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AUTOMATION APPLICATIONS in GREENHOUSE

Sedat Karaman [1,*], Serkan Yazarel [1], Zeki Gokalp [2]

[1] Gaziosmanpasa University Agricultural Faculty Biosystems Engineering Department, Tokat, Turkey
[2] Erciyes University Agricultural Faculty Biosystems Engineering Department, Kayseri, Turkey

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Abstract
In this study, information is given about the automation applications that have become widespread in greenhouses these days. Technological developments such as sensors, softwares, microcontrollers, cameras, artificial intelligence applications etc. used in automation systems in the greenhouse sector give hope for the future of the greenhouse sector. Although the initial investment costs of automation systems are high; with the introduction of these technologies to the greenhouse sector, savings in labor costs, spraying, fertilization, time and overhead costs are reduced, thus reducing producer costs. In order to prevent unnecessary pesticide use and to meet the needs of the product in the right time at the right quantity, the purchase of products with high market value can be realized. Heating, ventilation, spraying, fertilization, frost protection systems are used in greenhouses. In addition, while harvesting and packaging of products, these applications, which are open to personal errors and wanting high working hours, can conveniently be implemented with the use of automation systems. Nowadays, the interest of the greenhouse industry is drawn on automation systems.

Keywords: automation, greenhouse, systems's Components

1. INTRODUCTION

Automation; it is the name given to controlled systems working with the integration of robots, various machines, sensors, computers and all or part of the human labor force in the same systems in order to increase production and service quality in plant and animal production, industry and other services (Figure 1).

For proper operation of automation systems; resource planning and production management systems (ERP / MES), controller control and data acquisition system (SCADA), distributed control systems (DCS), programmable logical controller, remote terminal unit (RTU), user interface (HMI), sensors, etc. have all or some of the basic components. These components are in contact with each other and should work as a whole (Karaçor and Keleş, 2007).

Today, automation systems are employed in various sectors. There are five major industries or areas in which automation systems are commonly used and these areas include machinery, factory, animal husbandry, agriculture (field-garden) and greenhouse automation. Automation systems are commonly used especially in agricultural (greenhouse production activities) and livestock activities (dairy barns, poultry houses). In this study, greenhouse automation systems were assessed in detail and recommendations were provided for future greenhouse automation practices.

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*Corresponding author, E-mail address: sedat.karaman@gop.edu.tr

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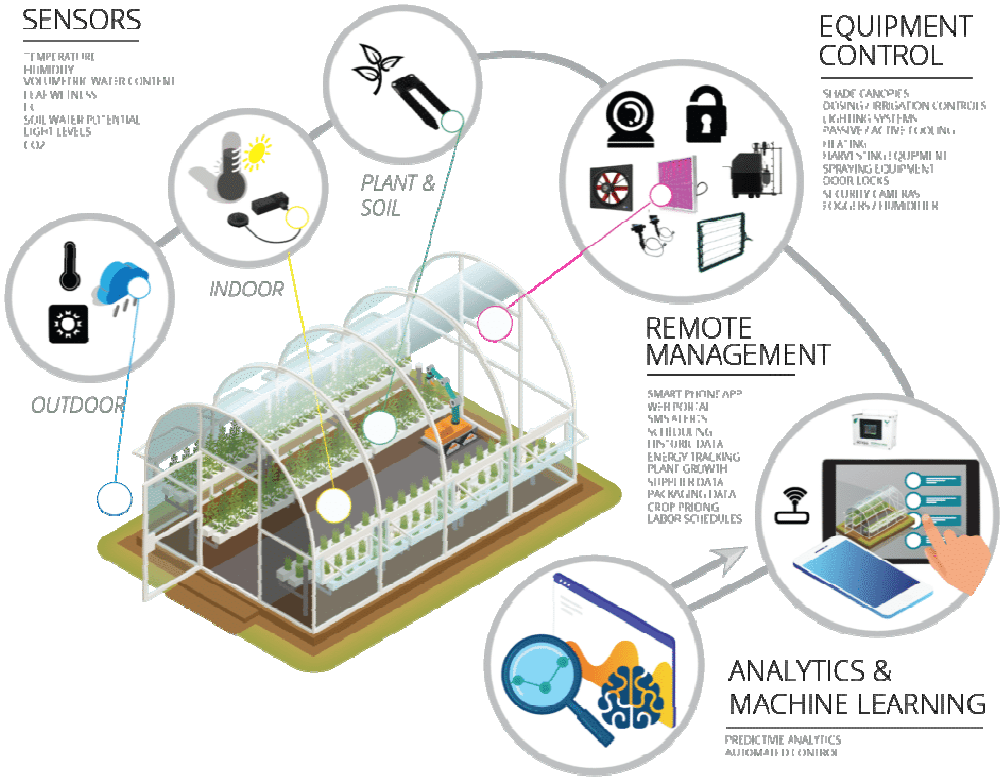

