SMART FARMING APPLICATIONS

(AKILLI TARIM UYGULAMALARI)

by

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ABSTRACT

With climate change, global warming and population growth, agricultural problems grew and product sustainability came under risk with classical agriculture. For this reason, digitalization has been directed in agriculture. It has been an effective approach that provides critical advantages to producers to make agriculture more sustainable.

The main purpose of digitalization in agriculture is optimizing complex agricultural systems by applying information and data technologies. The basis of smart agriculture is the IoT technologies. However, the focus of smart agriculture is accessing data such as temperature and humidity in real time and processing collected data in useful way. The processing of data collected by using different sensors with machine learning is making the collected information meaningful and usable.

The purpose of my project is instantly observing the temperature and humidity values collected through sensors, determining the optimum values suitable for agriculture and taking action as soon as the threshold point is exceeded. So DHT11 sensor, ESP8266 and Google Cloud are used for this. Today, cloud technologies provide effective solutions for real-time monitoring collected data from devices and machines. Different types of gateways are used transfering the collected data to cloud platforms. Here mosquitto was used as the MQTT server for the performance analysis. Near this machine learning methods used detecting disease in grown lettuce leaves. Detection of plant diseases is one of the most applied developments in agriculture determining whether the plant's leaves are healthy or ill. For this the data were preprocessed by image processing techniques using machine learning algorithm.

Keywords : Smart Farming, Cloud Systems, Cloud Computing, Plant Disease Detection, Machine Learning

ÖZET

İklim değişikliği, küresel ısınma ve nüfus artışıyla beraber tarımsal problemler daha da büyümüş ve klasik tarımla beraber gıda sürdürülebilirliği risk altına girmiştir. Bu sebeple, her alanda olduğu gibi tarımda da dijitalleşmeye yönelinmiştir. Tarımı daha sürdürülebilir hale getirme, zamanı ve kaynakları daha verimli kullanma gibi konularda üreticilere kritik avantajlar sağlayan, etkili bir yaklaşım olmuştur.

Tarımda dijitalleşmede asıl amaç bilgi ve veri teknolojilerine başvurarak karmaşık tarım sistemlerini optimize etmektir. Akıllı tarımın temelinde Nesnelerin İnterneti teknolojisi yer almaktadır. Bununla beraber akıllı tarımın odak noktası sıcaklık, nem gibi verilere gerçek zamanlı olarak erişip, toplanan verilerin işe yarar bir şekilde işlenmesidir. Yani farklı sensörler kullanılarak toplanan verilerin makina öğrenimiyle işlenmesi, toplanan bilgilerin anlamlı ve kullanılabilir hale getirilmesidir.

Benim bu projemin amacı da sensörler aracılığıyla toplanan sıcaklık ve nem değerlerini anlık gözlemleyerek, tarıma elverişli optimum değerleri belirlemek ve eşik noktasının aşılması halinde biran önce önlem almak. Bunun için ise DHT11 sensörü, ESP8266 ve Google Cloud kullanılmıştır. Günümüzde, bulut teknolojileri endüstriyel ve tarım alanlarında kullanılan cihaz ve makinelerden toplanan verilerin gerçek zamanlı olarak takip edilmesinde etkili çözümler sağlamaktadır. Toplanan verilerin bulut platformlarına aktarılabilmesi için farklı türden ağ geçitlerinden yararlanılmaktadır. Çalışmada tasarlanan ağ geçidinin performans analizi için ise MQTT sunucusu olarak Mosquitto kullanılmıştır. Sensör uygulamalarıma ek olarak, yetiştirilen marul yapraklarındaki hastalığı tespit etmek için makine öğrenmesi yöntemleri kullanılmıştır. Bitki hastalıklarının tespiti, tarımda teknoloji kullanımı alanında en çok uygulanan gelişmelerden biridir. Klasik makine öğrenmesi algoritması kullanılarak bir bitki yaprağının sağlıklı mı yoksa sağlıksız mı olduğunun tespit edilmesi yaklaşımında ilk olarak görüntü işleme teknikleri kullanılarak veriler ön işleme tabi tutulmuştur.

Anahtar Kelimeler : Akıllı Tarım, Bulut Sistemleri, Bulut Bilisim, Bitki Hastalıkları

Tespiti, Makine Ogrenimi

1 INTRODUCTION

With the environmental pollution and global warming, many agricultural lands become unusable with the effect of unconscious irrigation and wrong agricultural policies in the world. It has compelled the modern farmer to get more efficiency in less area and to do this in an environmentally friendly and sustainable way.

In order to ensure the sustainability of agriculture with environmentally friendly methods, a new agricultural methods has emerged. By this the aim is to establish a sustainable system with low input and high efficiency by making use of information technologies. It is truly modern agricultural management that uses digital technologies to control and optimize farming activities. Here the main purpose is optimization in the agriculture based on the new technological developments. A large amount of data should be collected using new technological methods in this precision agriculture.

Unstructured data sets which called “big data” do not make sense on their own. The combination of processing the collected data, that is, output management, with the outline of precision agriculture has given birth to technologies called "smart farming". The purpose of smart agriculture is to identify problems with the analysis of the collected data and to present practical solutions for the target at an early stage. The digital collection, storage and analysis of data from the field is defined as ’digital agriculture’.

The combination of processing the collected data, that is, output management, with the concept of precision farming has revealed "smart farming". The aim of smart agriculture is to identify problems with the analysis of the collected data and to present practical solutions for the target at an early stage. The digital collection, storage and analysis of data from the field is defined as ’digital agriculture’. The data is collected with digital technologies such as sensors, satellites and unmanned aerial vehicles, interpreted by big data analysis and made available to the farmer through web-based platforms. Smart agriculture can be defined as the implementation of data and information technologies for optimizing complicated agricultural systems. The focus of these systems are on both the access to the data and the processing of the collected data. It is significant to process the collected data, using different sensors with machine learning and to make the collected information meaningful and usable. It is aimed that smart farming systems will autonomously make the necessary determinations and analyzes and take the producers into action by withdrawing meaningful information with machine learning algorithms and analyzes to be applied on the collected data in real time. Recently, studies on machine learning in different application areas have shown that deep learning and artificial intelligence methods have achieved the highest success in solving the problem of processing big data collected by different imaging systems. Due to problems with processing data from sensors, deep learning methods are rapidly become standard.

Processed big data with machine learning methods applied in smart agriculture ensures to the producers that (7) tracking their products in real time, (69) by giving an early warning system, when necessary, to be able to solve potential problems related to cultivated plants before they progress and (9) will be able to quickly make the necessary analyzes for very large agricultural lands autonomously and remotely.

Here my first main objective is contributing on sustainable agricultural strategies with image processing technics. It's observed that image processing technics are already obtained in lots of agricultural innovations. And disease detection is one of the major features on these contributions. Here followed the steps as

1. Image Acquisition
2. Image Preprocessing
3. Image Segmentation
4. Feature extraction
5. Classification

This will be ensure minimize the costs or to find out disease before it happens or to find out the reason of disease. Plant diseases a type of nature catastrophes which affect the ordinary growth of plants and subject to plant's end of life in the course of the whole growth process of plants. With the old methods of the agriculture, it was not possible to early detection of the plant disease. So this causes loss of time, efficiency, labor and profit. It is important to determine the symptoms of diseases in early phases when they occur on the growing leaf. So I applied to MATLAB that we can focus on the lettuce and to image processing technique that we can precise plant disease's detection and identification.

