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An internet of thing (IoT) Ecosystem for planting of coriander (*Coriandrum sativum* L.)

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ABSTRACT

The internet of things (IoT) is a network of physical devices and is becoming a major area of innovation for computer-based systems. Agriculture is one of the areas which could be improved by utilizing this technology ranging from farming techniques to production efficiency. The objective of this research is to design an IoT to monitor local vegetable (Coriander; *Coriandrum sativum* L.) growth via sensors (light, humidity, temperature, water level) and combine with an automated watering system. This would provide planters with the ability to monitor field conditions from anywhere at any time. In this research, a group of local vegetables including coriander, cilantro, and dill weed were experimented. The prototype system consists of several smart sensors to accurately monitor the mentioned vegetable growth from seedling stage to a fully grown plant which will ensure the highest production levels from any field environment. Three different types coriander were measured under these parameters: height, trunk width, and leaf width. The result showed that IoT ecosystem for planting different types of coriander could produce effective and efficient plant growth and ready for harvest with a shorter time than conventional method.

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1. INTRODUCTION

The internet of things (IoT) refers to a network of physical devices that are embedded with multiple electronic devices, software, sensors, and exchanging data service via the internet [1], [2]. IoT environment is an integrated transport system to dynamically route respond to change the traffic needs and conditions. IoT has been used in various types of applications such as creating smart homes, smart cities, connected cars, connected health, as well as in agriculture or smart farming. As the agricultural industry plays such an important role as part of Thai business, finding solutions, and opportunities to improve the current agricultural methods for Thai farmers could be beneficial it could help increase the efficiency and effectiveness in producing these goods. IoT application in agricultural industry can be used to monitor, provide real time control of the process, and track several controlled variables that promote vegetable growth such as light, humidity, temperature, and water. The basic IoT system architecture consists of three different layers with different functions: Yi [3] first layer is the physical sensing layer which contains embedded devices that make use of sensors to gather data. Second layer is the middleware layer which provides the function to facilitate manage the communication between the activities of sensing devices and the application layer. The third layer is the application layer which is responsible for mapping the information onto applications which planters will be able to use to send commands to objects over the Internet via mobile application, webapps and/or browsers [4].

In this study, the paper presents a prototype of an internet of things (IoT) ecosystem for planting of coriander (*Coriandrum sativum* L.). Coriander, a member of the apiaceae family, is among the most widely used medicinal plants, possessing nutritional as well as medicinal properties. Coriander is an annual plant that yields within 40-50 days and the edible adult coriander height is approximately 30-40 cm [5], [6]. The culantro height is approximately 15-51 cm, leaf width is 20-30 mm [7], the average height of dill weed is 30 cm**,** and leaf width less than 0.5 mm [8]. The prototype is specifically designed to monitor a system which consists of many smart sensors to accurately monitor coriander growth from seed to plant. The sensors are designed to collect information about the environment that the plant undergoes such as light, humidity, temperature, and watering system. This system will then decide on the actions to be taken based on the given controls such as to sprinkle to maintain the humidity, to adjust the temperature, and the watering system via the internet.

2. THEORETICAL BACKGROUND AND RELATED RESEARCHES

2.1. Internet of things (IoT)

The fundamental of IoT has connecting physical objects, sensors, and other smart technologies altogether into one system [9]. IoT provides an immediate access to information about physical objects that leads to innovation on services and processes with higher efficiency and productivity [10]. IoT was related several technologies which are wirless sensor, rfid, and cluoud computing [11]. However, The development of IoT to the green technology. Green IoT can may improve energy efficiency and that of other system, help reduce environment pollution [12], [13].

