Engineering Adaptations Optimizing IOT in Agriculture

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Abstract

The Internet of Things (IOT) is changing agriculture with a higher quantity of sensor inputs and control outputs. This is due to lower per-unit costs and greater reliability of data transmission. This comes at a critical time, when agricultural automation can assist in lowering labor demand/costs, as well as improve resource utilization efficiencies, especially water.

IOT has the unique capability to utilize and combine data from non-proprietary and different resources, such as point-specific data, public or government data, farm and crop data. This data can combine to not only display data, but to display and report on actionable task items to provide real-time control or make real-time decisions and alarming.

Irrigation control is now more than a time clock, smart control enables modifications to schedules based on any monitored variables, ETc, soil moisture, temperature, etc. Many forms of control can now be accomplished remotely, including irrigation scheduling and VFD automation. The capability of remote control is successfully enabled, because the monitoring allows reliable feedback to actions in the field.

Distributed (wireless) sensors are available at an attractive price range, that allows for system design utilizing an effective number of representative sensors over a larger acreage.

Keywords: Control, Internet of Things, IOT, Monitoring, wireless, measure, agriculture, water, efficiency, automation, remote control

Introduction

There is a transformation of monitoring and control happening in Agriculture. The cost and complexity of sensors and control systems are coming down, while the quantity of available hardware options are increasing. This is happening at the same time the application needs are increasing with the high cost and availability of labor is high. And the cost effectiveness, and/or flat-out requirement, for smart utilization of resources such as water and fertilizer is ever increasing.

IOT, 'Internet Of Things', simply refers to a collection of physical devices and systems that are internet enabled, and have the ability to operate and interact with other devices, computers and/or people. IOT devices and systems can range from very simple to complex, but the underlying premise is that IOT systems inherently provide more ability (sensors and control points) at a much smaller cost. IOT in Agriculture, being a conservative industry, lags behind the industrial sector in widespread adoption of the technology; but is rapidly growing into the space.

Wireless, distributed, sensors are changing the scope and footprint of what can realistically be installed in the field due to lower costs and increased data transmission distances.

Utilized appropriately, the agriculture industry and growers are increasingly realizing the benefits of the monitoring and control systems in increasing productivity and efficiencies of operations.

Target Goes From Management to Operations

Historically, monitoring and control systems were installed on a limited basis to provide feedback to management on operation effectiveness.

For example, a soil moisture sensor or two would be put in the field and results would be stored and analyzed by a manager who knows the specifics about the resident crop, soil type and irrigation. This analysis by the manager, due to time constraints, would happen once a week, month, at the end of the season, or even not at all.

An IOT System has the inherent ability to pull data from several different resources, such as VFDs, water level, soil data, crop data, weather data, irrigation data, all coming from different sources, allowing the pertinent and actionable items to be pinpointed and displayed real-time, provide control feedback, alarms and reporting.