In this study, in order to increase the productivity of lettuce plants, grown in vertical hydroponic system , a disease detection study was carried out from leaves via the techniques of image processing. And at the same time used ESP8266 and DHT11 to see and decide the best enviromental temperature and humidity. So here my second objective was to follow up the humidity and temperature data. So I used the DHT11 sensor to gather the data and use the NodeMCU ESP8266 development board to send the data to the Cloud. By the DHT11 sensor, the data was collected in real time and then collected data was sent to the Cloud. For the contact between NodeMCU board and Google Cloud enabled with the MQTT protocol. When the data is on Google CloudIOT Core, data required to be stored in the database. By Google Cloud Functions, we can write the data in the database. At last we could see the change of the environmental temperature and humidity in our platform as real time.

Today, cloud technologies present important key helps in real-time monitoring of data which are collected from devices, sensors and machines used in various areas as industrial, agricultural etc. For transferring the acquired data to cloud platforms, various kinds of gateways can be used. In this study, a low-power, low-cost Internet of Things (IoT)-based gateway prototype design that can be used in industrial areas is presen- ted. MQTT protocol, which is frequently used in IoT applications, is used to send the agglomerated data at the gateway to the cloud platform wirelessly. The conceived gateway can detect the difference on the data due to it's programmed algorithm. In this study Mosquitto was used as the MQTT server for the performance analysis of the designed gateway. It is a perfect messaging protocol that also meets today's requirements for IoT and M2M (Machine to Machine) applications. In other words, it allows small electronic devices to network and talk among themselves. When we talk about networking, various wifi/ethernet/gsm etc., we can establish a network and communicate between the hardware and our electronic circuits. But these are expensive, very power consuming and non-overlapping for IoT, M2M style applications. Since there are technologies, similar alternative systems, protocols, etc. developed.

IoT applications and provide advantages in terms of both cost and time in studies such as the communication of machines, the processing of data from sensors and the monitoring of warehouses.

2 SMART FARMING SYSTEMS

Smart farming is one of the hottest and a popular topic in engineering and agriculture domains. Internet of Things (IoT) based devices are mostly preferred to pursue the plant during its growth period and cloud computing based platforms are developed for environment management (69). Main goal of such applications are to apply innovative solutions to increase the efficiency of harvesting. In the literature, there are many studies target the smart farming and the Information and Communications Technology (ICT) based applications used in agriculture (9). Mulla et al. summarize the remote sensing applications in smart farming until 2013 (48). Agarwal et al. (1) gather various perspectives of smart farming : technological side, economical side, social side. Authors underline that technology is not the only solution for smart farming but also social and economical impacts of smart farming should be considered.

Remote sensing with sensors, drone and satellite technologies, mapping the fields, artificial intelligence, robot technologies, image processing technologies can be listed as smart agriculture applications.

Sensors are devices that measure and determine some physical quantities. After the determinations made, they convert them into electrical signals.

Sensors are frequently preferred in the field of smart agriculture. In particular, sensors are preferred for the measurement of agriculturally important factors such as air and soil properties.

The problem of growing qualified agricultural products combined with the effects of population growth, climate changes and global warming, the pursuit of producing higher quality products with lower costs has brought along the necessity of using the possibilities of technology in order to overcome the problems in the agricultural sector. Studies on this subject have shown that smart farming systems play a significant role in solving these problems.

In the literature various IOT devices has been placed in farm activities to evaluate all kinds of data remotely and ensure this information to the farmers in real time. There are various types of IoT sensors for agriculture as well as IoT applications. We can count usage areas of the IOT devices in Smart Farming as below.

1. To monitor climate conditions
2. Automation of Greenhouse
3. Crop management
4. Monitoring and management of cattle
5. Precision farming
6. Agricultural drones
7. Estimated analytics for smart farming
8. End-to-end farm management systems

Here most significant and valuable farming applications are highlighted. Most preferred hardware platforms, communication technologies and IoT cloud services for smart farming applications are analyzed. Main goal of such applications can be listed as follows :

1. Irrigation management
2. Pest and disease control
3. Greenhouse condition monitoring
4. Soil monitoring
5. Water quality monitoring
6. Precision agricultural
7. Dairy management

2.1 Vertical Farming

The newest part of soilless agriculture has been added to our lives with the concept of vertical agriculture. Vertical farming systems are agricultural systems where production is made with artificial lighting in climate-controlled environments and the production lines are placed vertically on top of each other. In this method, plants are grown in a controlled area using technology that provides optimum conditions. In short, there is no longer a space restriction in production that is independent of soil and light. It is not dependent on climate and soil to produce. With this method, production can be made in any field. Optimum conditions are provided by vertical farming. In this way, much more efficiency can be obtained. Because in vertical farming plants are grown in a controlled environment, the risk of disease and pests is minimized, and the weed problem is completely eliminated. In this way, production can be made using much less pesticides. This innovative system consumes 95% less water than other systems and saves considerable space and soil.

It has been an interesting agricultural approach in the world of agriculture as it saves water and requires less space. It is accepted as an attractive system for farmers thanks to these strengths. For the same reasons, it also provides the appropriate environment for sustainable agriculture. The most basic feature that distinguishes these systemsfrom other competitors is the possibility of producing food in a closed area. The first requirement of growing food indoors is the proper adjustment of the light, humidity and temperature values in the indoor environment and following these settings optimally during food cultivation (1; 5). Agriculture systems that require less soil and less water attract more attention and promise a much more sustainable way of producing food, as the land that can be cultivated in the world is decreasing day by day and the shortage of water worldwide is expected to start soon.

Vertical farming has many advantaged implications for the climate change and environment. With the advantages of vertical farming, it is possible to buy more products in less space, labor and cost savings can be made. Production can be made anywhere in city centers and it is possible to obtain a reliable product. Agriculture in the city improves the air quality of the city and it is an ideal farming method in terms of soil and area shortages. Instead of indexing agriculture only to the village, it is possibleto make the same products produced in the villages more advantageous by reducingthe fuel cost and preventing the crushing of food. In addition, using ultraviolet lights, production can continue throughout the year. Greenhouse heating expenses are low. Production areas are very diverse. Plants are fed in a controlled manner and plant den- sity per unit area is high. Watering becomes easier and plants do not suffer from water stress. The time between harvesting the previous crop and starting the new production is shorter than the traditional agriculture and no weed etc problems. Production is pos- sible where the soil is not suitable for plant production. So the concept of growing food in an indoor environment in a vertical manner creates several opportunities: handle future food demands, significantly less water, eliminate weather, crop effects and di- minish the diseases, less exposure to chemicals. On the other hand, the investment to build such a system can be costly. Pollination in such an environment is another problem to solve. Besides, these systems rely on technical infrastructure where any technical failure should be well considered (21). Still, once we gather more information and discover the workings of plants that need to be grown, we can further optimize the growing environment to increase harvest size and reduce energy consumption.