2.2. Cloud computing

Cloud computing is a large-scale computing used low-cost process and Internet capability. The application areas of IoT include smart home, smart agriculture, and smart monitoring [11]. The smart agriculture application involves a large distributed array of monitoring sensors and a large distribution network. Cloud computing includes three services consisting of; 1) platform as a service (PaaS), 2) infrastructure as a service (IaaS), and 3) software as a service (SaaS) [14]. In this research, a cloud computing technology in IoT is being utilized to view sensor values via the Internet. Cloud computing technique was used to machine learning tools, data mining, and artificial intelligence. Data are sensed from device sensors, virtual sensors which retrieve data using web service technology to easy to be stored, processed, and anlyzed [15]. IoT devices can be detected and collected of datasets. Real time of datasets are sent to the cloud and preprocessing for big data [16] and preprocessing for big data analysis [17], [18]. In addition, the cloud computing in power system was relized the requirement of high brandwidth and low latency. A privacy protection strategy via computing, data prediction, and preprocessing were necessary in IoT [19].

2.3. Responsive web development

In the past, the interface libraries are inconsistencies, high maintenance cost, and more complicated process. So, responsive web development can be created with HTML5 coding, CSS, and JavaScript coding. Bootstrap is popular and efficient tool to develop responsive web. Bootstrap is a free toolkit for creating websites and web applications. It contains HTML and CSS-based design templates for typography, forms, buttons, navigation, and other interface components [20].

2.4. Literature review

The research in smart agriculture area is proposed all filed of aspects to improve the quality and quantity of productivity of agriculture. Smart agriculture ecosystem consisted of four different components: hardware controller devices, sensor devices, data storage, and presentation component.

2.4.1. The hardware controller

The hardware controller devices were usually used with Arduino Uno, [21]-[26] and Raspberry Pi [27]. These devices are designed to manage and control the sensors. The input will be received from the sensor and monitoring devices. They are connected to the internet and can be accessed from anywhere.

2.4.2. Sensor devices

Sensor devices are used to monitor the control and read the information to monitor the environments of planting. The sensors that are commonly used in agriculture consisted of temperature sensor [26], [28], [29] water level sensor [23]-[26], [28], [29], humidity sensor [26], [29], soil moisture sensors [29], light sensor, [26], [29] and pressure sensor [21], [26], [29]. The sensor devices are related with hardware control devices which are a part in physical layer. These sensors are designed and responsible for checking the environment of planting.

2.4.3. The data storage

The data storage, usually through cloud server [21]-[26], [28], [29] stores the data of the devices with the details of sensor name, sensor ID, sensor status, date, and time of the sensor. The sensors received data and information is read with the hardware controller device and send to the cloud server. The architecture was to develop a client server system to be able to access via web or android application.

2.4.4. The representation of information

The representation of information from these devices is done by using web browser [21]-[22], [28] or mobile application [23], [26], [28], [29]. The web application is responsible for supporting a responsive design. The application shows the statistics of the general and overall data with details of the system such as sensor name, sensor ID, sensor status, date, and time. Moreover, the application will show the sensors real time information. Therefore, the user was able to access web application or mobile application easily and comfortably.

3. RESEARCH METHOD

3.1. Proposed prototype

In this section, the sensors on real time monitoring of IoT environments will be illustrated. Figure 1 shows the architecture layer of IoT based coriander data cloud platform. Integrated devices such as several sensors (light: LS, humidity: HS, temperature: TS, and water level: WS) are connected to a controller (Raspberry PI). The controller can access the sensor values, process and obtain these data and transfer these data via the internet using cloud computing. The IoT Service will decide the action to be taken based on these controlled parameters with various views of data and the output results will be shown from the cloud computing on various layouts based on size and capabilities of the device.

