Smart Greenhouse and Smart Agriculture

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***Abstract*—In addition to the problem of growing high quality agricultural products combined with the effects of rapid increase of population around the world, climate changes and global warming, the search for producing higher quality products lower costs brought the necessity of using the opportunities of technology to overcome the problems in the agricultural sector. Studies on this subject have shown that Smart Greenhouse systems play an important role in solving these problems. In this study, an Arduino controlled Smart Greenhouse setup was prepared. In this research, in addition to the greenhouse control is not only autonomous, but also remote control of the smart greenhouse with mobile devices was provided by using bluetooth technology in case of need. The data in the Smart Greenhouse environment are read by sensors and controlled by the software, developed by researchers and the interventions such as heating, cooling, irrigation are either performed automatically or manually with the help of the Android application developed when required. In our research, Smart Greenhouse and plants with equivalent characteristics were selected and their development was examined. As a result it has been seen with the data we obtained through the research that, our system with the prototype, can be applied to large-scale greenhouses.**

I. Introduction

The evolution of information technology has led to the solution of many impossibilities. Over the years, our mobile phones, tablets and cars have become smart, and with the rise of smart technology, they have become a new standard in the sectors [1]. The change of traditional agricultural technique to modern techniques has been possible with the inclusion of advanced technology in this sector [2].

Greenhouses are facilities where production and development conditions are artificially provided in regions or climates where the growing conditions of a plant cannot be achieved. It is a common method so that a vegetable, fruit or flower is not limited to the seasons and regions in which it can grow [3].

It is estimated that the first greenhouse was used in a botanical garden in Italy towards the end of the 15th century. Later, especially in Europe, in the 17th century, protective and translucent greenhouses were started to be built by making use of the properties of glass [4].

In this study; In Indonesia, which is known as an agricultural country where the majority of its population is farmers, it has been observed that the need for potatoes has increased in parallel with the increasing population and the development of the fast-food industry. Therefore, it has been stated that there are problems arising from fluctuations in the quality and quantity of garden plants. It has been stated that the use of a smart greenhouse can increase the yield and production quality, so it has been stated that a smart greenhouse design suitable for potatoes can solve the problems of farmers [5]. In the study, an automatic greenhouse system with prototype scale was designed to provide a solution for the maintenance of potato varieties in a greenhouse based on the Arduino UNO microcontroller and to meet the needs in more efficient conditions. Soil sensor and light sensor are used in the system for temperature and humidity parameters. Thus, it is aimed to maintain temperature, soil moisture, light intensity and air humidity in accordance with the necessary conditions in potato planting. According to the operation of the system, a fan, LED light strip and a water pump are used [5].

In the study, a prototype was prepared for smart greenhouse management and a remote wireless control system was designed with software. The main purpose of this study was determined to increase the yield rate of plants. The control system used in the design was checked over and over again in real time with the microcontroller. Sensor information was taken through Arduino UNO microcontroller and controlled wirelessly by software prepared with MS Visual Studio. In addition, the main factors, Sunlight, Temperature and Humidity, are controlled by the entire system. Care has been taken when receiving data from the sensors, and the data obtained are analyzed and observed through algorithms. This has made the operation of the smart greenhouse different from any conventional greenhouse available on the market [2].

In this study, the remote control of the Arduino-based automatic irrigation system via smart devices with Android operating system was investigated similarly by using a humidity sensor. In this study, an economical and easy-to-use Arduino-based automatic irrigation system using smart devices with Android operating system for remote control has been developed. In order to be able to design the system, various soil types and certain products were examined and sampled. As a result, a soil moisture sensor proportional to the moisture content obtained from the soil used in the greenhouse was used [6].

In the study, the control system of the smart greenhouse controlled by an Android-based software using an Arduino microcontroller was designed. This study has been carried out in order to contribute to the solution of high quality food shortage in the world in recent years. here, smart information technology has been used to grow plants using smart greenhouse technology. The importance of creating smart greenhouses in residential areas and allowing the plants to grow throughout the year is highlighted. For these reasons, it

is aimed to manage mini greenhouses developed using an Arduino based microcontroller and Android device [7].

