Smart Iraqi Farms Based on Internet of Thing

Jamal Al-Tuwaijari[1], Loui H. Abbas[2]

[1]Professor of College of Computer Sciences, University of Diyala, Iraq, Email: Dr.altuwaijari@uodiyala.edu.iq
[2]Ministry of Communication, Iraq, Email: louayaltamimi@gmail.com

Received: 17.04.2024 Revised : 18.05.2024 Accepted: 23.05.2024

ABSTRACT
The concept of smart agriculture in Iraq includes innovative methods of farming that integrate technology and sustainable practices to enhance agricultural productivity and efficiency. By adopting techniques such as using water-efficient irrigation systems and conserving resources, Iraq can address the challenges associated with climate change and water scarcity in agriculture. Therefore, the topic of smart agriculture in Iraq, based on the Internet of Things, was adopted in this dissertation . was divided into 3 stages : 1- In this stage, the following sensors were used (NPK1, NPK2, NPK3) to measure the basic soil elements nitrogen, phosphorus, and potassium. The following sensors (X1, X2) were also used to measure PH, soil temperature, and conductivity. This is for the sample that was irrigation intelligently and the data was collected in the form of a quantitative Excel file, and the total of record in system of 5 sensors (4823) record. In this system, several measurements were taken for nitrogen, phosphorus, potassium, PH, soil temperature, and conductivity, and then the average readings were taken to calculate the final value for each of the factors.2- In this stage, the sensors (NPK4, NPK5) were used to measure the following parameters: potassium, nitrogen, and phosphorus. Other sensors (X3, X4) were also used to measure other parameters as well, such as conductivity and PH. And the total of records in system of 4 sensor (2991) record. The data collected from the above sensors was used as the data set that will be used in comparison with the smart system (5 sensors). Also, the irrigation process here used traditional irrigation, which had a negative impact on agricultural production, as we saw in the results of the data analysis. Compared to using the smart irrigation method, which had a positive effect on the product as well as on mineral soil elements such as nitrogen and potassium. Also The C programming language was used to program the Arduino. 3- In this stage, the smart irrigation system, the result was reached that the amount of water used was saved approximately 60%, and this was calculated through the mathematical calculation of the sample used. This indicates the difference in saving water between using smart methods of irrigation and traditional methods of irrigation. Also, the smart irrigation process preserves the soil, increases the product, and also preserves the mineral components of the soil. The irrigation process is carried out quantitatively by reading from the soil moisture sensor, and when the moisture reaches 200 or less, the smart valve is opened. Otherwise closed and, the sensor will read again. Note that the readers are programmed every 24 hours, and this number depends on the type of the plant and the season, whether summer or winter. After that, the water is turned on for 10 minutes according to the programming for the sample. This can be changed according to the need , sample and the type of plant . And This procedures implemented in Arduino IDE language . To evaluate the data and determine if the soil was appropriate for agriculture or not, four algorithms (machine learning algorithms) were used: decision trees, random forests, support vector machines, and KNN. In order to implement these methods, the Python programming language was utilized

Keywords: Smart Agriculture, Agriculture in Iraq, IoT, Machine Learning, Smart Farm