Figure [2.1] presents the vertical farming named Microgarden and producted by Arcelik Manufacturing in Turkey. Products such as MicroGarden include automatic water and air circulation mechanism and LED lamps to simulate the day lighting. Besides, these systems manage the growth, estimated time to harvest, ambient temperature, remai- ning water level, and automated watering, lighting and air circulation mechanisms.

Figure 2.1 – Microgarden-Arcelik

When the coronavirus outbreaks and have seen barren shelves, that time many produ- cers and food suppliers couldn't know that how should they move without equipment to make transition and most of them couldn't sell their fresh food and millions of tons of them rotted and wasted. Thus they thought that they must redesign fresh-produce supply chain to make it more flexible in answering the challenges in America. The main idea was also make the fresh produce supply chain more inclusive and more sus- tainable (9). Also in Europe vertical farms started to increase rapidly. Various differentkinds of vertical farms found in Europe as PFALs (plant factory with artificial light) presents as shown in Figure [2.2] which are located in industrial buildings, container farms, in store farms where the consumption or the purchase is high like supermarkets or restaurants, and appliance farm which targeted for in house and office usage. Similarly we can see a container farm of Agricool in Figure [2.3] and in store farm of Infarm in the Metro's store from Paris, France in Figure[2.4]. (7).

Figure 2.2 – The PFAL of Jones Food Company in North Lincolnshire, England (7)

Figure 2.3 – A container farm of Agricool in Paris, France (7)

Concept of growing food in indoor environment in a vertical manner creates several opportunities : handle future food demands, significantly less water, eliminate weather, crop and disease effects, less exposure to chemicals. On the other hand, the investment to build such system can be costly. Pollination in such environment is another problem to solve. Besides, these systems rely on technical infrastructure where any technical failure should be well considered (21).

Figure 2.4 – An in store farm of Infarm in the Metro’s store in Paris,France(7)

2.2 Hydroponic Systems

Due to the difficulties to reach to the source, researches focus on growing plants in indoor environments. It is demonstrated that plants could be grown with a water solution containing minerals required by the plants. Such systems are called hydroponicsystems and it is one of the recent solutions that introduces growing plants withoutsoil (57; 64).

A hydroponic farming is a method of growing plants in a water based, nutrient rich solution. A basic hydroponic system has a horizontal chamber. That chamber has a series of holes for flower pots. Each hole has its own smaller holes in its bottoms to enable root growth outside of the pot to access the plant nutrients. The water pump circulates water and the other nourishment from the reservoir system through this chamber. This water loop distributes the water and nourishment at optimal times to maximize growth (33; 62).

Main advantage of such system is that the growth rate is increased. Since plants don’t need to consume energy to gain nourishment, based on an optimal experimental setup, plants may ripen up to 25% faster and produce up to 30% more than the same plants grown in soil (43). In these setups, environmental situations and ph level of the solution must be tracked to assure optimal conditions for the plants. Besides, such system is soil-less, thus any weed problem, fewer pests or plant diseases on the yield can not be occured. As a consequence, insecticide and herbicides will less preferred (18).

However, hydroponic systems for sure are not perfect. The biggest problem of hydroponic systems is the investment cost. Since it requires a special setup and monitoring equipment along side the nutrition solution. Besides, the nutrition solution should be monitored and balanced on a daily basis. In case of any pump damage, whole products or herbs may die in short term since these herbs require a fresh supply of water. Hence, experiences and technical knowledge is essential in these systems (61; 8).

In Figure [2.5] Figure [2.6] we can see respectively basic hydroponic farming setup and types of hydroponic farming which show us the fundamental of the hydroponic systems.