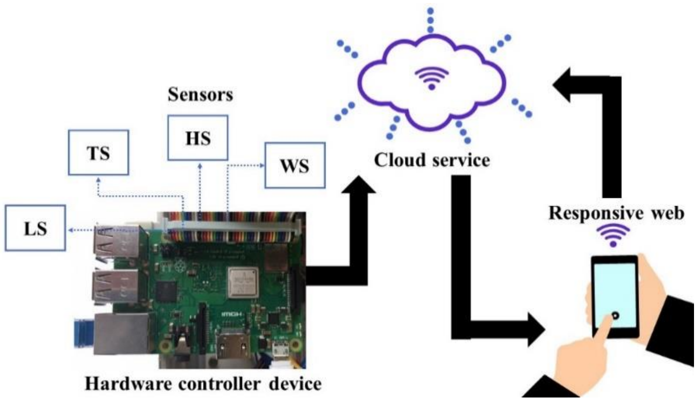

Figure 1. Framework of IoT ecosystem

3.2. Device selections

The prototype consists of 4 different devices combined to create a system. In this section, the functions and rationale of using 4 different devices will be explained. Raspberry Pi is a small sized computer that runs using the Linux operating system. It has USB sockets that can be plugged with a video output and information can be input into the device. It has general purpose input/output (GPIO) pins and is connected to custom electronics. It is integrated with WIFI and Bluetooth connection. Raspberry Pi has enough capacity and capability of performing every task, for examples, about browsing the internet, playing videos, making documents, and playing games [27], [30].

The temperature and humidity sensor (DHT11) is a digital temperature and humidity readings. The DHT11 exports digital signals. The advantages of using this device is that it is easy to set up and a wire for the data signal. These sensors are popular to be used in remote weather stations, soil monitors, home automation systems, and smart farm [30], [31]. Arduino Uno is used to readings of the hygrometer. Arduino collects analog data from hygrometer and convert analog data to digital data (ADC) [27].

3.3. System architecture

The system architecture is designed and implemented for the internet of things ecosystem for planting. Raspberry Pi is connected to sensors (light, humidity, temperature, and water level) via GPIO but GPIO pins has 40 pins then not enough to use many sensors. So, the connecting between GPIO and sensors need the breadboard. Breadboard is a device for connected between one device and other devices without soldering them. These holes are connected in strips. The temperature sensor (TS) is the DS18B20 sensor as waterproof version. The DS18B20 has an operating temperature range of -55 °C to +125 °C and is accurate to ±0.5 °C over the range of -10 °C to +85 °C. This device has an onboard analog to digital converter so easily connected it up to a digital GPIO pin on the Raspberry Pi. DS18B20 was consisted of 3 wires, the red wire connects to 3.3-5 V power, the yellow wire (data pin) connects to GPIO, place a 10 K ohm resistor between VCC, the data pin, and the black wire connects to ground. The water level sensor (WS) has a water detection area range of 16 mm. to 40 mm. and easy to connect to a digital GPIO pin. WS has 3 pins (ground, vcc, signal) [32]. The signal pin is an analog output. WS detection for a water tank. Placing a water level sensor in the tank to detect the presence of water. The connecting between WS and raspberry pi is MP3002 (analog-to-digital converter). The humidity sensor (HS) is the DHT11 as relative humidity measure. The DHT11 has an operating humidity rang of 20-90% RH and readings with ±5% accuracy. The DHT11 was consisted of 3 wires, the red wire connects to 3.3-5 V power, the white or the yellow wire (data pin) connects to GPIO, place a 10 K ohm resistor between VCC, the data pin, and the black wire connects to ground [33]. The last sensor is light sensor (LS) as LDR sensor. The LDR sensor is light-dependent resistor or photocell to detect light and to measure the brightness level of the ambient light. The LDR was consisted of 3 wires, the red wire connects to 3.3-5 V power, the white wire connects to GPIO and the black wire connects to ground. Water pump control is used manually by user, when the system showed alert light (red light) for high temperature above 35 °C on responsive web. User turns on water pump switch, but temperature was low below 35 °C user turns off switch. Figure 2 shows the system architecture of the Raspberry Pi and sensors connected via GPIO. It consists of 2 parts: i) Raspberry Pi and sensors and ii) real time of data of humidity and temperature are displayed on the responsive web design.

