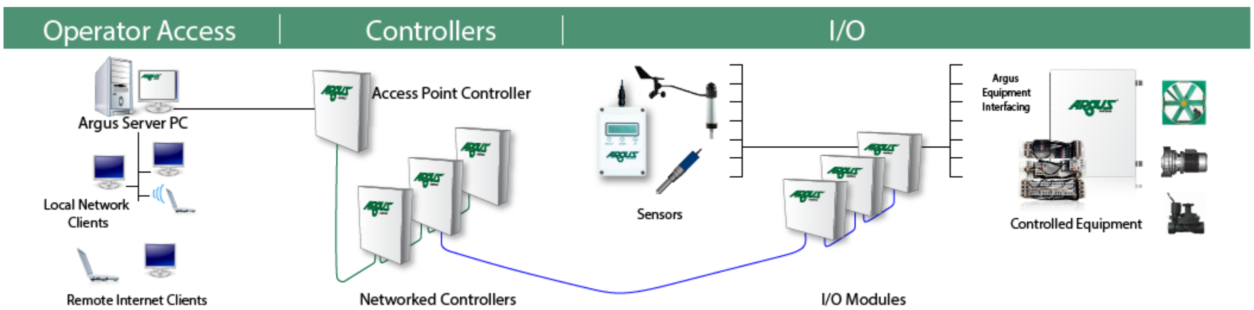
Some of the milestones in the GLASE research plan involve pilot studies at commercial greenhouses. There are four main phases in each pilot study:

1. Energy audit, modeling, and data collection for one year of operation
2. Basic LASSI (light and shade control only)
3. CO_2 LASSI (light, shade, CO_2 control)
4. Real-time LASSI (light, shade, CO_2 control with custom-built LED luminaires that may have dimming or spectral tuning capabilities)

After LASSI algorithms are vetted in a controlled research setting, the system would be installed at the pilot facility. Ideally LASSI would be integrated with the existing control system onsite. The next section describes preliminary work done at Cornell in integrating LASSI with Argus, one of the most widely used greenhouse control systems.

3 Argus Integration

Cornell University uses the Argus Titan II system for greenhouse environmental control. Although in the past some experiments have employed custom control systems that operated lighting relays directly, interfacing with the building control system is preferable for fault tolerance and simplicity. Below is a simplified diagram of a typical Argus Titan II system.



LASSI has been successfully integrated with Argus Titan II at Cornell to facilitate research in custom lighting control algorithms. The sections below describe each of the major components in the integrated system.

3.1 Titan II Controller

Multiple Titan II controllers, shown below, form the backbone of the Argus control system in each greenhouse complex. By interfacing with the Legacy Network Port on a single Titan II controller, the entire Argus system within that building is accessible.

3.2 Legacy Network Port

Each Titan II controller has a Legacy Network Port that is normally used to provide backwards compatibility with older Argus technology. An additional option is to connect this port to an Argus ISODN board.

3.3 Argus ISODN Board

This component acts as a translator between the Legacy Network Port on a Titan II controller, and a MODBUS RTU network.

3.4 Raspberry Pi

There are many possible hardware solutions that can interface with a MODBUS RTU network. For Argus integration, a Raspberry Pi was chosen as a single-board solution. The Pi is inexpensive and small enough that it could be conveniently installed in the Argus cabinet that houses one of the Titan II controllers. Built-in wifi allows communication with other Raspberry Pi nodes in the building. The Pi runs Raspbian Linux which is a convenient platform for the custom control software developed by the CEA group at Cornell. The MODBUS network is accessed from the Pi via a serial connection.

3.5 Li-Cor Quantum Sensors

These sensors, shown below, measure PPF (photosynthetic photon flux) in $\mu mol/m^2/s$ in the 400-700 nm range. The values from the quantum sensors can be integrated to measure DLI (daily light integral) in mol/m^2. In many cases quantum sensors are wired into Argus I/O cards, then the sensor values can be read by the Pi over the MODBUS network. In other cases it is not convenient to have the quantum sensors wired directly into Argus, either due to lack of I/O ports in a particular zone, or the desire for additional sensors. In that case a slave Raspberry Pi can be placed in that zone and can read quantum sensor data directly using an Arduino. The sensor data is then communicated via wifi to the building's master Pi that runs the custom lighting control algorithms for each zone.

3.6 Arduino

In cases where quantum sensors or other sensors aren't interfaced directly with Argus, the Arduino is a convenient solution. An Arduino can input data through many methods, such as analog or digital I/O. This data is sent to a Raspberry Pi via USB-to-serial connection. In the case of Li-Cor quantum sensors, the data can be read directly with onboard A/D conversion, but add-on boards with higher resolution are recommended in this case. Even so the signal must be appropriately filtered because it is highly susceptible to EM interference. Even the blinking of an LED can introduce unwanted noise. Although initial success was found with a software low-pass filter, a much more effective solution is to use Li-Cor amplifiers (shown below) that are custom-built to produce the highest fidelity signal. This is the current solution implemented in Cornell's Argus integration.

3.7 MODBUS Communication

MODBUS communication with Argus is bi-directional, in that sensor data can be read from the Argus system, and commands for actuators can be written back to Argus. The limitations are number of MODBUS addresses, frequency of access and the bandwidth of the RTU network. In practice the integrated system could interface with hundreds of control points, more than enough to cover a typical Cornell greenhouse complex.

4 Future Work

While thus far Argus Titan II is the only commercial greenhouse control system with which LASSI has been successfully integrated, other commercial control systems may be possible as well. The MODBUS interface is convenient but not a requirement. For example, if a control system could read analog voltages or digital I/O signals, those could be used to send commands from LASSI to the environmental control system. Sending data back to LASSI is more difficult, because most control systems utilize proprietary communication protocols, and typically do not provide an interface to an open protocol such as MODBUS or BACNet as Argus does.

In the future, Argus integration will be extended to facilitate CO_2 LASSI control experiments.

5 References

Albright, L.D., Both, A.J., and Chiu, A.J. (2000). Controlling greenhouse light to a consistent daily integral. Trans. ASAE *43(2)*, 421-431 http://dx.doi.org/10.13031/2013.2721

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