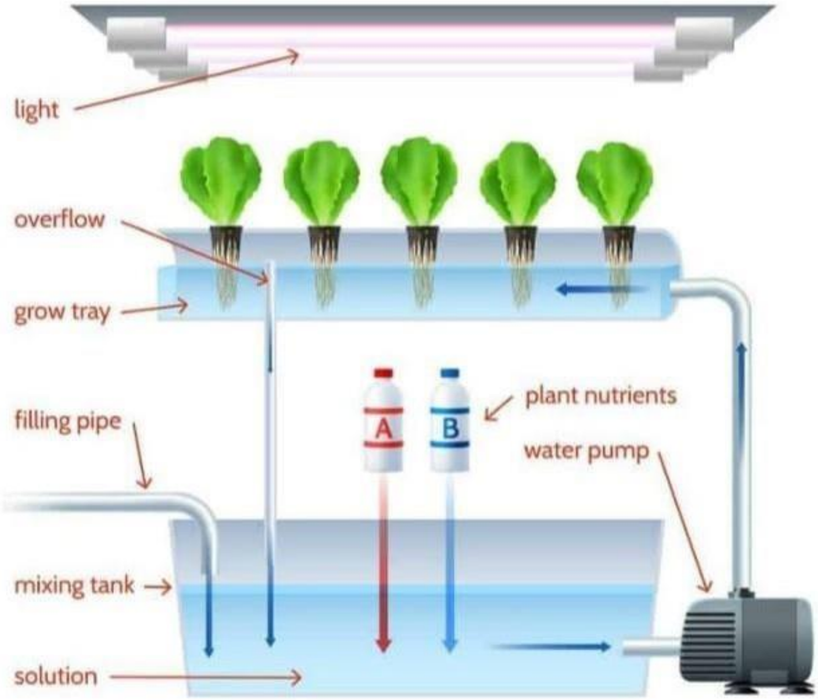


Figure 2.5 – Basic Hydroponic Farming Setup

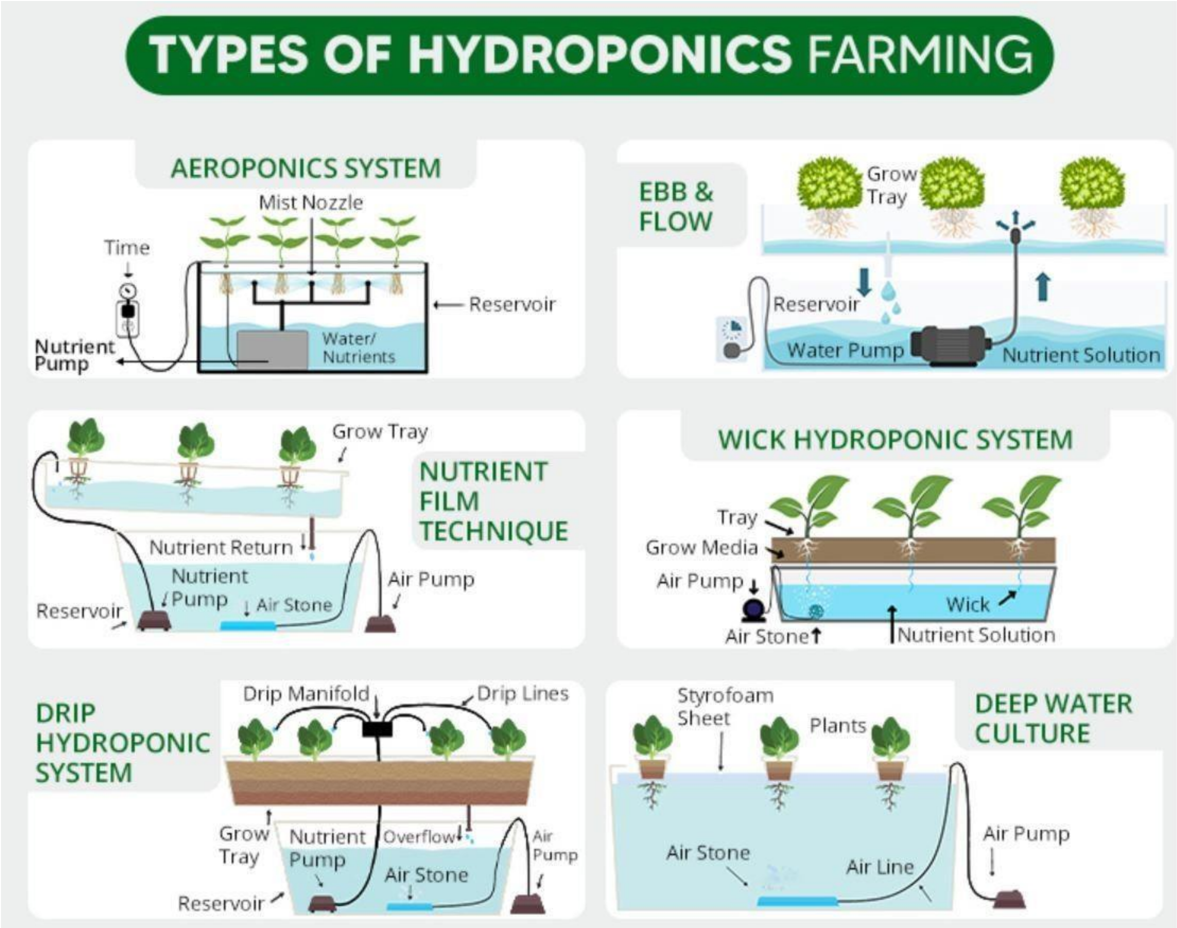


Figure 2.6 – Types Of Hydroponics Farming

2.3 Aeroponics Systems

All over the world, soilless farming techniques, independent of climatic conditions, emerge as an alternative production system.One of the new techniques applied in agriculture without soil is the aeroponic production system. Aeroponics system is a technique of growing plants suspended in the air, in which a nutrient solution in the form of mist or steam is given to the roots.

In Figure [2.7] we can see the draft of the aeroponics system and in Figure [2.8] we can see the aerofarms system.

Searching for effective ways to grow plants in space, NASA developed the aeroponics method in the 1990s and coined the term "aeroponics", which defined as "plants that grow in an air/fog environment with no soil and little water."

Plants grown in aeroponics systems have been indicated to receive much minerals and vitamins, making them healthier and potentially more nutritious.

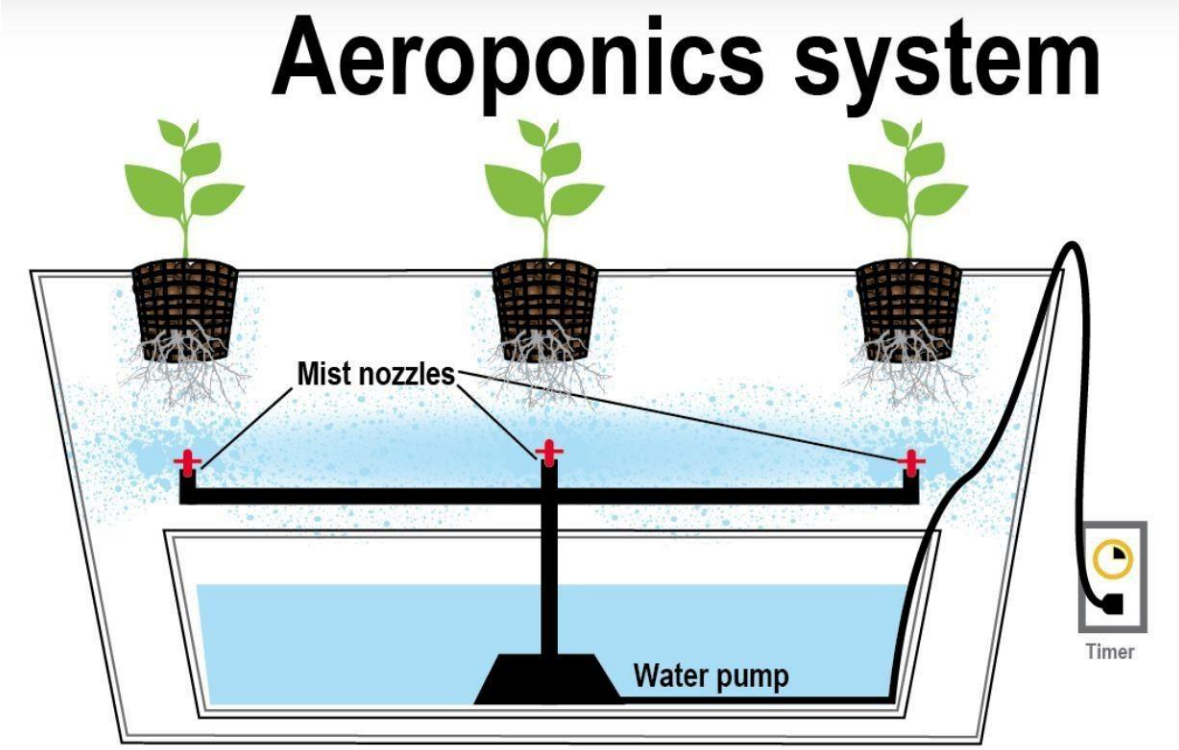


Figure 2.7 – Aeroponics Systems

In the literature, there are many researchs on this systems too.

I. A. Lakhiar et al. (34) mentioned early fault detection and diagnosis in aeroponics using intelligent systems as wireless sensors. So several parameters can be followed byfarmer and whole system could be controlled by remotely. Moreover, it provides the information that how the key parameters of aeroponics correlate with plant growth in the system.

F. Francis et al. (20) aimed an automated aeroponics system with sensors by evaluating the humidity, temperature, pH value of water and the lightness in the environment. Data are collected from each sensor with regular periods and loaded to a cloud to monitor these real time data.

S. C. Kerns et al. (31) combined aeroponics system with IoT technology. They used the IoT devices to design new automatic aeroponics system. The system is consisted from three components :

