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Gardening for You: A Smart Gardening Tool

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Abstract: Gardening can be a hobby as well as an opportunity to begin agriculture at a micro level. There might be many issues one might be facing related to gardening like how to check the environment conditions, irrigation, maximizing the produce etc. Concepts like Artificial Intelligence and Internet of Things (IoT) have proved to be of much more assistance to today's consumers. Keeping this in mind, we are proposing the following set of ideas:(1) Create an automated irrigation system suitable to small scale gardening which can scale up to traditional farms. (2)Create an array of sensors which track different gardening and weather condition like soil moisture, soil PH etc. (3) Create a web-app so that the gardener can see all the data collected by the sensors and make systemic changes to his/her gardening methods. (4)Create an image processing system for plant disease detection by taking the images of the leaves of the specific plant as input.

Keywords: Gardening, IoT, NodeMCU, Deep Learning, Image Processing

I. INTRODUCTION

There are three basic needs of a man: Food, Shelter, and Clothing. As one can guess, the first need that comes to our mind is food. The primary occupation of man was agriculture. Millennia has passed, and man has entered the advanced world of technological development, but the basic needs of survival have not yet changed. Since agriculture has now taken a backseat, it's a rising question of how man fulfils his nutritious needs. Fortunately, we have come across a solution that can satisfy man's needs as well as can act as a hobby: Gardening

As man has estates under his name, the trend of gardening has increased in recent years. From flowers, we have now come to have mini-farms that can supply almost all of the food items we need. But due to the ever-busy life of a human being, it's challenging to maintain the mini-farms that have been created.

As stated above, due to technological advancements, agriculture- which accounts for our food supply, has taken a backseat. In the view of the environmental threats that we could face, afforestation and gardening have been encouraged as actions for sustainable development. The shortage of agricultural lands has led to futuristic methods of gardening that have taken shape, such as modular gardens, elevated veggie patches, etc. But the busy schedule of today is a risk to this promising action.

However, technological advancements have proven to be a solution to these problems. Internet of Things(IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Many of the applications include home automation systems, health monitors, security systems, etc. Given such a wide range of applications, it's very much possible to design an automated system that can act as a gardening tool or assistant.

Our goal is to create a platform which will help consumers to maintain and analyse their garden. This includes an automated irrigation system suitable for small scale gardening, which can scale up to traditional farms. We intend to track different gardening and weather conditions like soil moisture, pH, etc. Through this, we would provide insights to the user into how different conditions can affect the crop. Our system would also suggest measures to have suitable gardening experience and also to grow the needed food supply for oneself. This process would be interactive for the user through a web application where one can see the related data collected by the sensors and thus can make systematic gardening changes.

This project envisions creating an automated system that will act as an assistant to carry out the user's gardening activities which can eventually create a mini farm where the user can cultivate the basic supply for his/her nutritional needs. The IoT based smart gardening system would give valuable information about the soil to the end user through cloud which proves to be a promising medium of giving information. The sensors used i.e. Soil moisture, temperature and the luminosity sensors will prove very helpful to the user as these parameters are of extreme importance to the

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gardener with regards to the soil in which the user would be gardening. Implementing an irrigation system by taking the soil data would reduce the main work of gardening that is irrigation. The technology to have a choice for manual or automated irrigation would increase the confidence in the user to carry out the activities and also on the product.

II. Literature Review

The IoT is a network of physical objects—vehicles, devices, buildings, and other items—embedded with electronics, sensors, and software. Network connectivity enables these objects to collect and exchange data. It monitors and keeps track of your garden's environmental conditions and gives recommendations regarding plants that would do best in your garden based on soil composition. The internet of things has made quite a lot of strides in the past few years; the ability to monitor operations surrounding infrastructure is also a factor that IoT can help. [9] For example, sensors could be used to monitor events or changes within structural buildings, bridges, and other infrastructure. This brings benefits with it, such as cost-saving, saved time, quality-of-life workflow changes, and paperless workflow. Gardening can be considered a very tedious task with a strict regimen. With the help of IoT, we can automate the entire watering system and analyse different factors affecting plant growth. With the help of data from the sensors, various vital elements can be monitored effectively. The most important part is the hardware in IoT projects, selection of an efficient device will make the project reliable. [12]

