Dual-Mode Enabled IoT-Based Smart Balcony Gardening in Urban Area

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Abstract Presently, wide adaptation of IoT in different areas of applications has gained extreme exposure. In the field of agriculture, the role of IoT is remarkably increasing in recent days. In this paper, a novel smart farming technique is introduced. Here, few crops, like tomato, mint, onion, and chickpea are considered for the experimental purpose, can be grown irrespective all seasons. In this paper, sensors are embedded in the lawn exploiting the data related to different environmental parameters and depending on the status of the obtained data it is operated in two modes manual mode and automatic mode, respectively. The uniqueness of this prototype is with inside the dual mode of operation of the device in concurrence with the cost analysis.

Keywords IoT · Sensors · Balcony gardening · DHT11 · ESP32 · Dual-mode

1 Introduction

In recent world of information and communication technologies, automation enabled smart agriculture is a potential area for the application of Internet of Things [1]. Nowadays, due to high density of human habitation in urban area, balcony gardening has become an emerging area of exploration of nature. IoT-based automation and controlling of gardening environment and exchange of sensor-based obtained data to the cloud through the device layer are obtained [2]. Moreover, increased crop productivity with minimized water consumption for automatic watering system is showcased [3]. Further, associated works in the discipline of modernized watering system in agriculture are based on wireless networks [4], IoT-based green house control system with data analysis [5], and automated plant watering system [6]. Moreover,

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literatures related to smart irrigation using Raspberry Pi [7] study on photovoltaic schemes for smart agriculture [8] which are promising area for exploration. Application of cloud computing and stick-based live temperature and moisture monitoring is implemented in the paper [9]. Development of Arduino microcontroller-based smart irrigation system with DC pump is illustrated in [10] as well as the concept of plant phenol-typing is proposed in the presence of IoT-cloud gateway in [11]. Study of crane-based various control strategy on smart agriculture is presented in [12]. Further, WSN-based smart crop monitoring is also showcased in [13]. In this paper, a smart balcony-based gardening system is represented utilizing the advantages of IoT. The intension of this design implementation is to monitor the moisture and temperature with the ability to control and maintain those parameters automatically. The circumstance of the lawn can be supervised remotely via the advanced digicam device in conjunction with the quantity of water to pour relying on the considered parameters. These system parameters can also be maintained and controlled remotely. This feature can create an edge over other existing IoT-based balcony gardening system. So, this prototype system can be considered as a smart gadget that can efficiently operative both in the manual and automated mode; thus, it can be termed as dual mode of operation. For this farming, some vegetables are selected that can be grown in any season. For this system, tomato, mint, onion, and chickpea are chosen which are found in all seasons in the north and eastern parts of India. The different parameters required for such type of farming of those vegetables are shown in Fig. 1 with proper figure of chosen vegetables Fig. 1a–d.

2 Principle of Operation

The recent progress in the area of IoT-based communication system involves smart balcony gardening. Such system can be implemented by employing various sensor devices [9, 14] like light, humidity, temperature, and soil moisture for monitoring and automatic controlling those parameters for nourishing the indoor plants. The IoT-based smart balcony gardening monitoring system is presented by Fig. 2.

An IoT-based system is implemented using input–output interface for sensors, memory for storage, audio and video, and Internet connectivity for operation of the monitoring applications. The requisite component for implementation of smart balcony garden monitoring system is described below:

(i) The incorporated DHT11 sensor in this prototype acquires the required humidity and ambient temperature for various crops. This sensor works relentlessly to update the temperature and details of humidity to the microcontroller.
(ii) Soil moisture sensor is used to detect the moisture of the soil as the irrigation of soil is based on the initial moisture sensor.