1. INTRODUCTION

Agriculture in Iraq is the primary means of subsistence for the population. It has been noted that the agricultural industry has not seen much crop development over the last ten years. Since crop rates are declining, food prices are steadily raising. This can be caused by a variety of things, including water waste, poor soil fertility, misuse of fertilizer, climate change, illnesses, etc. Effective agricultural intervention is crucial, and the solution is better management, regular crop maintenance, and inspection, all of which incorporate IOT integration with wireless sensor networks, sensor-based parameter sensing, and SMS notification of the concerned parties. It has the ability to alter how agriculture develops and makes a significant contribution to making agriculture smarter.In order to increase production of crops, monitoring devices are employed in the field to gather data on farming conditions (such as light intensity, humidity, and temperature). IoT (Internet of Things) technology is a current trend in several industries, including agricultural monitoring systems. Typical farming, handling crops and cattle requires human work, which frequently results in wasteful resource usage. The idea of "smart farming" can overcome this drawback by providing farmers with training in IoT usage, access to the GPS, and data management skills in order to improve the amount and quality of their output.Modernizing agriculture may be facilitated by combining wireless sensor networks with cutting-edge technology like the cloud and the internet of things.IoT is a network of physically interconnected devices that may be accessed online. It is made up of things, sensors, communication systems, processing, and computational units. The cloud server, a computational and processing device, receives the data from the sensors and transmits it to it over the Internet [1]. The number of Internet of Things (IoT) devices has rapidly expanded in recent years due to the rapid advancement of digital advancements. In the coming decade, millions of new gadgets, sensors, and applications will be available online thanks to cutting-edge digital technologies. Interconnected sensors and devices produce and send a wide variety of data across network architecture [2].Smart systems and IoT (Internet of Things) are similar ideas. The IoT and other technologies are used in the next generation of computing and information systems, known as smart systems, to give real-time networked information and control [3]. IoT devices must be integrated into a wider architecture with components that can actualize smartness in order to become intelligent. [4].An Internet of Things (IoT) platform is a software package or cloud service that offers tools and capabilities to connect and manage different types of endpoints in an IoT ecosystem. It acts as a bridge between actual things and practical knowledge, making it possible to gather, store, analyze, and manage data produced by connected assets and assets [5].

2. METHODOLOGY

A smart system for farming, sometimes referred to as smart agriculture or digital farming, uses Internet of Things (IoT), sensors, and automation technologies to increase the productivity and efficiency of farming activities. With the use of these technologies, farmers can keep an eye on and manage a number of variables, including soil moisture, temperature, climate, and crop development, enabling them to create the ideal circumstances for crop growth.Smart farming, often referred to as digital farming is the use of data and information technology to enhance intricate agricultural systems. It incorporates both hardware components, such as sensors and drones, and software components, such as programs and mobile applications, to include both individual equipment and all agricultural activities.The following of the stages involved in smart farming

2.1 The primary preparation

Smart life is evolving day by day, thanks to the development of microelectronic components, and artificial intelligence technology has made many ideas a tangible reality. They are precise electronic components, or with electronic properties, that convert and transfer physical quantities, such as nitrogen, potassium, calcium, moisture, temperature and soil type into data through which we can analyze the important elements in the soil that plants need. Two types of sensors have been use; the first typeA soil NPK sensor is a tool used to gauge the concentrations of phosphorus nitrogen ,and potassium ,three necessary nutrients. These minerals are essential for plant development and are a major factor in the fertility of the soil. The soil NPK sensor may be used to measure the amounts of phosphorus, potassium, and nitrogen in the soil as well as to assess the fertility of the soil. This makes it easier to conduct a methodical evaluation of the state of the soil. In horticulture, soil science, and agriculture, soil NPK sensors are extensively utilized. Farmers and gardeners may use the precise and up-to-date information they give to make well-informed decisions about fertilization and fertilizer management.While the second type named Multi Parameters Sensor is used to measure the amount of pH, temperature, conductivity, and humidity in soil. The sensors were distributed in twoagricultural fields, where the first field represents smart agriculture while the second ring represents the field of traditional agriculture as shown in figure below.

2.2 Reading data

In smart agricultural field, the electric circuit consist of ESP32, RS485, three NPK sensor (NPK1, NPK2, NPK3), and two Multi soil NPK (X1, X2) sensors connect together as shown in figure (1). The sensors mention above is planted in the ground to read data in the soil every fifteen minutes and sent through the Internet of Things to be stored in the database. After that the data was analyze accurately every week and presenting the results to the agricultural extension team in order to reviewing the data, after that the guidance is directed by the extension team if the elements in the soil are sufficient to meet the need of the plant or not. If it is not enough to fill the plant food, the ratio of each element that must be added to fill the shortage is determined.