Smart Garden includes NodeMCU as a hub. NodeMCU is an open source IoT platform. It runs on ESP8266 Wi-Fi SoC from Espessif Systems, and hardware based on the ESP-12 module available at lowest cost. It is a Single –board microcontroller consisting of 128kBytes of memory and 4Mbytes of storage. It was designed for easy programming and allows easy prototyping for developers. There are essentially three ways to build NodeMCU firmware: cloud build service, Docker image, Linux Build Environment. It consists of an inbuilt Wi-Fi module which allows us to upload the values of the sensors to the firebase including NodeMCU as a hub. NodeMCU is an open source IoT platform. It runs on ESP8266 Wi-Fi SoC from Espessif Systems, and hardware based on the ESP-12 module available at lowest cost. [13].

The system consists of temperature, light, humidity, soil moisture and CO sensor. These sensors will measure the primary environmental factors light intensity, temperature, CO levels, humidity and soil moisture level relative to our garden. All these sensors will give the analog voltage representing one particular environmental factor. The micro-controller will convert this analog voltage into digital data.

The RHT03 (also known by DHT-22) is a low cost humidity and temperature sensor with a single wire digital interface. The sensor is calibrated and doesn't require extra components so you can get right to measuring relative humidity and temperature

A Light Sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called "light" and which ranges in frequency from "Infra-red" to "Visible" up to "Ultraviolet" light. Spectrum. The light sensor is a passive device that converts this "light energy" whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as "Photoelectric Devices" or "Photo Sensors" because they convert light energy (photons) into electricity (electrons).

Soil moisture is the water that is held up in the spaces between soil particles. Soil moisture is an important factor for crop growth; therefore, to a crop farmer, it is important to monitor and acquire information about the amount of moisture in the soil. Soil moisture can be measured and determined using various methods and instruments. In this project, we employ soil moisture sensors that measure the volumetric water content directly by electric resistance. The sensors are calibrated for a resistance between 0 to 1023 levels, when the current flows through the two probes of the sensor. The more resistance is observed between the two probes, - the soil is drier; and the less resistance reflects the fact that the more moisture is in the soil. [4]

This controller is suitable for any type of motor - Single or Three Phase. Switches ON the pump when the water in the overhead tank goes below the pre-decided minimum level. Switches OFF the pump whenever the soil moisture level meets the required conditions. Shall again switch ON the pump when the soil moisture levels are low. [11]

Data Visualization is the process that helps in the communication of the insights and patterns discovered or found in the data. This involves the direct interpretation of the data in a non-technical way that the business can relate to. It also comes with actionable insights that were discovered through the Data Science process. [1] This step is where the

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storytelling comes in. It is always advisable to let your data tell a story as it is one of the most effective ways of communicating your results. Python offers multiple great graphing libraries that come packed with lots of different features. No matter if you want to create interactive, live or highly customized plots, python has an excellent library for you. To get a little overview here are a few popular plotting libraries:

- Matplotlib: low level, provides lots of freedom
- Pandas Visualization: easy to use interface, built on Matplotlib
- Seaborn: high-level interface, great default styles
- Ggplot: based on R's ggplot2, uses Grammar of Graphics
- Plotly: can create interactive plots

Line Charts, Histograms, Scatterplot, Bar Charts, Box plots, Violin plots, Heat maps, etc., are some of the essential visualization techniques. [8]

We have also found out two systems that are currently popular:

1. IOT based smart Gardening system: These systems hold a set of sensors located in the soil which relay information to the cloud [16][17]. This data from the cloud is displayed in the app/ frontend. Some examples of the data to be recorded are Soil moisture Percentage, Soil temperature and Luminosity sensor. The microcontroller used for this system is generally the ESP2866.
2. Automated irrigation systems: These systems provide automated irrigation to the garden. The servo motor is connected to a microcontroller. The servo motor is fitted on to the valve of the water supply and whenever the user wants (or if pre-set conditions are met) then the motor is switched on. The microcontroller used for this system is generally the ESP2866.