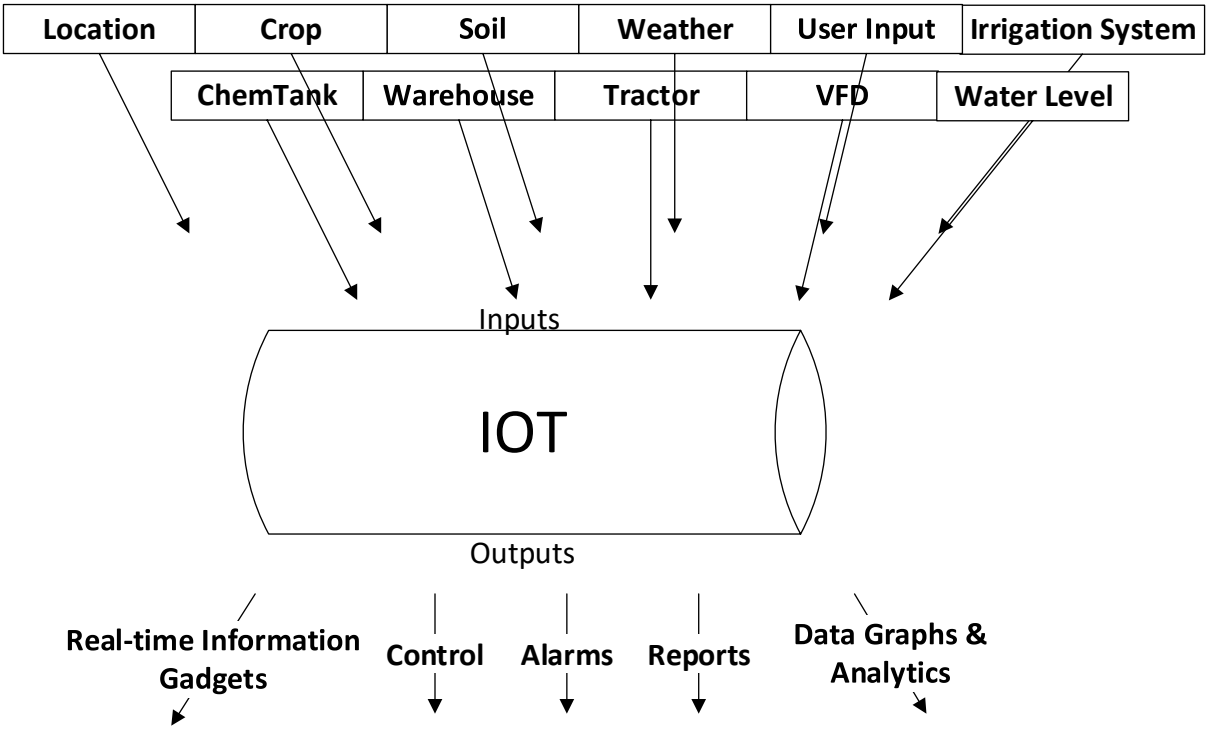

Figure 1. IOT System Overview

Unlike an all-encompassing, massive, proprietary or government computer program, the context, data and interpretation can come from disparate sources. This is an advantage to the industry and to the growers. Weather data can come from public networks if available, or not; irrigation data can come from the irrigation designers, sensor data can come from many different manufacturers' products, forecast data can come from private or public networks.

The outputs can be simple data gadgets, complex control, alarms based on data or pest reports; the organization is able to decide the priorities, information and outputs that provide the most cost-benefit for the organization.

A temperature alarm has been around for decades, but now that alarm can come in the form of a text message, email and voice phone call in English and/or Spanish, and have a history associated with who responded and when. How about a similar alarm that calls you to say "your irrigation is scheduled, but is not happening"? This is taking alarms to the next level, not based on data only but on information regarding your irrigation system.

The most beneficial use of the IOT system is therefore the irrigator, or the applicator, or the agronomist, as the data and/or control is to help and enable the operator do their job more efficiently and effectively. The system also provides an invaluable teaching tool for the manager in training, improving operations and catching problems before they become large.

Irrigation Control Has Changed

Labor costs, or lack of available labor, combined with limited or restricted water and pesticide use has driven the need for automated monitoring and control. The days of setting an irrigation schedule for a month are over. Irrigation zones have become smaller for better, more efficient, irrigation.

Wireless Control

Wire and trenching are expensive and a continual problem with wire theft, breakage, and remapping. Wireless valves are now robust, and make the 16-port controller obsolete, now the industry has a 100+ port controller. To effectively manage this new irrigation system, some supporting information for each valve such as location, crop, and soil is necessary. An irrigator may be able to program each valve from a keypad at the pump panel, or from a screen by valve, but this is not the best utilization of the irrigator's time and talent. An irrigator gains knowledge and capability when he can focus on zones, crops and soils; rather than Valve 67, 72 & 84.

Extend High-End Labor Resources

Farms are diverse and often geographically separated, combine that with the requirement of conserving and limiting resources; this means the irrigator and manager's time is a precious resource and will continue to be. A simple display of current status, highlighted maps with irrigation zones, allows the irrigator to view status of multiple irrigation systems in minutes. The irrigator can locate issues or problems in a daily or twice daily system review from his phone and go directly to the problem or dispatch staff with direction.