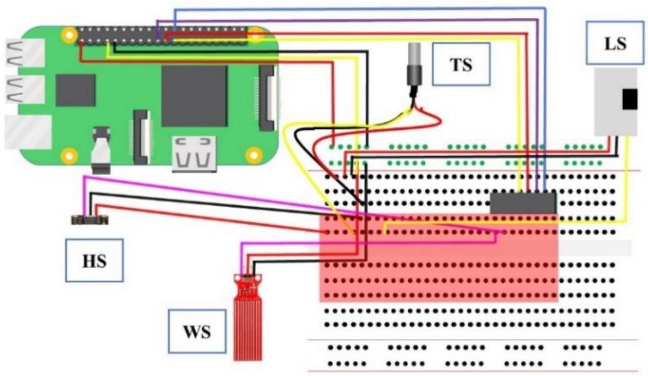

Figure 2. Architecture of raspberry pi and sensors

3.4. Implementation

3.4.1. Input

The input process is keeping a record in a CSV file consisting of a time stamp, humidity, ambient light, and temperature. The logging data from Raspberry Pi utilizes Python, Excel to collect data, and save the output of the collection or analysis. This CSV file is uploaded to a cloud server (google firebase).

3.4.2. Output

PHP is an open source, a general-purpose scripting language. PHP proved to be useful and popular. PHP code is designed to be included easily in a HTML file and runs on a variety of operating systems for the usage in websites. Moreover, PHP is customizable and the open source license allows programmers to modify the PHP software and add or modify features as needed to fit their own environment. User interaction module of GUI is responsible for various interactions with users including drawing of graphical interface, disposing of users accidents, receiving data at particular time stamp, sending humidity, temperature data from the sensors, and presenting all these information in visual form. The data will be displayed on the responsive web design.

3.4.3. Experiment conditions

Three different types of seeds were prepared, and each was planted into their individual capsule as shown in Figure 3. The device is monitoring several controlled parameters to determine if there are any changes in the environment as shown in Figures 4 and 5. Water level sensor will send out signals when the water level is lower than the controlled water parameter, then the pump will automatically water the plants. Along with the water level sensor, the device also monitors the changes in temperature, humidity, and the sensor will send this information to the web interface. When the temperature and humidity are out of the controlled range, signals will be sent to the water pump, allowing water flow in the set up plantation system.