The following two products are in the market currently:

1. Gardena Smart Gardens: This company provides a range of smart products such as a robotic lawn mower and automated irrigation system. However this system is intended for backyards with grass and not for growing produce. This product also provides the user with a mobile app which helps with scheduling various gardening tasks.[18]
2. Rise Gardens: Rise gardens is a product meant for indoor gardening. It comes with a custom box which already has in- built lighting and irrigation techniques installed. It is meant for growing small herbs and root plants in an indoor environment.[19]

III. PROPOSED WORK

This research aims to design and implement an IoT based smart gardening system. We start with building out a small-scale garden. In the early stages we will nurse the plants in the normal way. There will be a sensor network placed in the garden which will help us read the environmental conditions the plants are growing in. Once we have the data regarding the environment, we will transfer the data to a web app which can be both viewed in mobile as well as desktop devices. In the web app, along with displaying the data procured by the sensors we will also have an analytical dashboard which will display the data in an easy-to-understand graphical format.

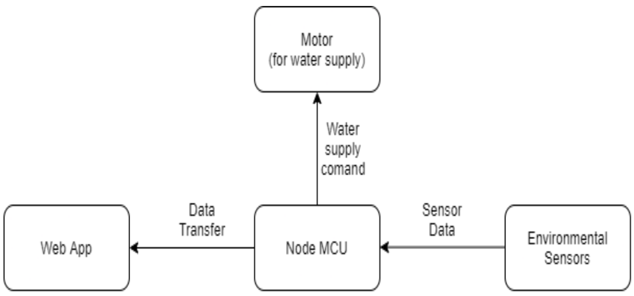

Fig. 1 Proposed Work Summary of the smart gardening system

A. Sensors

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Once we are satisfied with the growth in the garden we will start building out our sensor network. This network will contain a range of sensors which will help our system to recognize various factors which affects our garden (mainly soil and weather conditions)

Some of the sensors we have recognized are as follows:

1. Soil moisture sensor
2. DS18B20 digital thermometer
3. Sunlight/Luminosity sensor
4. DHT11 humidity sensor (also works as air temperature sensor)
5. Motor (for automated water supply to the plants)

To run theses sensors we will be using the microcontroller: Node MCU ESP8266.

B. Web App/ Mobile App

Once we have our sensor system up and running we will collect the data in real time and upload it to a cloud service (most probably firebase).We will then create a web app which displays these values in real time. The web app will be connected to the sensor network. This web app will also be converted into a mobile app using Cordova.

C. Image processing for plant disease detection

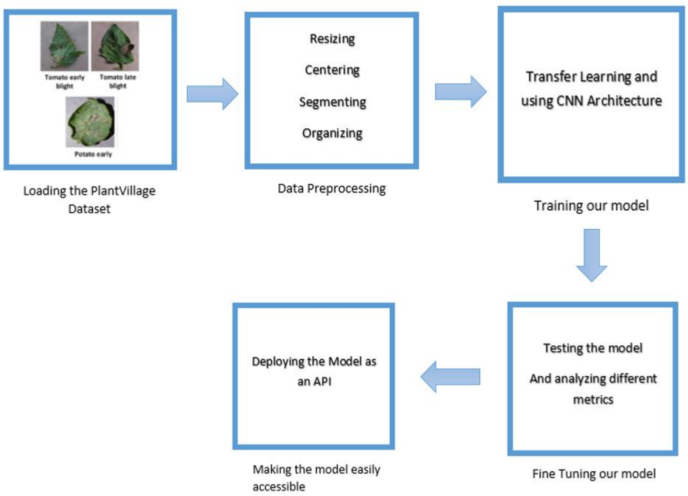

Fig. 2 Proposed Work Summary of the image processing for plant disease detection

Deep learning is a machine learning technique which teaches computers to perform activities that comes naturally to humans and by learning every day-to-day ventures. In deep learning, a computer model learns to classify tasks directly from the text, sound, images or video clips. Deep learning models can achieve state-of-the-art accuracy, sometimes even surpassing human-level performance. Models are trained by using massive labelled data sets and neural network architectures that contain various layers. Nowadays, deep learning is achieving higher levels of recognition accuracy than ever before. Recent advancements in deep learning have improved to such a stage that it outperforms humans in classifying objects in images. In simple words, it is a procedure of automatically predicting and analysing the given information by the user.[20]

D. PlantVillage Dataset

It contains 54,306 images of plant leaves, which have a spread of 38 class labels assigned to them. Each class label is a crop disease pair, and we attempt to predict the crop-disease pair given just the image of the plant leaf. We need to resize the images to 256 × 256 pixels, and then perform both the model optimization and predictions on these downscaled images.[22]