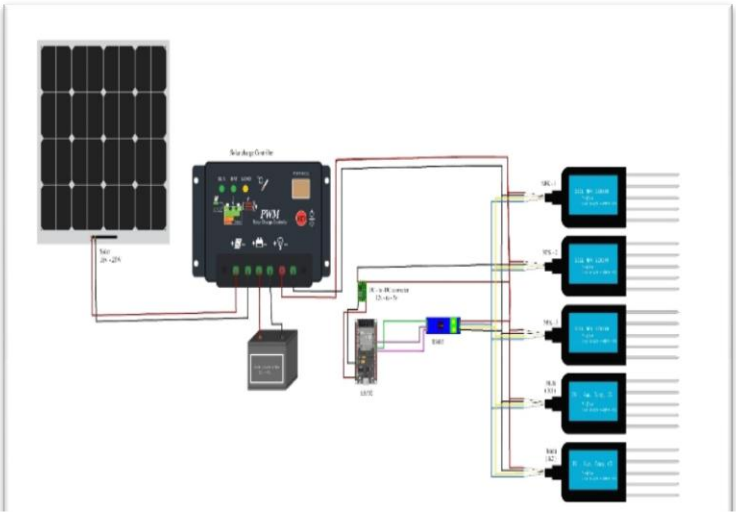

Fig 1. Smart farm sensors circuit

In traditional agricultural field, the electric circuit consist of ESP32, RS485, two NPK sensor (NPK4, NPK5), and two Multi soil NPK (X3, X4) sensors connect together as shown in figure (2). The sensors mention above was planted in the ground to read data in the soil every fifteen minutes and sent through the Internet of Things to be stored in the database. After that the data was analyze accurately every week and presenting the results to the agricultural extension team in order to just reviewing the data and compare with smart agricultural field.

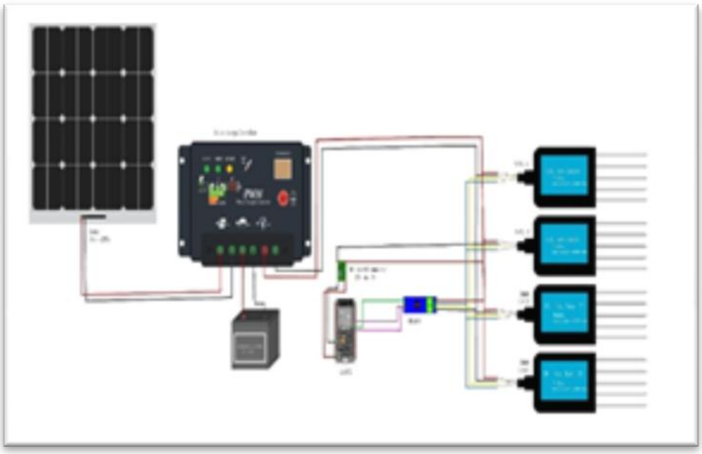

Fig 2. Traditional farm sensors circuit

3.Data Analysis

Data was collected through readings taken from sensors, which were collected in the cloud, and then displaying that data in an Excel file via Google Drive. As for the quality of the data collected, it will be mentioned later to clarify how the data was collected, the methods used to collect it, and the reason for choosing the type of data.An essential aspect of research projects and programs is data analysis, that is done in order to draw conclusions and knowledge from the data. It entails looking over the findings, applying the right analytical techniques, and making sure the data is accurate and legitimate. Data analysis provides informative information through the detection of relationships, and patterns in the data. In many different industries, it's employed to make deductions, streamline workflows, boost productivity, and aid in decision-making. For data analysis, a types of methodologies and techniques are used, such as statistical analysis, preprocessing techniques, quantitative measurements, and uncertainty evaluation .Analyzing data provides results, enables greater decision-making, and improves the development of better products and services.

3.1 Machine Learning to Data Analysis

Processes for data analysis can greatly benefit from the integration of machine learning in terms of predictive power, automation, fraud detection, customer knowledge, and continuous development. While traditional data analysis abilities are still necessary, developing machine learning skills is becoming more and more relevant as a complimentary skill for data analysts. Machine learning is revolutionizing data analysis in agriculture by enabling more accurate predictions, optimized decision-making, and enhanced productivity. In this dissertation ,four machine learning algorithms were used to decide if the soil good for agriculture or not, based on the data that was read from the sensors. The algorithms that were used for prediction are (Decision tree, Random forest, Support vector machine, KNN). The reason for using four algorithms because of knowing the optimal algorithm for these systems. 70% of the data is used to train the system, and 30% makes the prediction.