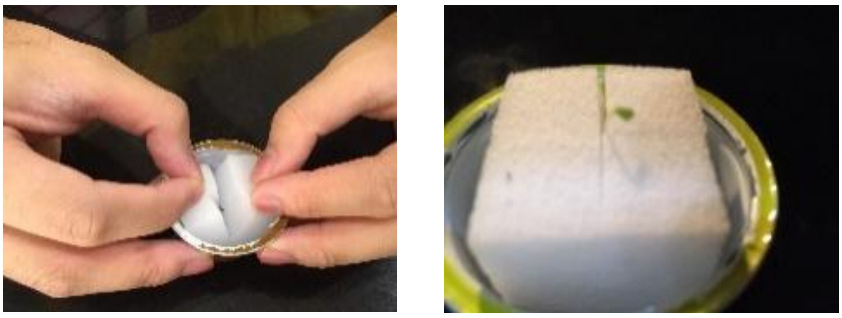

Figure 3. planting of coriander seeds into the designated capsules

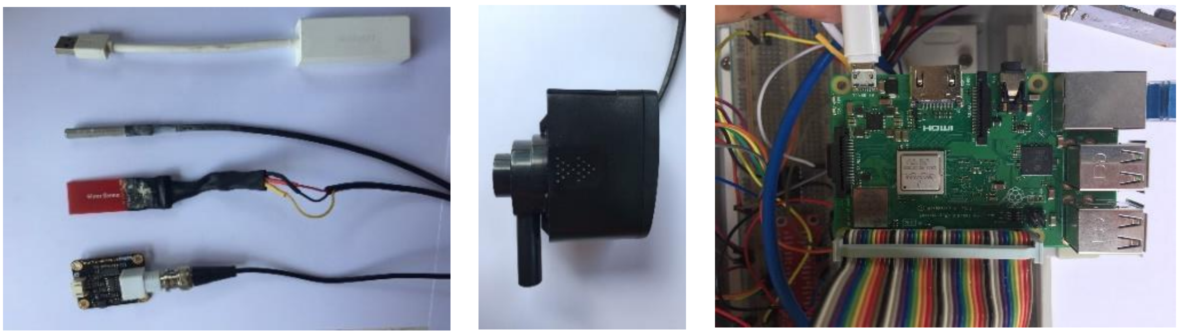

Figure 4. Hardware controller device, sensor devices and water pump

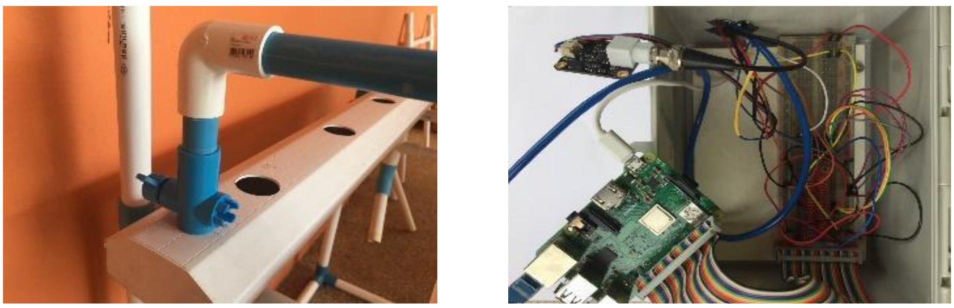

Figure 5. The device set up with different sensors to determine changes in water level, temperature, and humidity level.

4. RESULTS AND DISCUSSION

4.1. The samples

In Thailand, coriander is an economic plant and is a famous ingredient for cooking as it is one of the crucial vegetables in many of the Thai dishes. The local coriander species and African coriander species are popularly used and grown in the country with the following differences in their characters and properties. The characteristics of local coriander are small, with thin leaf, small seed, early flowering, having a short life and providing a very pungent smell. While the characteristics of African coriander tends to be bigger in size, with thick, big leaves, having lighter fragrance, and longer life than local coriander. In this research, 3 local types of corianders are selected for the experiments: coriander, culantro, and dill weed. 10 samples were used per coriander type.

4.2. The result

After the device is installed in the specified location, the result parameters including time stamp, humidity, and temperature were displayed through the User Interface. Results showed that all 3 plant cultivations had similar measurements. The results of this experiment with data collected after 30 days are shown in Figure 6 and Tables 1-3. Table 1 show the average height of coriander of 10 samples is 25.16 cm, trunk width 13.15 mm, and leaf width 2.53 mm. The average height of the coriander grown under this system after 30 days is slightly lower than the average height of coriander grown conventional method which requires 40-50 days before harvest (30-40cm). So, the growth of the experimented coriander might be comparable to the growth of the conventional method after 40 days.

(a) (b) (c)

Figure 6. Show plant height, trunk width, leaf width of; (a) coriander, (b) cilantro, and (c) dill weed

Table 1. Shows plant height, trunk width, leaf width of coriander after 30 days

Sample	plant height (cm)	trunk width (mm)	leaf width (mm)
1	25.2	12.7	2.5
2	25.3	13.1	2.8
3	24.9	13.9	2.2
4	24.6	13.3	2.7
5	24.2	12.8	2.8
6	25.9	12.9	2.8
7	25.9	12.9	2.4
8	25.2	12.9	2.8
9	25.9	13.3	2.1
10	24.5	13.7	2.2
Average	25.16	13.15	2.53

The Table 2 show the average height of culantro of 10 samples is 25.06 cm, trunk width 10.14 mm. and leaf width 27.17 mm. The average height and the leaf width of culantro grown under this system after 30 days showed comparable results with the average height and leaf width of culantro grown with the conventional method which requires 40-50 days before harvest (15-51 cm for height and 20-30 mm for leaf width). Thus, this system resulted in 10-20 days faster time to harvest than the conventional method to yield the same quality of harvest.