1. A mobile application
2. Service platform

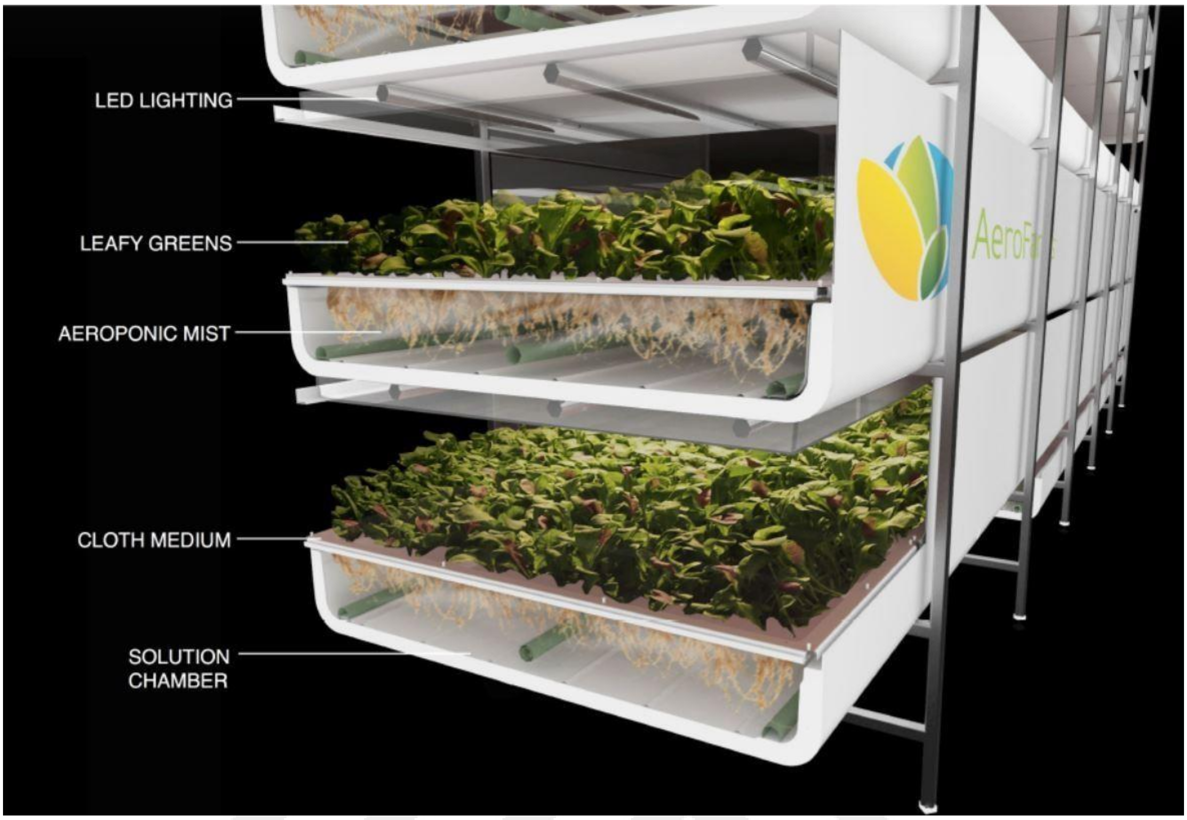


Figure 2.8 – Aerofarms

3. IoT devices with sensors

Lakhiar et al. (35) provided detailed information for researchers and farmers, about aeroponics system. The study compares soilless systems and aeroponic system. And it supports that aeroponic system reduce water usage through continuous water circulation.

S. Karuniawati et al. (30) aims to optimize the growth light control function in an IoT-based aeroponic system using random forest classification and the sensor fusion concept. So this study is the combine of the Machine Learning Techniques and IoT technologies.

3 LITERATURE REVIEW

To improve farm fertility is one of the basic essential objective of farming implementations and the systems. By using artificial intelligence (AI) and machine learning (ML) techniques ensure important answers to evolve the fertility and crop harvest. In machine learning methodology, we can see some basic techniques that can be implemented on the obtained data : regression, clustering, Bayesian models, instance based models etc. Besides, generally a decision tree is created which is formulated as classification or regression models.

3.1 IoT Based Smart Farming Systems

Shenoy, Jeetendra, and Yogesh Pingle et al. (63) focus to used IOT based solutions to decrease the transport cost and the interconnections from the farmer to the end consumer to decrease the damage and cost of the product.

Muangprathub, Jirapond, et al. (47) propose to develope a system which arrange optimum water value for agricultural products based on a wireless sensor network.

Dagar, Rahul, Subhranil Som, and Sunil Kumar Khatri et al. (13) suggested a basic architecture of IoT sensors which gather information and send it over the Wi-Fi network to the server. And according to this informations actions are taken by server.

Farooq, Muhammad Shoaib, et al. (16) investigated related technologies with IoT based agriculture systems including cloud computing, big data storage and analytics. Sensor and smart phone based applications developed for distinct aspects of agricultural management.

For Madushanki, R., H. Wirasagoda, and M. Halgamuge et al. (40) it is important to enhance the productiveness of farming and agricultural processes to improve yields and cost effectiveness with the IoT technologies by reducing human intervention through automation. This is an overview of sensor data collections, technologies, and sub-verticals such as water and crop management.

Also Placidi, Pisana, et al (53) monitored soil and ambient parameters with the low-cost soil water content sensors.

According to Srivastava, Abhishek, and Dushmanta Kumar Das et al. (66) collected data from the sensors are generally stored processed and visualized. With the obtained data we can make estimable smart decisions. For example the temperature of the environment can be set up automatically (It can be increased or decreased). Also, many organizations provide better user solutions and decisions owing to this obtained data.

Arshad, Jehangir, et al. (3) integrated decision support layers using cloud and network-based DSS to achieve optimum efficiency by providing early warning via sensors. This model consists of a sensor model including temperature, humidity, NPK, soil moisture, pH, conductivity sensors. It provides the transfer of statistics to the cloud over the internet through Serial Peripheral Interface (SPI) communication protocol, Long Range (LoRa) using smart irrigation system and controlled fertilizer module. In other words, LoRaWAN based on smart farming decision support system was used for optimum product efficiency.

Tokekar et al. (68) introduce the importance of sensor technology for precision agriculture. Authors work on sensor planification to minimize the sum of the travel and measurement times. Besides images captured by UAV are also integrated to the system to increase the efficiency. Robotic technologies are also involved in the study.

Tripicchio et al. (71) propose using drones to manage the large area and fast treatments. The study presents a computer vision techniques applying on the captured images from drones to detect the area. Such system provides analyzing the watering level within plants and to spray water only required region.

Jayaraman et al. (26) focus on IoT based smart farming application and they present SmartFarmNet, an IoT platform that allows plant biologists and farmers to analyze and visualize plant performance data. Such platform, in parallel provides managing huge data generated from hundreds of thousands of IoT sensors. As this study, Kaloxylos et al. (28), Gondchawar et al. (23), Suma et al. (67) and Prathibha et al. (54) propose a similar cloud based IoT solutions for environment management for smart farming.

Martínez et al. (44) put emphasis on the farm productivity by using a middleware. Authors propose a semantic web with what semantic metadata can be recorded among with the data of the sensors to ensure condition conscious.

Kamilaris et al. (29) indicate the major difference between IoT solutions for smart environments and farming. Authors declare that existing IoT based frameworks in the context of agri-food industry do not satisfy users' needs. In such environments there are other parameters that should be considered such as weather conditions, regulations etc.). In that study, a semantic framework Agri-IoT is presented for smart farming applications that gather various heterogeneous sensor data streams. Proposed framework supports large-scale data analytic and management of inter-operability of deployed/integrated devices.

Similarly, Ferrandez et al. (19) propose an edge layer computing based IoT model. In the study, a ubiquitous sensor network platform is developed to build a monitoring and control installation on smart farming scenarios. Besides, Roopaei et al. (58) propose a cloud platform and relevant services for irrigation monitoring.

Lopez et al. (38) underline the need of a general worldwide database with a normalized schema that contain farming information. Authors believe that such database is extremely valuable for stakeholders in the context of smart farming. Thus, they propose a software architecture and a a fire-ware where a cloud computing for smart farming is available.