Figure 1. Smart Greenhouse Remote Monitoring Systems (Source: https://www.postscapes.com/smart-greenhouses/)

2. COMPONENTS OF SYSTEMS

ERP (*Enterprise Resource Planning)*: Resource planning is a concept and it is the general name given to the systems and software that enables the effective and efficient use of the employees involved in production activities such as labor, materials and machinery in production.
MES (*Manufacturing execution system*): The difficulty of integrating multi-point systems that provide a data management system through a common user interface is systems developed for single and integrated analysis of multiple supply management components (Saenz de Ugarte el al., 2009).
SCADA (*Supervisory Control and Data Acquisition*): As the name implies, it focuses on the controller level, not the complete control system. Therefore, it is usually just a software package that is placed on top of the hardware on which it is interfaced through Programmable Logic Controllers (PLCs) or another commercial hardware module (Daneels and Salter, 1999).
DCS (*Distributed Control System*): These are systems which are formed in a plant or industrial process by means of connecting different manufacturing processes to individual inspections with the help of a large number of controllers. In these systems, each manufacturing process is controlled separately. The advantage of these systems is that the error occurring in one part does not interfere with the operation of the other parts. Usually used in large scale production enterprises (Anonymous, 2019a).
RTU (*Remote Terminal Unit)*: It is the name given to remote terminal units that can send data received from the sensors to the base station via a communication system. The RTU displays the

*Corresponding author, E-mail address: sedat.karaman@gop.edu.tr

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data obtained from the base station and also allows the operator to perform remote control tasks (Ahmed and Soo, 2008).

HMI (*Human-Machine Interface*): It is a set of hardware and software that enables communication between operators and machines and makes user inputs suitable signals for machines (Anonymous, 2019b).

SENSORS: It is the name given to the devices used in greenhouse activities, which perceive the environmental conditions of the products and transmit them to the related systems, perceive the environmental conditions and provide data about their status and changes. Some of the most commonly used sensors in greenhouses (Figure 2);

- Temperature / Humidity Sensors: They can measure instantaneous amount of temperature and humidity inside / outside greenhouse.
- pH Sensors: This device is used in fertilizer applications and it provides information by measuring the pH values of the mixture instantly.
- EC Sensors: They can measure the electrical conductivity of irrigation water and fertilizer applications.
- Rain Sensors: Mounted on greenhouse roofs, these devices can measure the intensity and amount of rainfall falling on the greenhouse roof.
- Wind Sensors: These are the devices that can measure the wind speed instantly.- PAR Sensors: These are the devices that measure the amount of energy received from the sun rays instantly.

In general, sensors are fully automatic systems or devices that inform users instantaneously and aim to minimize the damages that may occur in greenhouses (Figure 1) (Anonymous, 2019c).

Automation processes can be realized in greenhouses by using ERP / MES, SCADA, DCS, PLC, RTU, HMI and some or all of the sensors.

Figure 2. Sensors (Anonymous, 2019c)

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3. AUTOMATION SYSTEMS IN GREENHOUSES

Environmental conditions are of great importance in order to obtain high and quality yield in plant breeding. One of the most important of the greenhouse climate parameters is the greenhouse temperature. In greenhouses, heat is of vital importance for plants, so heating systems are needed in some greenhouses.

Heating costs in greenhouse established in Turkey constitutes 24% of total production costs. In other regions, it constitutes 20-60% depending on the climate (Baytorun, 2017). According to a study by Alpay (2018) by developing ANN (Artificial Neural Nets) model and fuzzy logic system, the energy consumed by the developed system for heating was 20% less than traditional systems.