3.2 SPSS

SPSS was employed in the data analysis. A software program Applied to analysis of statistical is called SPSS (Statistical Package for the Social Sciences). It is extensively utilized in many different sectors, including marketing, health sciences, and social sciences. SPSS offers tools for managing data, analyzing statistics, visualizing data, and integrating its products with other technologies. SPSS is often used for data analysis and interpretation in avariety of areas, including government, healthcare, academia, and market research. A broad range of data formats are evaluated with SPSS, such as server log files, organization customerdatabases, Google Analytics, survey findings, and scientific research results. SPSS is an effective software program for analyzing and interpreting data

4.RESULT

4.1 The result analysis data after use SPSS

The researcher used the (T) test for independent samples to find out whether there is a significant difference between (4 sensor) and (5 sensor) at a measure of significance of (0.05). There will be a difference of significant at (0.05) if the value (P – Value) is less than (0.05). The term "sample size" is explain below.

The variable	Population size	Sample size
4 sensors	2991	341
5 sensors	4823	356

- **Nitrogen**

The T-value of the research sample for thenitrogen variable, shows that there is a significant difference at the significance level (0.05) for the sample on the nitrogen variable because the value (P – Value) is less than (0.05). The value of the ETA square was (0.554), which is a very high value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.554	695	29.37	338.95	573.23	653	**5 sensor**
				14.51	33.71	341	**4 sensor**

- **Phosphorous**

The T-value of the research sample for the phosphorus variable shows that there is a significant difference at the measure of significance of (0.05) for the research sample on the phosphorus variable because the P value is less than (0.05). The value of the ETA square was (0.872), which is a very high value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.872	695	68.70	201.28	883.28	653	**5 sensors**
				33.52	124.55	341	**4 sensors**

- **Potassium**

The T-value of the research sample for the potassium variableshows that there is a difference of significant at the significance level (0.05) for the research sample on the potassium variable because the value (P - Value) is less than (0.05). The value of the ETA square was (0.873), which is a very high value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.873	695	69.15	201.10	880.65	653	5 sensors
				33.78	117.49	341	4 sensors

- **Soil Moisture**

The T-value of the research sample for the soil moisture variable shows that there is a significant difference at the significance level (0.05) for the research sample on the soil moisture variable because the value (P - Value) is less than (0.05). The value of the ETA squared was (0.240), which is a very high value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.240	695	14.83	4.57	20.09	653	5 sensors
				2.91	15.77	341	4 sensors

- **Temperature**

The T-value of the research sample for the temperature variable shows that there is a significant difference at the significance level (0.05) for the research sample on the temperature variable because the value (P –Value) is less than (0.05). The value of the ETA square was 0.019, which is a small value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.019	695	3.64	2.87	32.082	653	5 sensors
				2.46	31.34	341	4 sensors

- **PH**

The T-value of the research sample for the PH variable shows that there is a significant difference at the significance level (0.05) for the research sample on the PH variable because the value (P – Value) is less than (0.05). The value of the ETA square was (0.200), which is a very high value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.200	695	13.17	0.69	6.63	653	5 sensors
				0.71	5.94	341	4 sensors

- **Soil Salinity**

The T-value of the research sample for the soil salinity variable shows that there is a significant difference at the significance level (0.05) for the research sample on the soil salinity variable because the value (P - Value) is less than (0.05). The value of the ETA square was (0.214), which is a very high value.

P - Value	Eta Squared	df	T	Std. Deviation	Mean	N	Group
0.000	0.214	695	13.74	163.42	394.14	341	5 sensor
				67.74	262.94	356	4 sensor

4.2 The result analysis of data by using Machin Learning

Four algorithms were used(Decision tree, Random forest, Support vector machine, and KNN) to analyze the data and decide whether the soil was suitable for agriculture or not. So that the Python programming language was used to implement these algorithms. The results were as follows:

- **Decision Tree Algorithm Implementation**

In the above figure (3) explain the run of decision tree algorithm here we notice the accuracy rate (0.914996) and values of each recall, precision, and F1-score (Metrics like the recall, accuracy, and F1-score are used for evaluating how well categorization models perform)