Ray et al. (55) present a exhaustive review of IoT spreadment for advanced agricultural applications and IoT based agricultural frameworks. Zamora et al. (74) propose a IoT platform based on edge and cloud computing for precision agriculture (74).

And similar to my project ; Sahay et al. (60) had used the same components as my project to monitor environment as temperature, humidity and CO2 level Using IoTand google cloud service at real time. Soliman et al. (65) integrated IoT with Cloud computing and Web services. The purposes of this attempt (7) to let in intelligence into sensors and actuators using Arduino platform, (69) to network smart things using Zigbee technology, (9) to simplfy coactions with smart devices using Cloud services,
(48) to improve data exchange using JSON data format.

Liawatimena et al. (37) mentioned the importance of the early warning system. If there are risky values for product, it is important to take action earlier. And thisis possible with pursuing temperature, humidity, air pressure, sunlight, soil moisture, rainfall etc. This study provide a trustworthy open data platform that is accessiblefor related labors, Google Cloud Platform is selected to serve this aim to reduce the

TABLE 3.1 – Overview of Existing Studies of Smart Farming

Study	Methodology	Application
Tripicchio et al. (2015)	computer vision	spray water
Tongke et al. (2013), Tokekar et al. (2016), Gondchawar et al. (2016), Martinez et al. (2016), Pratihibha et al. (2017), Suma et al. (2017), Zamora et al. (2019)	robotics, IoT based cloud computing platforms	precision Agriculture
Kaloxylos et al. (2014), Kamilaris et al. (2016), Jayaraman et al.(2016), Ferrandez et al. (2016), Lopez et al. (2017)	robotic, IoT based firmware and platforms	large-scale data analytics and environment management
Roopaei et al. (2017)	Cloud of things	Irrigation Monitoring
Ray et al. (2017)	IoT based agricultural framework	innovative researches in agricultural

hazard of sustaining a trustworthy wide validity platform. Google Cloud IoT Core is configured via MQTT protocol message sent by sensors and Google NoSQL database is for configured to store the message.

Vamseekrishna et al. (48)combine IoT and linear regression algorithm in machine learning. Collected the humidity and temperature data from diverse places using Message Queuing Telemetry Transport (MQTT) protocol and initialized the data that collec- ted from sensors in Amazon Web services (AWS) cloud. And through linear regression algorithm in machine learning, they foresight the humidity and temperature.

Malhotra et al. (42)used DHT11 sensor to collect temperature-humadity values and FC-37 to collect rain density. The sensors installed on the raspberry pi gathers the data and stocks it in the pi. The data is stocked as CSV file. And collected data is analysed by R.

3.2 Machine Learning Based Smart Farming Systems

In machine learning applications there are two main approaches which are Support vector machine and neural network. The linear SVM splits to two different classes by a discrimination function which is determined by support vectors, conversely, the characteristics of a neural network are defined by its node structure. In these approaches, k-mean is mostly preferred ML algorithm. It is an unrestrained clustering algorithm for structuring the data which based on the geometrical distribution (4).

Additionally, artificial neural network approaches may be feasible on our data which is basically ANN is originated by the human brain functionality. When human brain is considered, it composed of uncountable neurons which communicate bidirectionally and process whichever information ensured. ANN can be considered as a simple model of human brain. Such structures are layered i.e. nodes of this network compose a topology and nodes are constructed in multiple stratums (36).

In the literature, different ML and DL models are used in agriculture for product efficiency, soil and water management, illness and weed detection, genus recognition etc.

Disease detection is one of the significant challenge for plant growth and crop output. Such diseases can be caused by various kinds of fungi, bacteria, phytoplasma, viruses, viroids etc. As a consequence, plants may have trouble in absorbance and translocation of water and nutrients, photosynthesis. Besides, flower and fruit development, plant growth and development and cell splitting and expansion can also be affected(2; 56).

Jhuria et al. (27) focus on disease detection of plant. Authors proposes a observing the system to detect the disease on the leaf and fruits. The study uses neural network and image processing to achieve a disease detection and to increase the harvest efficiency. As Jhuria et al., Bhange et al. (6) present that the uneven climatic conditions causea decrease of agricultural yield. To avoid such effect, authors propose a web based toolto identify fruit disease by image processing and feature extraction and several data analysis methods. Chung et al. (10) introduce a SVM classifiers and a genetic algorithm to detect bakanae disease in rice seedlings. Similarly Ebrahimi et al. (14) propose using SVM classification methods and image processing for pest detection. Kim et al. (32) introduce cloud based prediction system for disease detection on strawberries. With the proposed approach, several information such as weather, distribution, pricing etc are collected and analyzed in agricultural decision makers services. Ferentinos et al. (17) introduce CNN models to identify plant diseases through simple leaf images of healthy or diseased plants.

In farming domain, plant stress and the detection of the health status are another critical challenges. Plant stress means that plant is not in the appropriate growth conditions. The environment must be optimized for the plant. Based on the analysis, plant stress can be occurred by different outside parameters such as drought or wind, over irrigation or root disturbance. Moshou et al. (46) introduce a machine learning based system to detect disease and water stress in winter wheat plants. An optical multisensor system that can detect and identify biotic and abiotic stresses is developed. For the disease detection, an algorithm is developed based on the combination of least squares support vectors machine (LSSVM) with sensor fusion. Behmann et al.(4) introduce a brief summary of machine learning applications in the literature to improve crop yields. These methods provide high dimensional data analysis with obscure statistical characteristics for sensitive product conservation by learning the structure of the model.

Pantazi et al. (51) propose self organizing map (SOM)-based models with a supervised learning approach to identify the health status of the winter wheat product. In that study, hyper-spectral imaging system is used to capture the environment and the plants.

Geipel et al. (22) propose using UAV to capture standard RGB imagery data-sets for corn grain yield prediction at three growing stages : early stage, mid stage and season stage. Images are processed to determine the crop height at different spatial resolutions. Authors also present different linear regression models and test these models for the estimation of corn grain efficiency.

Sa et al. (59) focus on the crop health and yield. To achieve autonomous crop management, authors propose a trustworthy and exact weed detection system to minimize damage to surrounding plants. In this study, CNN-based dense semantic classification is proposed with multi-spectral images captured by micro aerial vehicle.

Nahvi et al. (49) and Morellos et al. (45) are focus on the soil management to increase the farm productivity. Studies apply multivariate regression models for the model evaluation and the prediction model. Similarly, Coopersmith et al. (11) present novel machine learning models for real-time estimation of soil drying. The proposed models enable decision-support services as well.

Lottes et al. (39) introduce smart farming application by using unmanned aerial vehicles (UAV). Via UAV, farmers may get real time information about the type and distribution of the weeds in the area. Besides authors benefit from machine learning techniques to classify crops and weeds.

Plant identification is another important research topic of yield management. Grinblat et al. (25) introduce the CNN to identify plant from leaf vein patterns. In the experimental phase, proposed system is capable of classifying three diverse legume species : red bean, white bean and soybean. Plant identification cover weed detection as well. Weeds have a devastating impact in crop output and efficiency in general. Pantazi et al. (50) propose an active learning system for weed species recognition. For weed detection, special hyperspectral imaging system is used in that study. In their further studies, a detection and mapping of Silybum marianum is presented. The proposed system uses a hierarchical self-organising map and the data is acquired from a multispectral camera mounted on a fixed wing of UAV (52).