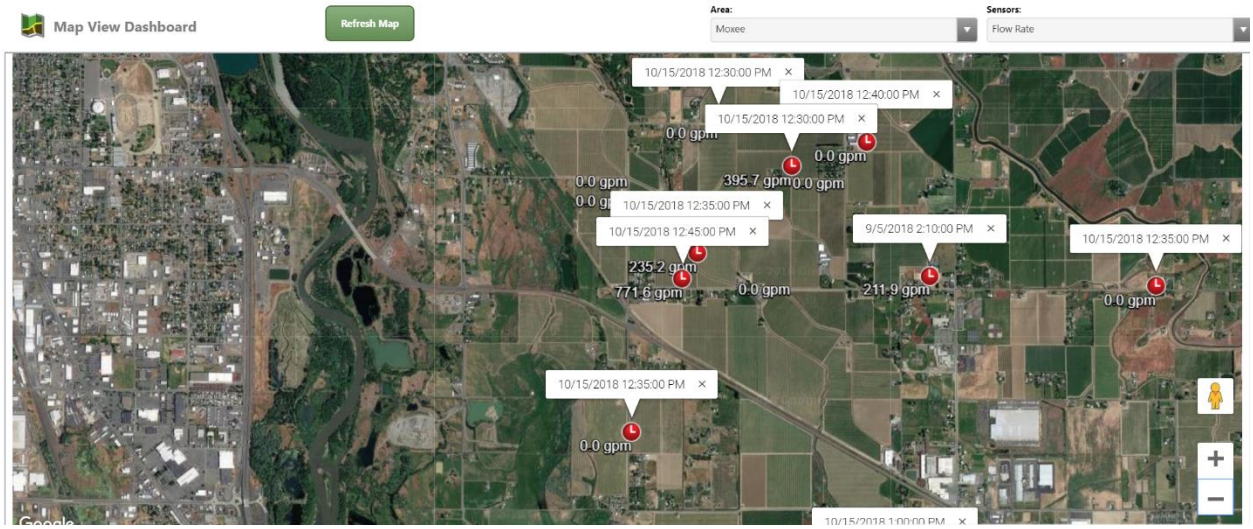

Figure 2. Map View of Flow Data

Growers have utilized the savings in time to extend the irrigated acres that an irrigator can cover, as well as leverage their time to concentrate on irrigation efficiencies and soil moisture.

The irrigator has the ability to view and download schedules from anywhere in the world with today's technology, no need to travel to the site; saving time and resources.

VFD's Are Here to Stay

VFD's offer sustained performance with continual changes in irrigation control adjustments. Valves can be added, turned off, or sustained based on maintenance, soil moisture, temperature or climate control; the VFD allows this to function without interruption.

However, the VFD has operating parameters, settings and faults that are normally reviewed, adjusted or reset by an experienced source such as a distributor, supplier or manager. IOT allows for the display and adjustment of these parameters remotely, saving grower and distributor's costs in deploying service technicians, and more quickly solving grower's issues.

Smart Irrigation Schedules

A time-based control system is the baseline but is not adequate for the long term. It can be made adequate currently by having someone continually looking at the data and changing the operating schedule. Or, the system can have the built in capability to adjust schedules via data and information.

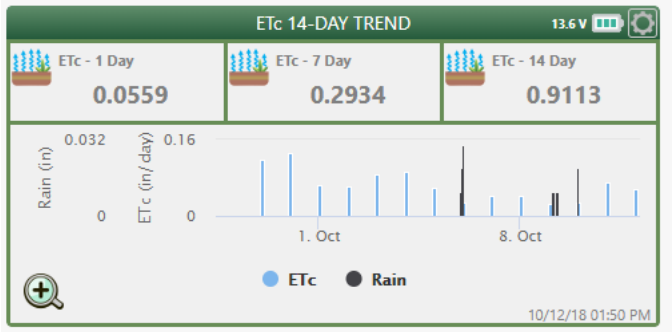

Figure 3. Daily ETc for the Specific Crop

An IOT based controller has many inputs from which control can be based. The same controller that operates irrigation, can turn on overhead for frost control, and in the heat of the summer turn on irrigation for climate control to reduce pest incidence or sunburn.

Of the early adopters, there is not one grower who has not changed their irrigation practices based on utilization of the new control capabilities. They learn of the cause-effect relationships and adjust accordingly.

Distributed (Wireless) Sensors

Sensors are now available that will communicate directly with the cloud, and not tied to a traditional power-hungry radio network utilizing dedicated, non-licensed frequency bands.

This brings the sensor cost down significantly, as the infrastructure of battery, modems and A/D conversions is minimized.

The system integrator now has more ability to effectively install a representative number of sensors in the field to get desired outcomes and analysis, rather than monitoring a few select locations.

Information Not Just Data

The tabular report, or graph of data, may be OK for regulators or managers hind-sight view; but this is not enough for operational personnel to make decisions. The data needs to be current and combined with supporting information and data such that operational personnel can perform actions based on the displayed information.