Ciger (2010) developed a system that does not require any technical staff. In this study, a software that can be used easily and can perform automation processes according to the product has been developed. In this system, heat sensors (positive and negative thermistors), light sensors (photo resistance (LDR)), relative humidity sensors (RoHS), 15-220 Volt relays, three phase contactors and greenhouse liquid flow control valves are used. Temperature, relative humidity, irrigation, ventilation, wind speed and direction information are transmitted to the processor via sensors and adapted to the automation program, thus enabling the program to automatically activate the relevant systems. The data and the transactions carried out by the program were transferred to a certain system on the internet and the user was able to access the system at any time and from anywhere via the internet.

Ayan and Senol (2016) realized a system by using a PLC controller which added 100 rules and within the limits of these rules, it controlled the values obtained from the temperature and humidity sensors and cultivated tomatoes and strawberries by air conditioning in the greenhouse. The system was connected to the internet and made available for remote intervention. The temperature and humidity information in the greenhouse were obtained instantly, kept at the desired level and full automation was realized and the need for human labor was reduced to zero. The system fulfills all the air conditioning requirements in the greenhouse without the need for manpower. The manpower factor was made in such a way that temperature, humidity measurements and irrigation, fogging, ventilation, heating operations were controlled by the fuzzy logic controller so that only crop harvesting time was required.

Sammons et al. (2005) designed and developed a robot consisting of a large tank, spray heads, valve, motor and microcontroller to hold pesticides that can autonomously spray pesticides. As a result, these spray robots have shown that they could successfully fulfill the physical characteristics specified in the National Center of the Greenhouse Horticulture Center and thus work in their greenhouses.

Baytürk et al. (2013) implemented an internet-based greenhouse automation system. The system aims to automatically control the environmental conditions of the greenhouse, the status and control of the irrigation system and to inform the users instantly in case of possible system failures. In this application, it is possible to intervene the greenhouse through a single device by means of embedded micro controllers and an embedded web interface. They stated that this system is cost-effective, remotely controllable and suitable for all environments.

According Yılmaz (2013), with the use of an automation system, production and labor costs were reduced by 65%, electricity consumption by 40%, fuel consumption by 30%, irrigation water use by 30%, fertilizer usage by 30%, pharmaceutical use by 35% and overall costs by 74%.

Today, meteorology station - Circulation and Exhaust Fan System - Fertilization System - Fogging System - Ventilation System - Artificial Lighting - Greenhouse Heating System - Greenhouse

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Cooling System - Thermal Curtain System - Greenhouse Irrigation System - CO2 System are used in automation systems.

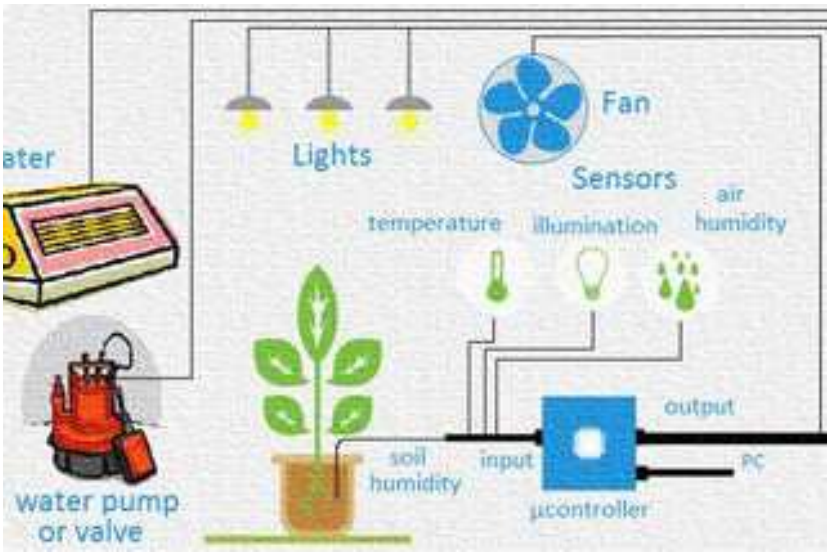

Figure 3. Greenhouse automation system (Source: https://www.instructables.com/id/Greenhouse-Automation-System-SAS/)

4. CONCLUSIONS

The widespread use of automation has been attributed to the unconsciousness of end-users, the fact that they are not able to dominate the subject, preferring to do these operations with human labor, preferring traditional agriculture, and finally high initial plant costs. These prejudices should be broken with adequate training and extension activities and although the initial plant costs of these systems are high in the long term, the benefits and gains to the producers in the long term should be explained and taught. Further research is recommended for improved automation systems to be used in greenhouses.

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