One of the sub research domain of plant identification is the geographic origin prediction of the food. For instance rice is one of the most consumed cereals in the world and the main food product in the diet of the Brazilian population. Maione et al. (41) introduce classification models that predict the geographical origin of a rice from its chemical components. In the classification model, support vector machines, random forests and neural networks are preferred.

Gopidas et al. (24) introduced us with the multispectral segmentation method for automated delineation of agricultural field boundaries in remotely sensed images. In this work proposed simultaneous segmentation and classification method based on the Deep Multi-scale U-Net (DMU-Net)structure with deformable convolutional layers.In addition using cellular automata based Gaussian filtering is used to enhance the multitemporal images, to remove "noise" and to enhance the major direction.The second approach is linear feature extraction based on some parameters such as higher STD, length, strength and contrast. In this way, information from diverse spectral bands can be used for depicting space borders with several characteristics.

We present a exhaustive review of machine learning approaches and applications in farming. Table tab :ml summarizes current machine learning applications in agricultural field. All of these studies respect individual approaches and proposed solutions are not efficiently connected with the decision making process. Meanwhile, machine learning applications in farming has existed with big data technologies and high-performance computing. Such applications need to use a great amount of information that have to be appropriately earned or created, processed and stored.

TABLE 3.2 – Usage of Machine Learning Techniques in Smart Farming

Study	**Methodology**	**Application**
Jhuria et al. (2013), Moshou et al. (2014), Bhange et al. (2015), Chung et al. (2016), Ebrahimi et al. (2017), Kim et al. (2018)	prediction model, neural Network, SVM classifier and image processing	disease detection
Geipel et al. (2014)	image processing and regression	managing corn grain yield
Coopersmith et al. (2014), Morellos et al. (2016), Nahvi et al. (2016)	multivariate regression models	soil management
Lottes et al. (2017)	machine learning techniques	distribution of weeds and classification of crops
Sa et al. (2017)	CNN-based dense semantic classification	crop health
Grinblat et al. (2016)	CNN	plant identification
Maione et al. (2016)	classification	geographic origin prediction
Pantazi et al. (2016, 2017)	hyperspectral imaging	weed detection
Moshou et al. (2014)	LSSVM	plant stress

4 PROPOSED APPROACH

In this study the first objective was contributing on sustainable agricultural strategies with image processing techniques and the second objective was collecting data by using sensors, widely and remotely determine and adjust the optimum growing conditions of the plant by processing the data.

In order to increase the productivity of lettuce plants, grown in vertical hydroponic system , a disease detection study was carried out from leaves by using image processing techniques with MATLAB. And at the same time used ESP8266 and DHT11 to seeand decide the best enviromental temperature and humidity.

4.1 System Architecture

We can analyze this study in two parts. At the first part disease detection from lettuce plant had been studied. It's observed that image processing techniques are already obtained in lots of agricultural innovations. And disease detection is one of the major features on these contributions.

Here followed the steps as Image Acquisition, Image Preprocessing, Image Segmentation, Feature extraction, and classification. This will be ensure minimize the costs or to find out disease before it happens or to find out the reason of disease.

Detection of the plant diseases is important to detect the symptoms of diseases in early phases when they seem on the growing leaf.

In summary, I applied to MATLAB in which I focused on the lettuce and used image processing technique for accurate detection and identification of plant diseases. And in Figure[4.1] we can see the draft of my project steps.

At the second part, my objective was to monitor the temperature and humidity data that we can see the summary in Figure [4.2]. So I used the DHT11 sensor to gather the data and used the ESP8266 (NodeMCU development board) to send the data to the Cloud as in Figure [4.3]. By the DHT11 sensor, the data was collected in real time and then collected data was sent to the Cloud. For the communication among ESP8266 and

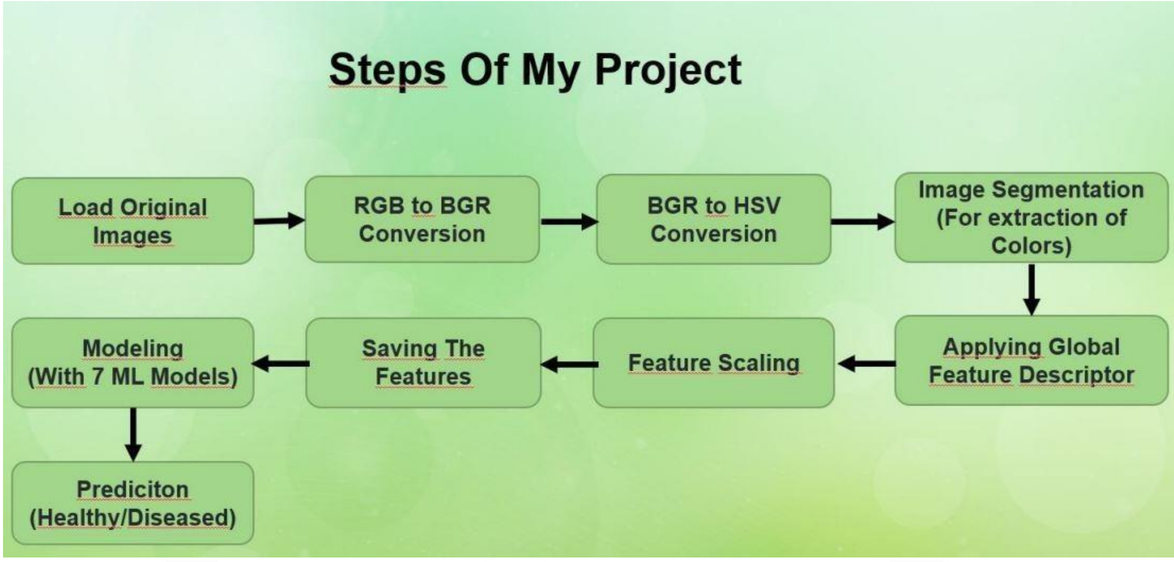


Figure 4.1 – Steps Of Plant Disease

Google Cloud enabled with the MQTT protocol. We need to store the data if it is on the Google Cloud IOT Core. By using Google Cloud Functions, the data can be written in the database. Finally we can see the change of the environmental temperature and humidity in our platform as real time.