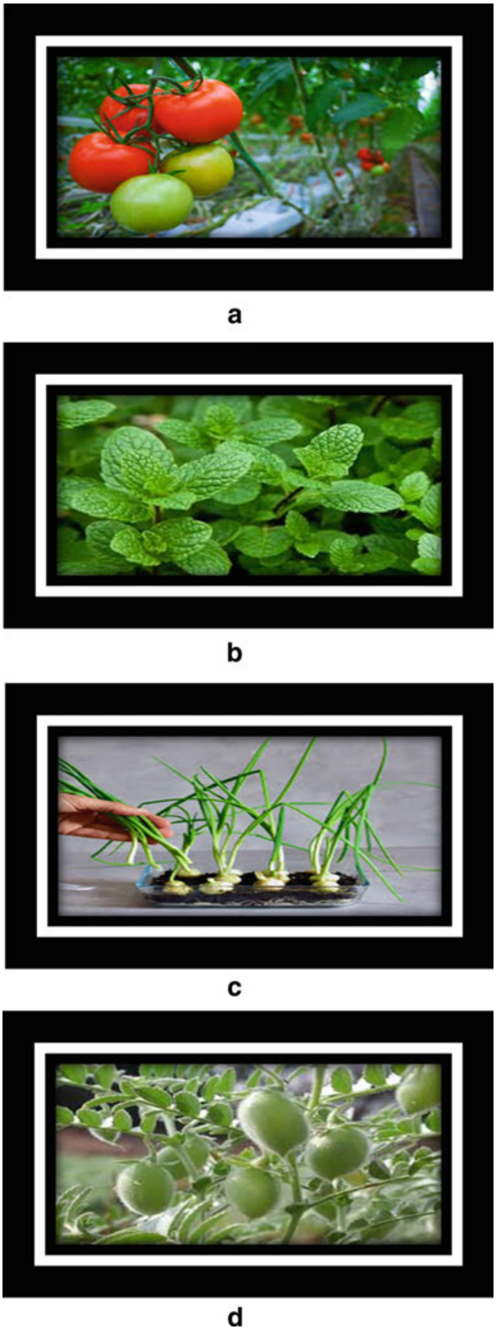

Fig. 1 Parameters require for particular vegetables, **a** Vegetable Name—Tomato (Temperature required: 18–35 °C, Soil type: any, Water required: 1.3 L per/ day), **b** Vegetable Name—Mint (Temperature required: 20–40 °C, Soil type: any, Water required: 1.5 L per/day), **c** Vegetable Name—Onion (Temperature required: 16°C to 30°C, Soil type: any, Water required:2 L per/ day), **d** Vegetable Name—Chickpea (Temperature required: 24–30 °C, Soil type: any, Water required: 1 L per/day)

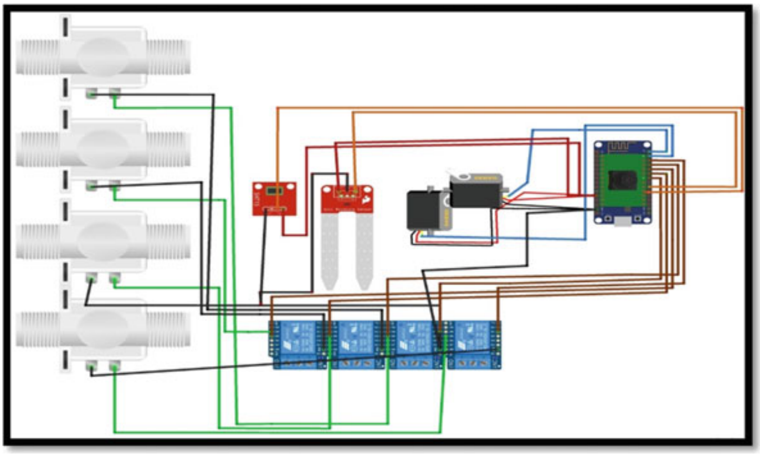

Fig. 2 Proposed model for Smart Balcony Gardening

(iii) In this system, the servo motor is used for the two-axis movement by an angle of 45° in four directions of the ESP32 cam platform, consisting of a microcontroller and camera module.

(iv) Esp32 camera is used as a microcontroller as well as an IP Camera. All sensors are connected to this module and all data will be uploaded to the cloud through this module only.

(v) There is a solenoid valve that is largely used for controlling the glide of water like a tap.

(vi) The necessity of a water flow sensor is to degree the extent of water in the pots in terms of 500 ml or 1,000 ml.

(vii) SMPS (5 V, 20 Amps): SMPS is used to power all associated circuits. From microcontrollers to all valves, this SMPS is connected to 220 V main supply.

The proposed IoT-based smart balcony garden monitoring system can operate in dual mode [15]. As per situation demand, it can operate in manual mode as well as automatics mode using android-based application. The following sections describe the details of the each of modes.

(i) Automatic mode: The principle of operation of automatic mode is shown in Fig. 2. In this mode, all the actuators work according to the given inputs obtained from sensors, i.e., temperature, humidity, and soil moisture sensors [14]. Initially, the android application in this model is fed with the information of the four different pot and their corresponds crop types values (Fig. 3). Then the system use to automatically keep track of temperature, humidity, and soil moisture for each crop in those pots and maintain watering accordingly. The water flow sensor measures the amount of water pouring to pots from valves and when it reaches the limit, valves are closed automatically. In every 10 min,

Fig. 3 Parameter variation in automatic mode. Initialization of input parameter

this system collects the data from sensors for 1-minute means remains in inactive mode for 1 min and then takes the actions if required and goes to sleep mode again. This system will update the condition of all the pots on the android application every 10 min (Fig. 4).

(ii) Manual mode: The operation of manual mode is shown in Fig. 3. In manual mode, there are buttons for operation of each valve for each pot, and below it, there is a small display that will display the amount of water going to the particular pot (Fig. 5). There is a camera also which will give the live feed of balcony so that anyone can easily monitor the pots and by their decision can be taken to water more or less to any particular pot (Fig. 6).