In this project, a study was carried out in the field of "Smart Agriculture, Smart Greenhouse" in order to keep up with the developing technology in the light of these developments. For this purpose, a smart greenhouse prototype was created, programmed in accordance with the determined climate conditions and it was aimed to be developed in the light of the obtained data.

II. METHOD

Nowadays, with the development of Industry 4.0 technology, it has become inevitable that every device we see and use around us can connect to the internet or determine a working order by making self-decisions. It is possible to give examples such as smart homes, smart cars, smart home appliances, smart factories. Depending on the developing technology, smart technologies have been used in all areas of life and these technologies have continued to develop over time. Advances in technology are adapted to smart technologies and updates are made according to the results. Nowadays, smart technologies have become a necessity in many areas.

In this project, first of all, as a result of the researches and examinations we have done, a method has been determined on how to direct our work. Then, by creating a smart greenhouse prototype, it was thought to monitor the development of the plants to be grown in the smart greenhouse. Subsequently, it is based on analyzing the results and determining what improvements can be made in this context. In addition, a preliminary study was carried out on how to grow different plants in the same greenhouse by following the development of flower and vegetable plants grown in the same greenhouse environment.

In the study, after the researches, the process steps were determined as follows.

- Determining the materials to be used,
- Creating the physical prototype of the smart greenhouse and determining the plants whose development will be monitored,
- Proper circuit design,
- Development of software suitable for Arduino Uno microcontroller
- Monitoring greenhouse values by developing a mobile application with Appinverter,
- Analyzing the data and evaluating the results.

In the study, the materials used to create and control the smart greenhouse prototype, the general properties of the materials and their intended use are explained below.

Arduino Uno Microcontroller Board: Arduino is an important electronic hardware and software-based microcontroller that has been widely used in recent years as an input / output (I / O) board. It is especially preferred in projects due to its low cost and ease of use [8].

Sensors: The elements that have the biggest share in adding the title of smart to the greenhouse prototype are the sensors used in the greenhouse. Sensors can also be referred to as detectors. Sensors play an important role in controlling the environment variables of smart devices. The information obtained from the sensors is presented to the software in order to analyze the values such as temperature, humidity, temperature and pressure of the environment. As can be seen from this information, sensors are our sensory organs that will help us understand the environment in the greenhouse.

DHT11 sensor: In our study, the DHT11 sensor was used to measure the temperature inside the greenhouse. The DHT11 sensor was deemed appropriate to be used in the project due to its cost and ease of use. The technical features of the DHT11 sensor used are given in Table I [9].

TABLE I. TECHNICAL SPECIFICATIONS OF THE DHT11 SENSOR

Temperature measuring range	0ºC - 50ºC
Temperature accuracy	±2ºC
Humidity measuring range	%20 - %90 RH
Humidity accuracy	±%5 RH

TABLE II. TECHNICAL CHARACTERISTICS OF SOIL MOISTURE SENSORS

Measuring range in dry soil	0~300
Measuring range in moist soil	300~700
Measuring range in water	700~950

HC-06 Arduino bluetooth sensor: Bluetooth connection is used for the communication with Android-based mobile devices and manual control of the smart greenhouse prototype that we have prepared. For this purpose, HC-06 Arduino bluetooth sensor is used [11].

In our study, a 16x2 LCD panel was used to show the data on the prototype and to show the interventions made through the greenhouse application. The information received from the mobile application is transmitted over the Arduino card. The data regarding the operation of the system obtained as a result of this information can be transmitted to the user via the LCD panel on the screen [12].

Ventilation Fans: It has been planned to use 2 wired plastic impeller fans on the greenhouse, one large and the other small, to provide air flow. One of the fans is positioned on the right side of the greenhouse and the other on the left. The main task of the big fan is to cool the air inside the greenhouse by throwing the hot air out of the greenhouse. The main task of the small fan is to ensure that the heat generated when the heater works is spread into the greenhouse without damaging the plants [13].

Irrigation System: In the irrigation system we use in our project, it is planned to use a brushless submersible water pump operating at 12V. It is planned that the water coming out of this pump will reach all soil surfaces through the plastic hose. Technical features of the submersible water pump used in our study are given in Table III [14].