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```
img_data.classes

'''
Output of img_data.classes:
['Apple___Apple_scab',
 'Apple___Black_rot',
 'Apple___Cedar_apple_rust',
 'Apple___healthy',
 'Blueberry___healthy',
 'Cherry_(including_sour)___Powdery_mildew',
 'Cherry_(including_sour)___healthy',
 'Corn_(maize)___Cercospora_leaf_spot Gray_leaf_spot',
 'Corn_(maize)___Common_rust_',
 'Corn_(maize)___Northern_Leaf_Blight',
 'Corn_(maize)___healthy',
 'Grape___Black_rot',
 'Grape___Esca_(Black_Measles)',
 'Grape___Leaf_blight_(Isariopsis_Leaf_Spot)',
 'Grape___healthy',
 'Orange___Haunglongbing_(Citrus_greening)',
 'Peach___Bacterial_spot',
 'Peach___healthy',
 'Pepper,_bell___Bacterial_spot',
 'Pepper,_bell___healthy',
 'Potato___Early_blight',
 'Potato___Late_blight',
 'Potato___healthy',
 'Raspberry___healthy',
 'Soybean___healthy',
 'Squash___Powdery_mildew',
 'Strawberry___Leaf_scorch',
 'Strawberry___healthy',
 'Tomato___Bacterial_spot',
 'Tomato___Early_blight',
 'Tomato___Late_blight',
 'Tomato___Leaf_Mold',
 'Tomato___Septoria_leaf_spot',
 'Tomato___Spider_mites Two-spotted_spider_mite',
 'Tomato___Target_Spot',
 'Tomato___Tomato_Yellow_Leaf_Curl_Virus',
 'Tomato___Tomato_mosaic_virus',
 'Tomato___healthy',
 'background']
'''
```

Fig. 3 Types of plants in the dataset

We will be using fastai which is built on top of Pytorch. Dataset consists of 38 disease classes from PlantVillage dataset and 1 background class from Stanford's open dataset of background images DAGS. **80% of the dataset is used for training and 20% for validation.**We will use the pre-trained **resnet34** model to solve the issue with the training. Batch size means we will feed x images at once to update parameters of our deep learning model. Set batch size to 64, if smaller GPU use 16 or 32 instead of 64.[20]

