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Tinatin Mshvidobadze
Gori State University
Doctor of Technical Sciences
tinikomshvidobadze@gmail.com
https://orcid.org/0000-0003-3721-9252

Analysis of a Smart Agriculture System Based on the Internet of Things

Abstract

The article highlights the interplay between the smart agricultural Internet of Things system and innovation-driven approaches in promoting harmonious coexistence between society and nature and promoting high-quality economic growth. The article discusses the methods of using IoT-based green technologies, which provide new ideas for the development of green innovations and the digital economy. To illustrate the effectiveness of the use of various digital technologies, we consider examples of digital, green and innovative development in agriculture. The article presents a comprehensive analysis based on existing research and paves the way for future in-depth research. The conclusions of this article have both theoretical and practical significance and suggest practical approaches to achieve sustainable development in various sectors.

Keywords: *smart agriculture***,** *IoT*, *agriculture*, *green technology*, *Python*, *aeroponic*

Introduction

To resolve the contradiction between the environment and socio-economic development, digital, green and innovation are key issues for sustainable economic development. The transition to a digital economy is a step towards rapid resource optimization and high-quality economic development. At the technical level, the digital economy includes emerging technologies such as big data, cloud computing, the Internet of Things (IoT), blockchain, artificial intelligence (AI) and 5G communication (Saiz-Rubio & Rovira-Más, 2020).

Green economy a new economic form that is developed with a market orientation, based on the traditional industrial economy. And aims to achieve the interrelationship between the economy and the environment. (Pearce,1989).

A recent report published by Allied Market Research – titled "Green Technology and Sustainability Market by Technology and Application: Opportunity Analysis and Industry Forecast, 2020–2027" – confirms, that large corporations or small and medium-sized enterprises have begun to integrate environmental policies into their business models (Tian, 2021).

In recent years, some manufacturing enterprises have begun to develop and produce green products with environmental efficiency, in order to increase market share and product competitiveness. In this context, the green supply chain has emerged, providing a new mode of operation for enterprises. The adoption of green supply chain management greatly contributes to the long-term viability of businesses and serves as an effective operational plan for the growth of modern businesses (Tseng et al, 2019).

Western countries have increased their funding for "green projects." For example, in 2021-2023, the European Union allocated 22.8 billion euros for the development of "green" activities, while the US allocated 94.4 billion dollars. South Korea and China are leading in this regard: Korea invested 38.1 billion dollars, 3% of the country's GDP; China invested 215 billion dollars, 3% of the country's GDP (Green Economics Institute, 2022).

With the widespread use of "global things" and artificial intelligence, the digital economy is also developing rapidly. Many new technologies and business models have emerged in agriculture. These innovations have changed the process of value creation (Pan et al., 2022).

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Research

The theoretical basis of the study is the work of researchers on innovative development and innovation management, journals, own research, research results of local and international organizations and Internet resources, on the basis of which the discussion and conclusions are illustrated.

The methodological basis of the study is both general scientific and economic research methods, namely: descriptive, analytical and explanatory methods, functional analysis and synthesis, systematic and logical approaches, grouping, comparison, evaluation and statistical analysis methods, on the basis of which important research issues are identified.

Smart Agriculture IoT System Example Using Python Programming

The Internet of Things is a technology that connects devices to a computing network and allows them to collect, analyze, process, and transmit data to other objects through software and hardware. For the most part, devices operate without human intervention, although humans can interact with them. IoT systems typically consist of a network of smart devices and a cloud platform to which these devices are connected (Yan et al, 2024).

We will discuss the use of powerful IoT technology to simulate a smart agriculture IoT system and solve this problem.

In order for computers to communicate with the Internet, it is necessary to define communication protocols (Gorli & G. Yamini, 2017).

For its ease of use, we have developed a Python library called *SmartAgro*, which aims to communicate with the server and facilitate the transmission of messages through Python software. The Python standard library is very extensive and provides a wide range of functionality.

If both enabling the *SmartAgro* service and connecting sensors to detect data are done on the same *UNIHIKER*, then it functions as both a client and a server.

The *SmartAgro* IoT system is used to determine the moisture value of an external soil moisture sensor, display the data on the screen, and simultaneously send it to the *SmartAgro* IoT platform for viewing on the platform's web interface.

After connecting remotely to Rowboard web menu, post entries for the topic "Smart Agriculture IoT System/Soil_Moisture_Value" will appear on the platform's website. (Figure 1).

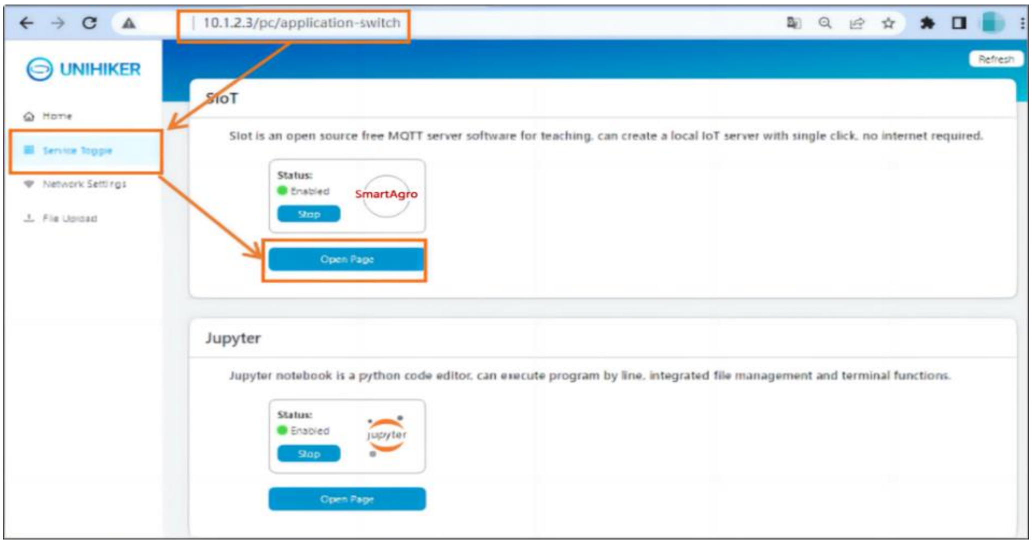

Figure 1. Sending Humidity Data to SmartAgro IoT Platform.