Table 2. Shows plant height, trunk width, leaf width of culantro after 30 days

Sample	plant height (cm)	trunk width (mm)	leaf width (mm)
1	25.2	10.5	27.2
2	25.3	10.9	27.3
3	25.3	10.2	27.2
4	25.6	10.0	27.2
5	25.9	10.3	27.1
6	25.2	10.9	27.1
7	24.3	10.3	27.1
8	24.2	10.3	27.1
9	24.1	10.6	27.2
10	25.5	10.0	27.2
Average	25.06	10.4	27.17

The Table 3 show the average height of dill weed of 10 samples is 26.37 cm, trunk width 6.86 mm. and leaf width 0.45 mm. The average height and leaf width of dill weed grown under this system for 30 days are slightly lower than average height and leaf width of dill weed grown with the conventional method which take 40-50 days before harvest (30 cm for height and approximately 50 mm or lesser for leaf width). So, the growth of the experimented coriander might be comparable to the growth of the conventional method given that the experiment would continue for 40 days.

Table 3. Shows plant height, trunk width, leaf width of dill weed after 30 days

Sample	plant height (cm)	trunk width (mm)	leaf width (mm)
1	26.2	7.1	0.5
2	26.1	7.2	0.2
3	26.2	7.3	0.2
4	26.7	7.2	0.3
5	26.8	7.1	0.3
6	26.1	7.1	0.7
7	26.7	7.1	0.9
8	26.2	6.5	0.3
9	26.2	6.0	0.2
10	26.5	6.0	0.9
Average	26.37	6.86	0.45

5. CONCLUSION

The prototype IoT ecosystem is used to automatically operate the watering system by having temperature sensor, humidity sensor, light sensor, and water level sensor to determine when the plants are under the environmental condition that requires water. The research also showed an excellent demonstration platform for IoT sensors to collect and store data. All three different plant samples grown under this automatically controlled system showed a result vs. conventional method in terms of their growth rate, height, width, and ready to harvest after 30 days. This system could produce effective and efficient plant growth and ready for harvest with a shorter time than conventional method. This smart agriculture could provide farmers and planters alternative method to do farming remotely, creating a more efficient agricultural system that could be beneficial for Thailand agricultural industry.

REFERENCES

[1] A. McEwan and H. Cassimally, “Designing the Internet of Thing,” West Sussex: United Kingdom: John Wiley and Sons, 2013.
[2] P. Tangwannawit, "Development of Smart Internet of Things (IoT) for Local vegetables," in *The 15Th International Conference in Applied Computer Technology and Information Systems*, Thailand, March 8, 2019.