```
data = ImageDataBunch.from_name_func(path, image_list, label_func=get_labels,  size=224,
                                     bs=64,num_workers=2,ds_tfms=tfms)
data = data.normalize()
```

Fig. 3 Normalisation process

ImageDataBunch.from_folder gets the label names from the folder name automatically. Once the data is loaded, we can also normalize the data by using .normalize.

- path: the path of the images directory
- ds_tfms: the transformations that are needed for the image. This includes centering, cropping and zooming of the images.
- Size: the size to which the image is to be resized. This is usually a square image. This is done because of the limitation in the GPU that the GPU performs faster only when it has to do similar computations (such as matrix multiplication, addition and so on) on all the images.

To train, the transfer learning method is being used, where one uses a pre-trained model for handling the task at hand. For this problem, the CNN architecture Resnet34 is being used. It has 34 layers in its neural network architecture and is trained on the ImageNet dataset. The Resnet or Residual Network essentially uses shortcut networks on top of feed forward networks. In plain feed forward networks, as the depth of the network increases the accuracy tends to get saturated. The residual networks do away with accuracy saturation by adding the shortcut networks. To create the

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transfer learning model, we will need to use the function cnn_learner that takes the data, network and the metrics. The metrics is just used to print out how the training is performing.[23]

IV. RESULTS

The following is the completion status of the gardening system and the plant disease detection model. We have an application and the website as well as the plant disease detection model in action along with its metrics.

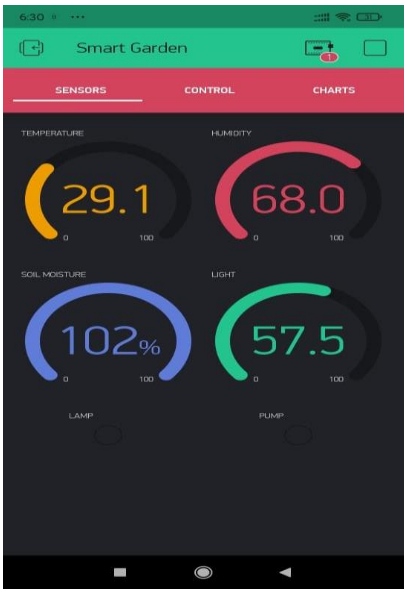

Fig. 4(a) Sensor data shown in mobile application

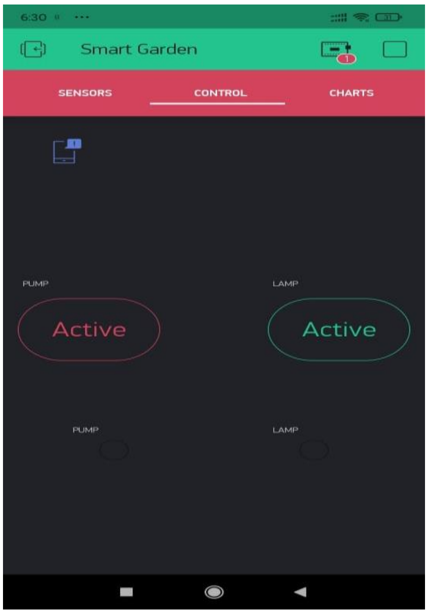

Fig. 4(b) Actuator controls in mobile application

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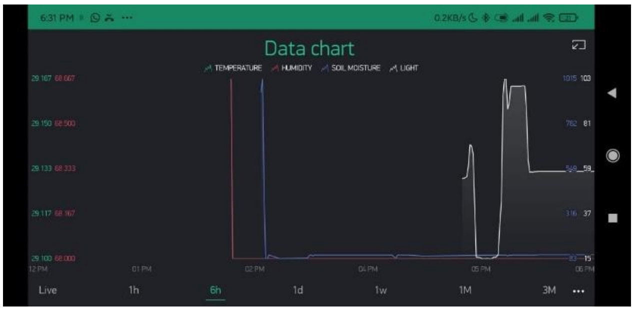

Fig. 4(c) Data charts in mobile application

From Figs. 4. (a), (b) and (c) we can see how the mobile application works.

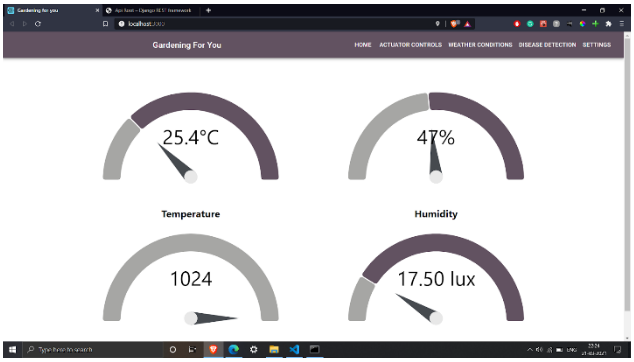

Fig. 5(a) Sensor data in website

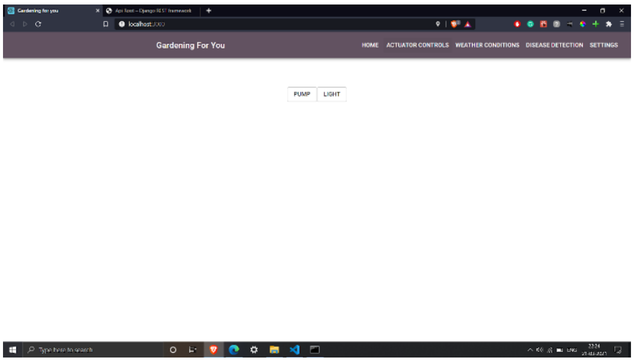

Fig. 5(b) Actuator controls in website

From Figs. 5. (a) and (b) we can see the functioning of the website regarding the automated system.

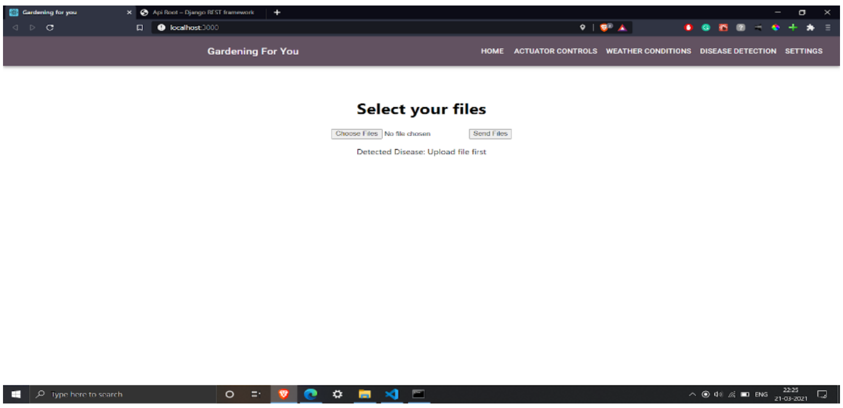

Fig. 5(a) File entry for image detection

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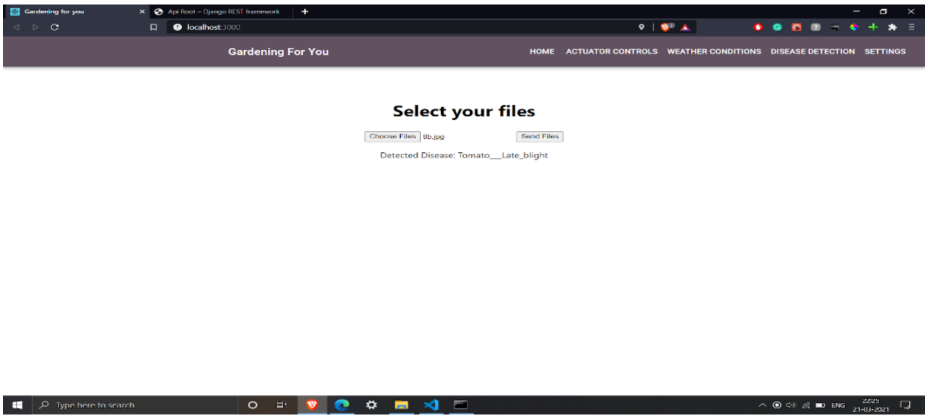

Fig. 5(a) Disease being detected