TABLE III. SUBMERSIBLE WATER PUMP SPECIFICATIONS

Flow rate	240 liters per hour (240L/H)
Power	4.8 W
Maximum liquid temperature	60ºC
Maximum working depth	3m

Heater System: Care should be taken when choosing a heater to ensure the heat balance of the greenhouses. Because, intense heat in a small environment can cause damage to plants. For this reason, it is planned that the heater selected will be activated for a short time with a small fan so that it does not give heat to a single point. In this context, a ceramic heater lamp is used. Ceramic heaters are generally used in chick incubators.

III. PRESENTED PROJECT

The rapid population growth combined with the effects of climate changes and drought has revealed the problem of growing quality products. The necessity to use the possibilities of technology has emerged in order to overcome the problems in the agricultural sector, which is one of the most important living resources in the World. Smart greenhouse management aimed to reduce production costs in terms of sustainable development and environment. In addition, it aimed to grow the desired products as a result of creating suitable climatic conditions in different seasons.

In this project, a study was carried out in the field of "Smart Agriculture, Smart Greenhouse" in order to keep up with the developing technology in the light of these developments. For this purpose, a smart greenhouse prototype was created and programmed in accordance with the determined climatic conditions, and it was aimed to be developed in the light of the data obtained. In the project, first of all, the studies on this subject were examined. The necessity of using smart technologies in agriculture and greenhouses has been observed in the studies examined. In the researches, examinations have been made on how and in which environments the smart agriculture application will yield efficiency. The prototype created as a result of the examinations was tested and updated as shown in Fig. 1.

(a) (b)

Fig. 1. Greenhouse prototype initial photos a and b

The prototype is planned as seen in Fig. 2 by bringing together the researches, materials determined according to the determined prototype and the studies examined. A greenhouse roof is made of wood laths by cutting through the cover part of the greenhouse. On the greenhouse prototype, many issues that need to be considered such as the inlet and outlet of the sensor cables, the location of the ventilation fans and the placement of the cables, the placement of the heater circuit, the location of the irrigation system and the lighting have been carefully planned.

Fig. 2. Placement of the light and heater on the prototype

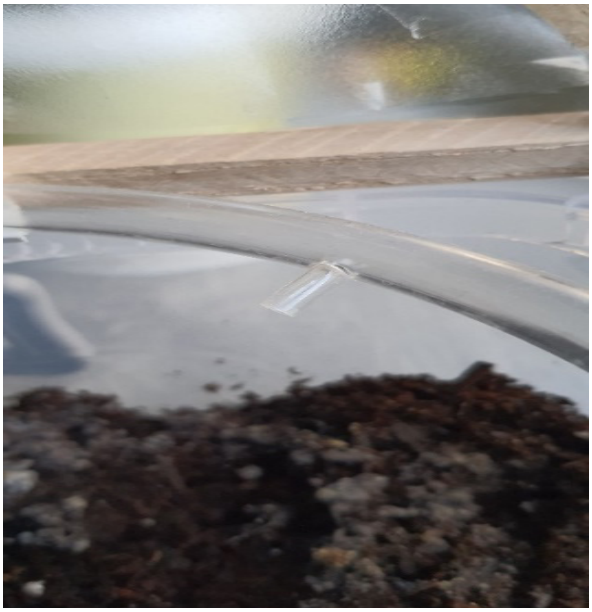

Fig. 3. Irrigation system layout on the prototype

The ground was prepared from pumice stone in order not to damage the roots on the greenhouse floor. Soil and some worm manure were added on the prepared ground and irrigation system were constructed as presented in Fig. 3. As a result of the researches, it was concluded that it would be appropriate to plant tomato, pepper and cucumber plants grown in approximately the same environments and begonia flowers grown in approximately the same values with them.