[3] L. Yi, H. Wang, J. Wang, K. Qian, N. Kong, K. Wang *et al.*, "Enterprise-Oriented IoT name Service for Agriculture Product Supply Chain Management," *International Journal of Distributed Sensor Networks*, vol. 11, no. 8, pp. 1 - 12, 2015, doi: 10.1155/2015/308165.
[4] A. N. Azlina, A. Zanariah and Y. Faridah, "Intelligent home automated system," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 15, no. 2, pp. 733-742, 2019, doi: 10.11591/ijeecs.v15.i2.pp733-742.
[5] B. Laribi, K. Kouki, M. M. Hamdi and T. Bettaieb, "Coriander (Coriandrum sativum L.) and its bioactive constituents," *Fitoterapia*, vol. 103, pp. 9-26, 2015, doi: 10.1016/j.fitote.2015.03.012.
[6] A. Anaeigoudari, M. Hosseini, R. Karami, F. Vafaee, T. Mohammadpour, A. Ghorbani and H. R. Sadeghnia, "The effects of different fractions of Coriandrum sativum on pentylenetetrazole-induced seizures and brain tissues oxidative damage in rats," *Advance Journal of Phytomedicine*, vol. 6, no. 2, pp. 223-235, 2016.
[7] M. S. Al-Said, K. I. Al-Khamis, M. W. Islam, N. S. Parmar, M. Tariq and A. M. Ageel, "Post coital antifertility activity of the seeds of Coriandrum sativum in rats," *Journal of Ethnopharmol*, vol. 21, no. 2, pp. 165-173, 1987, doi: 10.1016/0378-8741(87)90126-7.
[8] V. Chitra and S. Leelamma, "Hypolipidemic effect of coriander seeds (Coriandrum sativum): mechanism of action," *Plant Foods Human Nutr.*, vol. 51, pp. 167-172, 1997, doi: 10.1023/A:1007975430328.
[9] F. K. Shaikh, S. Zeadally and E. Exposito, "Enabling Technologies for Green Internet of Things," *IEEE Systems Journal*, vol. 11, no. 2, pp. 983-994, 2017, doi: 10.1109/JSYST.2015.2415194.
[10] R. Girau, S. Martis and L. Atzori, "Lysis : A platform for IoT distributed applications over socially commected objects," *IEEE Internet of Things Journal*, vol. 4, no. 1, pp. 40-51, 2016, doi: 10.1109/JIOT.2016.2616022.
[11] O. A. Dawood, "Fast lightweight block cipher design with involution substitution permutation network (SPN) structure," *Journal of Electrical Engineering and Computer Science*, vol. 20, no. 1, pp. 361-369, 2020, doi: 10.11591/ijeecs.v20.i1.pp361-369.
[12] R. Arshad, S. Zahoor, M. Ali Shah, A. Wahidl and H. Yu, "Green IoT: An Investigation on Energy Saving Practices for 2020 and Beyond," *IEEE Access*, vol. 5, pp. 15667-15681, 2017, doi: 10.1109/ACCESS.2017.2686092.
[13] A. Eslami Varjovi e S. Babaie, “Green Internet of Things (GIoT): Vision,applications and research challenges,” *Sustainable Computing: Informatics and System*, vol. 28, pp. 1-9, 2020, doi: 10.1016/j.suscom.2020.100448.
[14] W. He, G. Yan and L. D. Xu, "Devloping Vehicular Data Cloud Services in the IoT Environment," *IEEE Transactions on industrial Informatics*, vol. 10, no. 2, pp. 1587-1595, 2014, doi: 10.1109/TII.2014.2299233.
[15] R. Atat, L. Liu, J. Wu, G. Li, C. Ye and Y. Yang, "Big Data Meet Cyber-Physical Systems: A Panoramic Survey," *IEEE Access, Digital Object Identifier*, vol. 4, pp. 73603-73636, 2016, doi: 10.1109/ACCESS.2018.2878681.
[16] C. Perera, A. Zaslavsky, P. Christen and D. Georgakopoulos, "Context aware computing for the internet of things: A survey," *IEEE Communications Surveys and Tutorials*, vol. 16, no. 1, p. 414–454, 2014, doi: 10.1109/SURV.2013.042313.00197.
[17] J. Wu, S. Guo, H. Huang and W. Liu, "Information and Communications Technologies for Sustainable Development Goals: State-of-the-Art, Needs and Perspectives," *IEEE Communications Surveys and Tutorials*, vol. 20, no. 3, pp. 2389-2406, March 2018, doi: 10.1109/COMST.2018.2812301.
[18] Z. Asad e M. A. R. Chaudhry, “A two-way street: Green big data processing for a greener smart grid,” *IEEE Systems Journal*, vol. 11, no. 2, pp. 784-795, 2017, doi: 10.1109/JSYST.2015.2498639.
[19] S. Chen, H. Wen, J. Wu, W. Lei, W. Hou, W. Liu *et al.*, "Internet of Things based Smart Grids Supported by Intelligent Edge Computing," *IEEE Access*, vol. 7, pp. 74089-74102, June 2019, doi: 10.1109/ACCESS.2019.2920488.
[20] G. Mehta, K. Sharma and H. Saini, "Responsive Web Development," *International Journal for research in Applied Science and Engineering Technology*, vol. 2, pp. 272-277, October 2014.
[21] H. A. Ali, A. H. Duhi, A. L. A. Nabeel and M. J. Mnati, "Smart monitoring system for pressure regulator based on IOT," *International Journal of Electrical and Computer Engineering*, vol. 9, no. 5, pp. 3450-3456, 2019, doi: 10.11591/ijece.v9i5.pp3450-3456.
[22] K. Bhagchandani and P. Augustin, "IoT based heart monitoring and alerting system with cloud computing and managing the traffic for an ambulance in India," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 9, no. 6, pp. 5068-5074, 2019, doi: 10.11591/ijece.v9i6.pp5068-5074.
[23] P. Chandana, G. S. Pradeep Ghantasala, J. R. Virgil Jeny, K. Sekaran, D. N, Y. Nam and S. Kadry, "An effective identification of crop diseases using faster region based convolutional neural network and expert systems," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 10, no. 6, pp. 6531-6540, 2020, doi: 10.11591/ijece.v10i6.pp6531-6540.
[24] M. H. Ali and N. K. Ali, "IoT based security system and intelligent home automation multi monitoring and control systems," *International Journal of Robotics and Automation (IJRA)*, vol. 8, no. 3, pp. 205-210, 2019, doi: 10.11591/ijra.v8i3.pp205-210.
[25] R. Kaviyaraj, M. S. Karthika, L. A. Jeni Narayanan and Saleekha, "Recycling of Industrial Waste Water for the Generation of Electricity by Regulating the Flow Control Sensor using IoT," *International Journal of Advances in Applied Sciences (IJAAS)*, vol. 7, no. 4, pp. 347-352, 2018, doi: 10.22587/jasr.2018.14.2.4.
[26] P. Tanwannawit and K. Saengkrajang, "Development of Smart Internet of Things (IoT) for Local Vegetables," in *The 15th National Conference and International Conference on Applied Computer Technology and Information Systems*, Thailand, 2019.
[27] W. Rahman, E. Hossain, R. Islam, H. A. Rashid, N. A. Alam and M. Hasan, "Real-time and Low-cost IoT based farming using raspberry Pi," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 17, no. 1, pp. 197-204, 2017, doi: 10.11591/ijeecs.v17.i1.pp197-204.