A ‘Report’ is largely replaced by a ‘Gadget’ in IOT terms. A gadget has the following attributes:

- Information displayed and updated at a frequent interval
- Utilizes supporting information and data
- Can be moved around, or grouped, with similar or related gadgets

As an example, a soil moisture gadget shown in Figure 4 can show much more than soil moisture, since the gadget knows the irrigation system, crop and soil type. An operator may not understand the meaning of 25% volumetric soil moisture in a particular field and crop, but the gadget clearly shows the location specific 'upper' and 'lower' bound of irrigation, as well as the cause and effect of his applied irrigation.

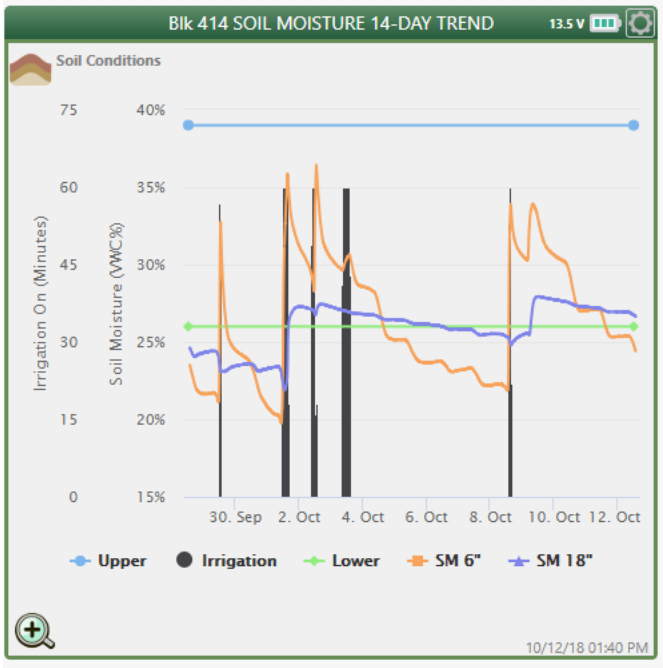

Figure 4. Soil Moisture Gadget showing volumetric soil moisture, irrigation on time, field capacity and Maximum Allowable Depletion(MAD)

Another corresponding gadget, shown in Figure 5, utilizes weather, crop and irrigation data to calculate suggested irrigation on-times to replenish 1-day or 7-day ETc. This operator knows from this gadget that he needs to run his irrigation system for 3 hours to replenish the last 7 days water use via ETc.

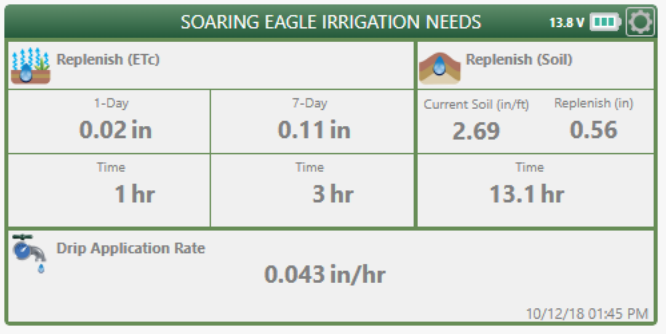

Figure 5. Irrigation Needs Gadget

Another real-time calculation shown in Figure 5 is the length of irrigation time needed to replenish the soil profile to field capacity. These are real-time calculations and data available for the operator and manager that is specific to their operation and management.

Conclusion

IOT in agriculture is here to stay, it is needed by the industry to increase effectiveness and efficiencies. Expanding existing labor's production and increasing water/nutrient efficiencies are the driving forces.

Enabled is a non-proprietary system of gathering data and information in a manner that can be utilized specifically for the grower at hand. The system can start small and be scaled in accordance with the needs and requirements of the grower.

There are several outputs of an IOT system: there are real-time 'smart' data displays called Gadgets, which combine raw data with site specific information to provide actionable information. Alarms, not just of raw data, but of system errors can come in the form of text message, email, and voice in English or Spanish. The system can alarm not just on temperature, but of irrigation system variables, pest alerts, and more in one system. Data analytics in the form of graphs and reports are standard.

Control systems provide the biggest return on investment, as remote access to monitored variables allow personnel to concentrate directly on system problems, greatly reducing the time allocated to troubleshooting and travel between sites. Inherent with the control systems is Smart Control, where control is effected by monitored variables, such as ETc, temperature, soil moisture, etc

Due to decreased cost and improving reliability and transmission distance. Distributed (wireless) sensors are enabling a new view into what can be accomplished with sensors distributed throughout the farm.

It is important to list the priorities and desired outcomes of any IOT system at the beginning, largely concentrating on daily, routine action items that aid in production, efficiencies or solving problems.