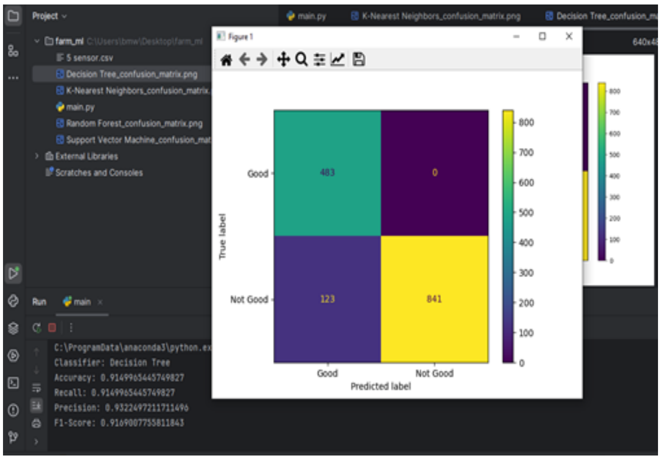

Fig 3. Decision Tree Algorithm Implementation

- **Random forest Algorithm implementation**

When implementing the random forest algorithm figure(4), we find that the accuracy value is very good, so we notice that it is a better algorithm than the decision tree because it takes more than one tree and then makes the decision. The accuracy rate of this algorithm (0.999388) and values of recall, precision, and F1-score. It is better compared to the decision tree algorithm.

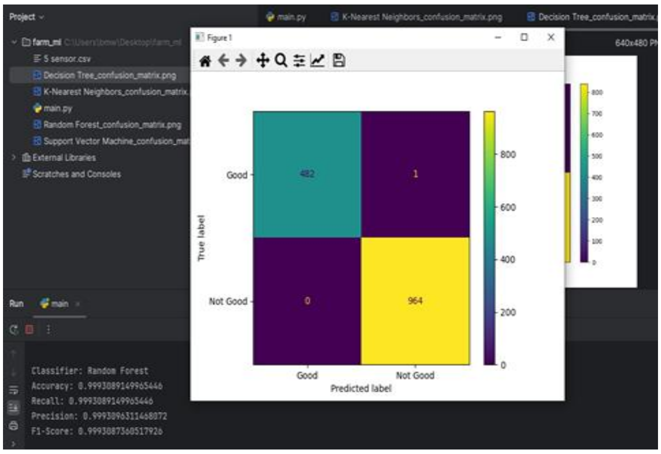

Fig 4. Run of Random forest

- **Support Vector Machine Algorithm Implementation**

When implementing the support vector machine algorithm figure (5), we find that the accuracy value is (0.9695922). It is less than compared to random forest algorithm and values of recall, precision, and F1-score too less compared to the random forest algorithm. This indicates that this algorithm is less efficient than the above algorithm.

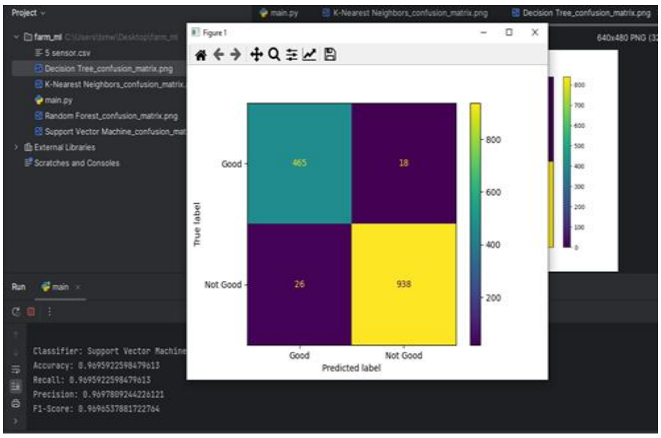

Fig 5. Support Vector Machine Algorithm Implementation

- **k-Nearest Neighbors (KNN) Algorithm Implementation**

After the run of this algorithm figure(6), we will observations the value of accuracy (0.98064) too less than the random forest algorithm. , and F1-score too less compared to the random forest algorithm.