Adding the platform notification subscription function to the dashboard allows irrigation to be controlled via the *SmartAgro* IoT platform web page when the soil is dry. The complete example program is as follows:

```
from unihiker import GUI  # Import GUI module from unihiker library
from pinpong. board import Board, Pin  # Import Board and Pin modules from pinpong library
import time  # Import time library
import siot  # Import siot library for SIoT communication
 gui = GUI()  # Instantiate the GUI object
 Board().begin()  # Initialize the UniHiker board
adc0 = Pin(Pin.P21, Pin.ANALOG)  # Initialize pin 21 as analog input mode
 SERVER = "10.1.2.3"  # MQTT server IP, enter your actual IP
CLIENT_ID = ""  # On the SIoT platform, CLIENT_ID can be left empty
IOT_UserName = 'siot'  # Username
IOT_PassWord = 'dfrobot'  # Password
IOT_pubTopic = 'Smart Agriculture IoT System/Soil_moisture_value'  # Moisture topic, "Project name/Device
name"
 siot.init(CLIENT_ID, SERVER, user=IOT_UserName, password=IOT_PassWord)  # Initialize SIoT with the
provided credentials
siot.connect()  # Connect to the SIoT platform
  # Display background image
img = gui.draw_image(w=240, h=320, image='img/stop1.png')
 gui.fill_rect(x=45, y=35, w=95, h=30, color="white")  # Draw a rectangle for humidity
gui.fill_rect(x=148, y=35, w=55, h=30, color="white")  # Draw a rectangle to display the humidity value
 text_1 = gui.draw_text(x=48, y=36, color="orange", text='humidity:')  # Display humidity
text_value = gui.draw_text(x=155, y=36, color="orange", text="")  # Display the humidity value
 while True:
    Soil_moisture_value = adc0.read_analog()  # Read the analog value
    print(Soil_moisture_value)  # Print the humidity value
    siot.publish(IOT_pubTopic, Soil_moisture_value)  # Publish the information to the SIoT platform
    text_value.config(text=Soil_moisture_value)  # Update the humidity value
    time.sleep(1)  # Delay for 1 second
```

Figure 2. Complete program in Python.

After connecting remotely to *UNIHIKER* and the results will be displayed. The dashboard shows that the temperature and humidity values are constantly updated and displayed in real time on the screen.

In this example, we discussed the use of remote methods on crops, combined with an IoT platform.

Innovative Technologies in Agriculture and Economic Challenges (Using Aeroponics on the Example of Georgia)

Along with the growth of the world population, the demand for clean and healthy agricultural products is increasing. It is necessary to develop and implement innovative methods in agriculture. In this regard, one of the most effective and new methods is aeroponics, which allows the cultivation of a 3-dimensional greenhouse in a minimal area, in the absence of soil, using a small amount of water. In this regard, Georgian companies are not lagging behind the processes taking place in the world and are actively involved in the improvement and development of the aeroponics system. We believe that the introduction of aeroponics will make a positive contribution to improving food security (Hamilton, 2000).

We will consider one of the Georgian startups "GSA Technologies", which aims to develop a 100% environmentally friendly greenhouse. To achieve this goal, the company used an unconventional, innovative method of plant vegetation, namely aeroponics.

The term aeroponics means working in the air. More specifically, aeroponics refers to the vegetation of plants without soil, in an artificially created controlled environment. According to Osvald, all the necessary nutrients and minerals are supplied to the plant by spraying them on the roots. Typically, the plants are equipped with spectral lighting to accelerate the vegetation process with maximum efficiency (Osvald et al., 2015). As a rule, spectral lighting is arranged above the plants to accelerate the vegetation process with maximum efficiency.

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Under aeroponic conditions, the roots of the plant were clearly visible and allowed the researcher to study its structure. Since then, many researchers have used this method to study various plants (Zobel et al., 1993).

Since the plant roots are in a controlled, oxygen-rich environment, one of the main advantages of aeroponics is its high yield. The development of modern technologies has further simplified this process. The availability of various measuring devices (including pH, humidity, and temperature meters), as well as the emergence of various mobile applications that simplify the control process, are increasingly strengthening the advantages of aeroponics over other traditional methods (Koghuashvili & Mamukelashvili, 2020).

Future trends in the integration of digital, green and innovative development include: the integration of digital technology and green technology, such as 5G, artificial intelligence, the Internet of Things, the Industrial Internet, big data and green and low-carbon industries, promotes the construction of smart cities through the integration of two-way scenarios of digital technology and green technology.

Conclusion

At the intersection of the digital, green and innovative economies, new trends in sustainable development are emerging, shaping the pursuit of sustainability and economic growth.

We discussed, "Smart Agriculture IoT System Example Using Python Programming" Smart Agriculture IoT System“. We have developed a software framework in the Python environment that allows agricultural crops to be controlled via an IoT platform website.

In these examples, we have shown the effectiveness of using remote methods on agricultural crops in conjunction with an IoT platform. Thus, the use of digital technologies is a prerequisite for promoting innovative development in agriculture.

Finally, the convergence of digital, green and innovation in the economy is shaping new trends in sustainable development.

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