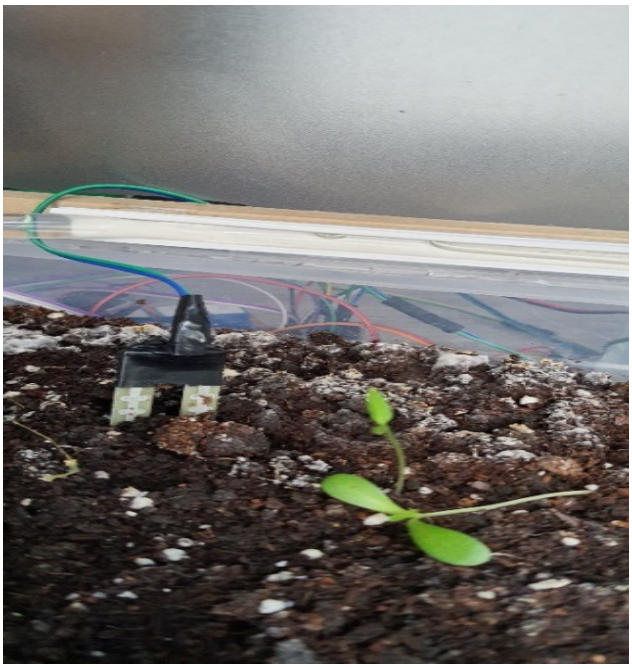

Fig. 4. Soil moisture sensors placed in the prototype

It has been decided that the temperature of the environment where these plants will be grown should generally be between 20 C and 30 C and the soil moisture should be above 50%. The system, which was created in accordance with the prepared prototype, was made software controllable by adding all the components as presented in Fig. 4 and 5.

Fig. 5. View of the system with all its components

Software control has been provided with Arduino in order to make the greenhouse operational for the control of the system. Arduino interface was used for the software and the system was enabled to operate autonomously. Arduino IDE interface was used while creating the software.

In addition, an interface has been created to enable the system to work manually with Android-based mobile devices when requested.

Depending on the values that the system receives from the sensors, it is ensured that the water pump, heating and cooling systems are turned On / Off according to the situation when necessary. And it is ensured that the LCD panel reflects the information on the screen continuously. In addition, codes were prepared in a way that allows the changes that occur automatically or manually in the system to be reflected on the LCD screen.

Appinvertor [15]is an extremely useful and simple platform that enables block-based mobile application development via web address. It has been decided to develop the mobile control part of our project on this platform. The program is designed to allow manual and automatic control of the greenhouse. The mobile interface prepared with Appinvertor is designed as shown in Fig. 6.