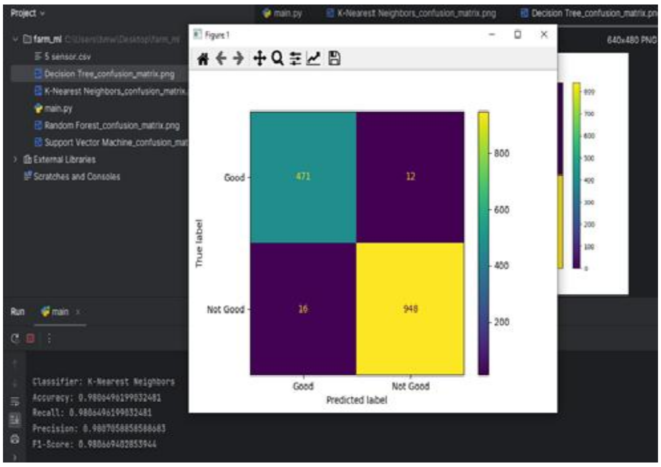

Fig 6. k-Nearest Neighbors (KNN) Algorithm Implementation

6. CONCLUSION

In this work, three stages were created and applied in the sample area regarding smart agriculture in Iraq, based on the Internet of Things. They were applied to plants of the Cucurbit family, and the cucumber plant was chosen

- The first stage which include (5 sensor) is used to read the nitrogen , phosphorus, potassium and electrical conductivity (EC) were used to read the soil elements, in addition to reading the soil PH by using sensors of a type called NPK, which is multi-reading. Also, another element was read, which is soil moisture, which It was treated with irrigation . The devices used in addition to sensors are Arduino, battery, solar, solar Charge Controller, and converter . The data is read by sensors and sent by the Arduino, which is equipped with Wi-Fi, and this data is stored in the Google Drive.Note that the sample is watered using smart irrigation by use smart valveThe Arduino is programmed for the irrigation period. It was initially 15 minutes to water the sample whose field area was 11 x 9 meters. After that, the period was reduced to 10 minutes. The time period depends on the field area and can be changed by programming the Arduino.
- The second stage which include (4 sensor) is used to read the humidity, temperature, PH, nitrogen , phosphorus, potassium and electrical conductivity (EC).So The data is read by sensors and sent by the Arduino, which is equipped with Wi-Fi and this data is stored in the Google Drive.In addition to the sample is watered using traditional irrigation.
- The collected data was analyzed in the form of an Excel file using the SPSS system, and the result was that the sample of the smart irrigation was much better than the sample of irrigation using traditional methods. The dissertation has actually proven that excess water in irrigation has a negative impact on the main soil elements, which are nitrogen, phosphorus, and potassium, and thus leads to poor production. Proving this is that the value of the mean is greater in a system with 5 sensors than a system with 4 sensors for the elements nitrogen, phosphorus, and potassium
- The data was processed every week, taking the average for each factor, then making the decision whether there was a deficiency or not after comparing the result with the normal value for each factor
- Four machine learning algorithms were used: Decision tree Random forest, Support vector machine, and KNN. A conclusion arrives random forests can achieve higher accuracy in some applications by harnessing the power of ensemble learning and providing additional benefits like feature importance analysis. But in the end, the choice depends on the current issue.

REFERENCES

[1] MushtaqullaBaig , Shivram B Singh, et al, "IoT Based Smart Farming System," Visvesvaraya Technological University, India,2021.

[2] J. Lin, W. Yu, N. Zhang, et al, "A Survey on Internet of Things: Architecture, Enabling Technologies, Security and Privacy, and Applications," IEEE Internet Things J., vol. 4, no. 5, pp. 1125–1142, 2017.

[3] Prof. Dr. Chih-Yu Wen, "Smart Systems and Internet of Things (IoT)," Department of Electrical Engineering, National Chung Hsing University, South District, Taichung City 402, Taiwan,2021.
[4] Marco Aiello, "IoT architectures: from data to smart systems, "www.frontiersin.org/articles/10.3389/friot.2022.959268/full , 2022.
[5] Natallia Sakovich, "10 Best IoT Platforms for 2023," The use of some special Internet of Things platforms contributed greatly to the success of the project in terms of data storage as well as the data protection process. The platforms that were used were ThingBoard and Blynk platforms.