```
learn = cnn_learner(data, models.resnet34, metrics=[error_rate, accuracy], model_dir='/tmp/models/')
```

```
learn.fit_one_cycle(20)
```

epoch	train_loss	valid_loss	error_rate	accuracy	time
0	2.959123	2.090360	0.633898	0.366102	00:20
1	2.171094	1.018883	0.283051	0.716949	00:17
2	1.473567	0.608471	0.181356	0.818644	00:17
3	1.043629	0.466199	0.144068	0.855932	00:16
4	0.769005	0.396333	0.118644	0.881356	00:17
5	0.591419	0.341573	0.111864	0.888136	00:16
6	0.478805	0.306834	0.088136	0.911864	00:17
7	0.376274	0.275808	0.076271	0.923729	00:17
8	0.323276	0.253138	0.083051	0.916949	00:17
9	0.282315	0.239859	0.071186	0.928814	00:17
10	0.245741	0.241398	0.072881	0.927119	00:16
11	0.218783	0.231011	0.077966	0.922034	00:16
12	0.191591	0.221069	0.069492	0.930508	00:16
13	0.172686	0.206725	0.067797	0.932203	00:17
14	0.152605	0.196321	0.072881	0.927119	00:16
15	0.145761	0.196197	0.067797	0.932203	00:17
16	0.127722	0.193305	0.067797	0.932203	00:16
17	0.125353	0.191236	0.066102	0.933898	00:16
18	0.125089	0.191702	0.062712	0.937288	00:16
19	0.119607	0.188920	0.062712	0.937288	00:17

Fig. 5(c) Model being trained

From Figs. 6 (a), (b) and (c) we can see the plant disease detection model in action. As you can see, we achieved a substantial accuracy of 93% with 20 epochs.

References

[1]. https://towardsdatascience.com/the-power-of-visualization-in-data-science-1995d56e4208
[2]. Yuthika Shekhar, Ekta Dagur, Sourabh Mishra "Intelligent IoT Based Automated Irrigation System" International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 18 (2017).
[3]. https://www.instructables.com/id/Raspberry-Pi-Powered-IOT-Garden
[4]. Julius Kakooza Kawemba "Design and Implementation of an IoT Farming System" InSight: RIVIER ACADEMIC JOURNAL, VOLUME 15, NUMBER 1, FALL 2019.
[5]. https://www.kdnuggets.com/2016/03/data-science-process.html
[6]. Geetika Chawla, Savita Bamal and Rekha Khatana "Big Data Analytics for Data Visualization: Review of Techniques" International Journal of Computer Applications (0975 – 8887) Volume 182 – No. 21, October 2018.
[7]. Yuan Alfinsyah Sihombing and Sustia Listiari "Detection of Air Temperature, Humidity and Soil pH by Using DHT22 and pH Sensor Based Arduino Nano Microcontroller" AIP Conference Proceedings 2221, 100008 (2020).
[8]. David Donoho "Years of Data Science" JOURNAL OF COMPUTATIONAL AND GRAPHICAL STATISTICS, VOL.26, NO.4, 745–766.
[9]. Carrión, Gabriela & Huerta, Mónica & Barzallo, B. (2018). Internet of Things (IoT) Applied to an Urban Garden. 155-161. 10.1109/FiCloud.2018.00030.

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[10]. Bulipe Srinivas Rao, Prof. Dr. K. Srinivasa Rao and Mr. N. Ome "Internet of Things (IOT) Based Weather Monitoring system" International Journal of Advanced Research in Computer and Communication Engineering Vol. 5, Issue 9, September 2016Z.
[11]. Satyam Kumar Sinha, Bhupendra Singh, Aashish Kumar Gupta "IOT Based Smart Garden Monitoring System" International Journal of Scientific & Engineering Research Volume 8, Issue 10, October-2017.
[12]. Elangovan, Ramkumar & Santhanna krishnan, Nagarani & Rozario, Roger & Banu, Arjuman. (2018). Tomen: A Plant monitoring and smart gardening system using IoT. International Journal of Pure and Applied Mathematics. Volume 119.
[13]. T.Thamaraimanalan, S.P.Vivekk, G.Satheeshkumar and P.Saravanan "Smart Garden Monitoring System Using IOT" Asian Journal of Applied Science and Technology (AJAST) Volume 2, Issue 2, Pages 186-192, April-June 2018.
[14]. Mubashir Ali, Nosheen Kanwal, Aamir Hussain, Fouzia Samiullah, Aqsa Iftikhar, Mehreen Qamar "IoT based smart garden monitoring system using NodeMCU microcontroller" International Journal of Advanced and Applied Sciences, 7(8) 2020, Pages: 117-124.
[15]. https://roboindia.com/tutorials/smart-rooftop-garden-using-soil-moisture-sensor-and-nodemcu/
[16]. Bulipe Srinivas Rao, Prof.Dr.K. Srinivas Rao, Mr.N. Ome. IOT based Weather Monitoring System.
[17]. IOT applied to an urban garden. Gabriela Carrion, Monica Huerta, Boris Barzallo.
[18]. https://www.gardena.com
[19]. https://risegardens.com
[20]. https://towardsdatascience.com/plant-disease-detection-web-application-using-fastai-b0c389b82371
[21]. Mohanty Sharada P., Hughes David P., Salathé Marcel "Using Deep Learning for Image-Based Plant Disease Detection" Frontiers in Plant Science vol 7, 2016.
[22]. Muhammad Hammad Saleem, Johan Potgieter and Khalid Mahmood Arif "Plant Disease Detection and Classification by Deep Learning".
[23]. Guiling Sun, Xinglong Jia, and Tianyu Geng "Plant Diseases Recognition Based on Image Processing Technology" Hindawi Journal of Electrical and Computer Engineering Volume 2018, Article ID 6070129.
[24]. S. D. Khirade and A. B. Patil, "Plant Disease Detection Using Image Processing," 2015 International Conference on Computing Communication Control and Automation, 2015, pp. 768-771, doi: 10.1109/ICCUBEA.2015.153.
[25]. Suresh, V & Krishnan, Mohana & Hemavarthini, M & Jayanthan, D. (2020). Plant Disease Detection using Image Processing. International Journal of Engineering Research and. V9. 10.17577/IJERTV9IS030114.
[26]. Arnal Barbedo, J.G. Digital image processing techniques for detecting, quantifying and classifying plant diseases. SpringerPlus 2, 660 (2013).
[27]. Ashwini C, Anusha B, Divyashree B R, Impana V, Nisarga S P, 2020, Plant Disease Detection using Image Processing, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) NCCDS – 2020 (Volume 8 – Issue 13).
[28]. Konstantinos P. Ferentinos: Deep Learning models for plant disease detection and Diagnosis. Computers and electronics in ariculture (2018).