3 Analysis of Power Consumption and Cost in Dual Modes

The implemented model shows smarter performance in terms of consumption of power. Here, ESP32 and SMPS are used. Here, connection is done of all sensors as well as ESP32 camera Vin pin with 5 V pin of SMPS. Max operating voltage of the sensors is 5 V. The power consumption operating current for every component is presented in Table 1. The power consumption operating current for automatic mode is presented in Table 2. The power consumption operating current for manual mode is presented in Table 3.

From this comparative analysis of power consumption in between two modes, it is observed that automatic mode is much more cost-effective than manual mode of operation. Depending on the need of the situation, this system can be operated in

Fig. 4 Parameter variation in automatic mode. Updated condition details

Fig. 5 Parameter variation in manual mode. Initialization of manual mode

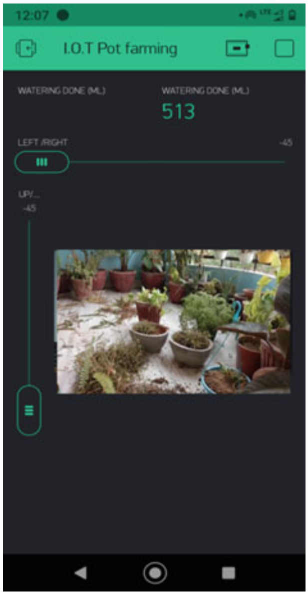

Fig. 6 Parameter variation in manual mode. Visual mode for taking decision

Table 1 Power consumption by the components

Sl. No.	Component	Operating Current
1.	DHT11	1.5 mA
2.	Soil moisture	5 mA
3.	Solenoid valve	6 mA (aprox)
4.	Water flow sensor	15 mA
5.	Servo motors (2)	10 mA

both the modes simultaneously throughout the month. In that scenario, electricity cost becomes on an average Rs. 6 in a month. From this perspective, this system can be considered as cost-effective system.

4 Conclusion

In this paper, the hardware and materials used to develop the prototype, allowed to make an accurate and cost-effective system. Moreover, the proposed model is quite economical as well as easily installable for users. In this model, dual mode of operation helps user to maintain balcony garden smartly. Thus, it can be summarized that this prototype system is beneficial, easy to use, and easily deployable in pot farming and lawn farming to effectively monitor crops with a user-friendly application and other alert functions.

Table 2 Power consumption in automatic mode

Calculation of power consumption per hour for sleep mode, (1 min active, 9 min sleep mode)		
Sl. No.	Description	Operating Current
1.	Current consumption in Active mode (when not watering)	(48 + 1.5 + 5) mA = 54.5 mA
2.	Current consumption in Active mode (when watering)	(48 + 1.5 + 5+6 + 15) mA = 75.5 mA
3.	Current consumption in Sleep mode	(3.5 + 1.5 + 5+6 + 15) mA = 31 mA
4.	Current consumption in 10 min (when watering)	(Current consumption in Active mode) + (Current consumption in Sleep mode) = (75.5 + 31) mA = 1.65 A
5.	Current consumption in 1 h (when watering)	(Current consumption in 10 min) × 6 = (1.65 × 6) A = 9.9 A
6.	Current consumption in 10 min (when not watering)	(Current consumption in Active mode(when not watering)) + (Current consumption in Sleep mode) = (54.5 + 31)mA = 0.86A
7.	Current consumption in 1 h (when not watering)	(Current consumption in 10 min (when not watering)) × 6 = (0.86 × 6) A = 5.16 A
8.	Current consumption in 1 day	Current consumption in 1 h (when watering) + Current consumption in 1 h (when not watering) × 23 = 9.9 + (5.16 × 23) A = 128.58 A
9.	Power consumption in 1 day	Power = Voltage x Current = 5v × 128.58 A = 642.9 W
10.	Consumption of electric units per days	Kilowatt per hour = (0.6429/24) = 0.02 units
11.	Average cost of per unit electricity is Rs. 8 (CESC). So, electricity bill to be paid for system	0.02 Units × 30 days x Rs. 8 = Rs 4.8 (approx)

Table 3 Power consumption in manual mode

Manual mode for 5 h in a day in rest 19 h Automatic mode is on		
Sl. No.	Description	Operating current
1.	Current consumption in Sleep mode	= 31 Ma
2.	Current consumption in Active mode(with camera on)	= 62.5 mA
3.	Current consumption in one day	(62.5 × 5) +(31 × 19) = 9.01 A
4.	Power consumption in a day	(Power consumption of automatic mode in a day) + (0.79 × power consumption in automatic mode in a day) = {[(9.01A × 5v) x 5 h] + (0.79 × 642.9)} W = (225.25 + 507.9) W = 733.2 W
5.	Consumption of electric units per days	Kilowatt per hour = (0.7332/24) = 0.03 units
6.	Average cost of per unit electricity is Rs. 8 (CESC). So, electricity bill to be paid for system	0.03 Units × 30 days x Rs. 8 = Rs 7.2 (approx)

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