[28] M. U. H. Al-Rasyid, S. Sukaridhoto, M. I. Dzulqornain and A. Rifai, "Integration of IoT and chatbot for aquaculture with natural language processing," *TELKOMNIKA Telecommunication*, *Computing*, *Electronics and Control*, vol. 18, no. 2, pp. 640-648, 2020, doi: 10.12928/TELKOMNIKA.v18i1.14788.
[29] K. Sekaran, M. N. Meqdad, P. Kumar, S. Rajan and S. Kadry, "Smart agriculture management system using internet of things," *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 18, no. 3, pp. 1275-1284, 2020, doi: 10.12928/TELKOMNIKA.v18i3.14029.
[30] S. Monk, "Programming the Raspberry Pi: Getting Started with Python," in McGraw-Hill, New York:USA, 2016.
[31] J. Doshi, T. Patel and S. k. Bharti, "Smart Farming using IoT, a solution for optimally monitoring farming conditions," *Procedia Computer Science*, vol. 160, pp. 746-751, 2019, doi: 10.1016/j.procs.2019.11.016.
[32] E. Mazuin Mohd Yusof, M. Ismail Yusof, R. Ali e z. I Hilmi Harjimi, “Welding station monitoring system using internet of thing (IoT),” *Journal of Electrical Engineering and Computer Science*, vol. 18, no. 3, pp. 1319-1330, 2020, doi: 10.11591/ijeecs.v18.i3.pp1319-1330.
[33] Z. Kasiran and R. Napi, "Randomize IPv6 Stateless Address Autoconfiguration in None-stable Storage Arduino Devices," *Journal of Electrical Engineering and Computer Science*, vol. 12, no. 1, pp. 254-260, 2018, doi: 10.11591/ijeecs.v12.i1.pp254-260.

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