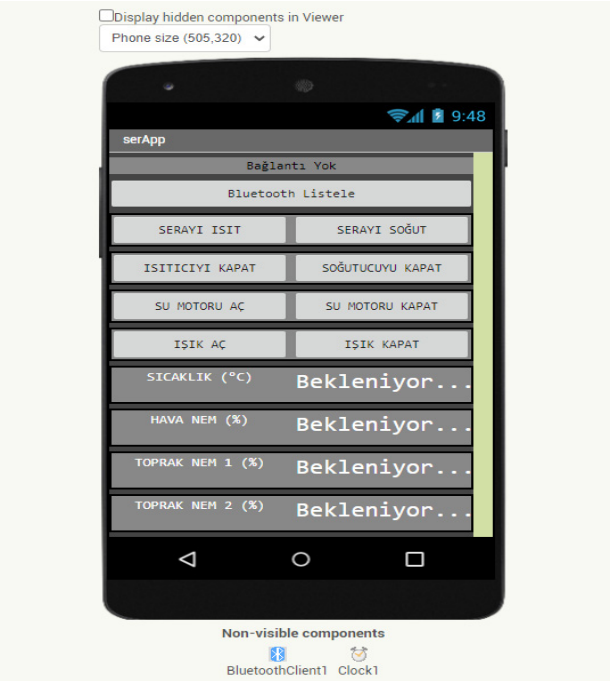

Fig. 6. Android application interface designed in Appinvertor

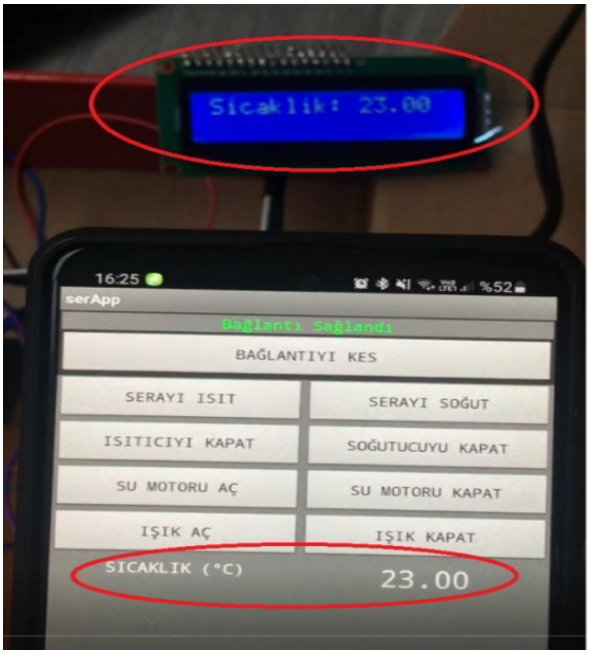

Fig. 7 Displaying the temperature in the application and on the LCD screen

Arduino connection is made with the help of HC-06 bluetooth module. The first data read from the sensors will be updated regularly at the bottom of the page. The temperature value read from the sensor is shown regularly both in the application and on the LCD screen as seen in Fig. 7. Other values can be followed in the same way. In addition, with the Android application, the smart greenhouse can be intervened at any time, regardless of the automation criteria.

IV. Conclusion

In this study, firstly, studies on smart agriculture were examined. Research has been carried out on smart greenhouse applications, materials used, prototypes created, technologies used in smart agriculture applications and determination of appropriate software. In terms of suitability to today's technology, studies that have been carried out especially since 2013 were examined while conducting the source research. In addition, the sources have been selected from studies conducted in different parts of the world. In this way, it was examined how smart greenhouse applications produced in different countries under different climatic conditions were developed. And the results of these studies were examined and compared. It is aimed to achieve the most efficient Smart Greenhouse application by comparing the results of different studies and making prototypes under the most suitable conditions.

References

[1] Singh, P., Saikia, S., 2016, “Arduino-Based Smart Irrigation Using Water Flow Sensor, Soil Moisture Sensor, Temperature Sensor and ESP8266 WiFi Module”, 2016 IEEE Region 10 Humanitarian Technology.
[2] Jafar, I.B., Raihana, K., Bhowmik, S., Shakil, S.R., 2014. “Wireless monitoring system and controlling Software for Smart Greenhouse Management”, 3rd International Conference On Informatics, Electronics & Vision 2014.
[3] Y. S. Arı,Birden Fazla Seranın, PLC ve SCADA Yazılımı İle Kontrolü ve İnternet Üzerinden İzlenmesi“, Yüksek Lisans Tezi, Marmara Üniversitesi Fen Bilimleri Enstitüsü, İstanbul, 2011.
[4] Turkcebilgi.(https://www.turkcebilgi.com/sera)
[5] Sari, I.A., Lestari, A.N.H.D., 2018, “Smart Greenhouse sebagai Media Pembibitan Kentang Granola Kembang Berbasis Mikrokontroler”, Prosiding Seminar Nasional Teknologi Elektro Terapan, Vol. 02 No. 01, ISSN: 2581-0049.
[6] Arvindan, A. N., Keerthika, D., 2016, “Experimental Inverstigation Of Remote Control Via Android Smart Phone Of Arduino-Based Automated Irrigation System Using Moisture Sensor”, 3rd International Conference on Electrical Energy Systems.
[7] Teslyuk, T., Denysyuk, P., Kernytskyy, A., Teslyuk, V., 2015, “Automated Control System for Arduino and Android Based Intelligent Greenhouse”, MEMSTECH 2015, Polyana-Svalyava (Zakarpattya), Ukraine.
[8] https://store.arduino.cc/usa/arduino-uno-rev3, (January 2020)
[9] https://datasheetspdf.com/pdf/785590/D-Robotics/DHT11/1, (January 2020)
[10] https://pdf.direnc.net/upload/gravity-analog-toprak-nem-sensoru-datasheet.pdf, (January 2020)
[11] https://components101.com/wireless/hc-06-bluetooth-module-pinout-datasheet, (January 2020)
[12] https://components101.com/16x2-lcd-pinout-datasheet, (January 2020)
[13] https://www.deltafan.com/Download/spec/AFB0712VHB.pdf, (January 2020)
[14] www.bldcpump.com , (January 2020)
[15] https://appinventor.mit.edu/ , (January 2020)