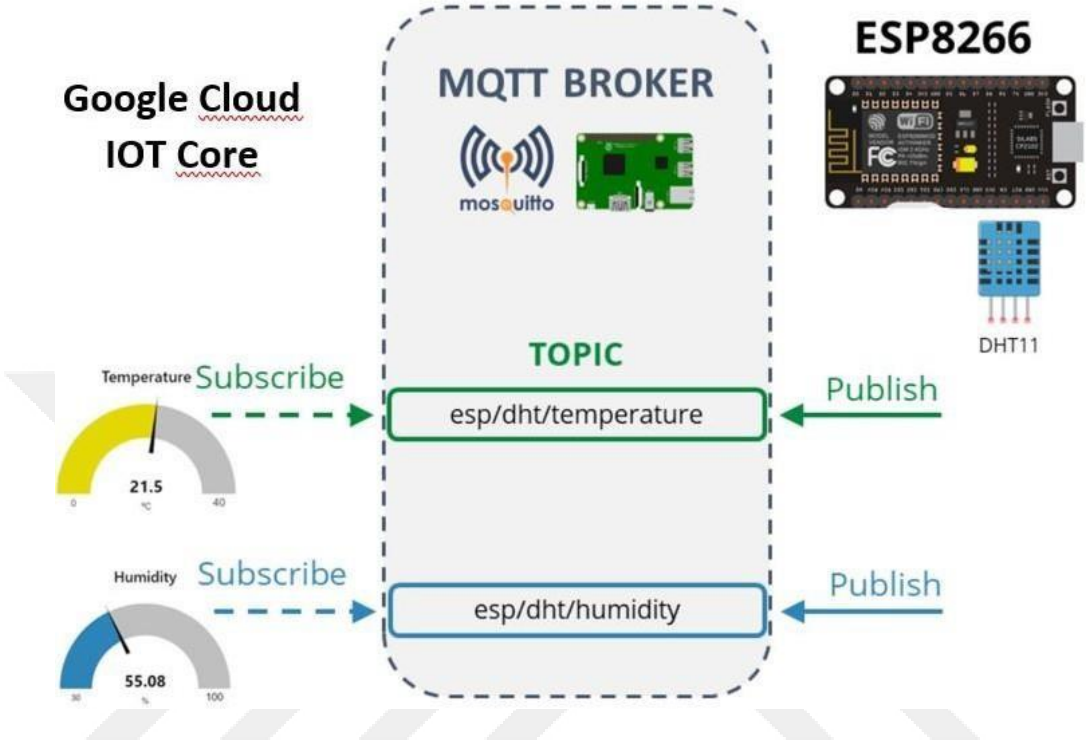


Figure 4.2 – Sending Data From Sensors

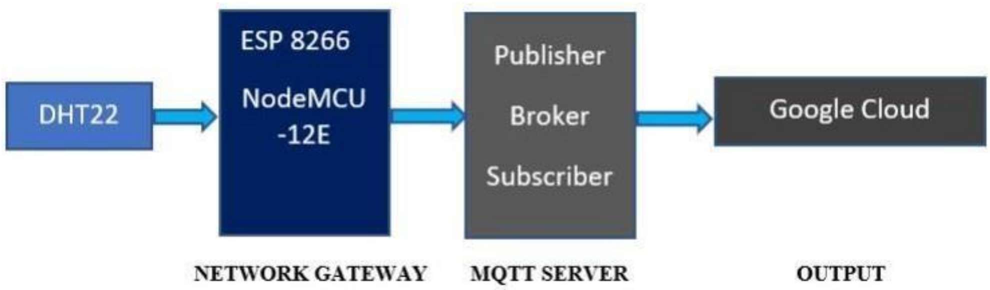


Figure 4.3 – System Design

4.2 System Components

For detecting disease from the lettuce plant, we need image data set of lettuce classified as healthy and unhealthy. It is easy to cultivate, observe and easy to find dataset about lettuce. I used ready-made lettuce dataset which was available on github at the below link.

https ://github.com/chandru11235/Lettuce-plant-leaf-Datasets

After finding the dataset, what we need the knowladge of image processing and machine learning techniques and MATLAB program.

So I applied to MATLAB based system in which I focused on the lettuce and used image processing technique for accurate detection and identification of plant diseases.

We can summerize that smart agriculture comprises of four major components which use IoT that as below ;

IoT devices ; Communication technology ; Internet ; Data storage and processing (73)

This 4 main pieces of machinery are crucial for any internet of things presentation. The definition of the IoT components as thus ; IoT devices – sensors, communication technology – communication, Internet, data storage and processing. (74)

For collecting temperature and humidity data, used DHT11 sensor and ESP8266 development board is used to send data to Cloud. Here, it was preferred to collect the temperature and humidity values in real time with the DHT11 sensor and send these data to Google Cloud IoT Platform. The communication among ESP8266 and Google Cloud was carried out via MQTT protocol.

For this Project the required IoT components and their usage purposes are as belowed.

DHT11 : DHT11 humidity and temperature sensor is an advanced sensor unit that gives calibrated digital signal output.

Arduino IDE : ESP8266, which is a card that can be connected to the Internet and is frequently preferred in IOT projects, can be coded just like Arduino UNO codes via Ardunio ide. In order to program the ESP8266, it is necessary to make the necessary card and library definitions to the Arduino IDE.

MQTT : The communication among the NodeMCU card and Google Cloud was carried out via MQTT protocol. The MQTT protocol is frequently used in IoT applications to provide wireless transmission of the data collected at the gateway to the cloud platform. Mosquitto was used as the MQTT server for the performance analysis of the gateway designed in the study.

Google Cloud Platform : The purpose of cloud computing technology is to store big data and access it at any time. All transactions and storage are done over the cloud.By storing all the programs, applications and data on the Internet in the cloud, it is possibleto easily access this information from any device and anywhere connected to the Internet.

Amongst the Cloud IoT solutions in the market, these three offers the most remarkable services for IoT Cloud Computing – AWS IoT, Google Cloud IoT and Azure IoT Hub. The comparison of them are as below table. (45)

Comparison Topics	AWS IoT	Google Cloud IoT	Azure IoT Hub
Market Share (2018)	52% (Leading in the industry)	19%	31%
IoT Cloud Services	IoT Core, Greengrass, IoT Device Manager, IoT – 1 Click, IoT Device Defender, FreeRTOS	Cloud IoT Core, Cloud Pub/Sub, Cloud IoT Edge	IoT Hub, IoT Edge, IoT Central, IoT Solution Accelerators
Analytics	IoT Analysis, Amazon Kinesis, Quicksight, Cloud Watch	Big Query, Compute Engine, App Engine, Stackdriver	Azure Monitor, Azure Storage, Stream Analysis, Power BI, Azure Event Hubs
Support ed Protocols	MQTT, HTTPS	MQTT, HTTPS	MQTT, HTTPS, AMQP
SDK	Java, Python, C, Android, iOS, Node.JS	Android, Go, Java, .NET, JavaScript, C, C++, PHP, Python, iOS	.NET, Java, C, Node.JS, Android, Native iOS
Authentication and Security	IAM Service, Cognito User Service, X.509 Client Authenticatio n, TLS for device – cloud encryption	X.509 certificates and private keys, IAM users and groups, RSA, Elliptic curve, TLS for device – cloud encryption	X.509 certificates, Token based (SAS) per device, TLS for device – cloud encryption
Pricing	Per number of messages – each message size 1Kb	Based on bandwidth usage	Number of messages/ per unit - each message size 4kb
Communication	Telemetry, Command based, JSON Web tokens	Telemetry, Command based, JSON Web tokens	Telemetry, State based commands usage, JSON Web tokens

Figure 4.4 – Cloud IoT Solutions

4.3 Methodology

In this study, in order to increase the productivity of lettuce plants, grown in vertical hydroponic system , a disease detection study was carried out from leaves by using image processing techniques. And at the same time used ESP8266 and DHT11 to see and decided the best environmental humidity and temperature.

My first objective was to observe the humidity and temperature of the environment to provide the optimum values for the plants.

IoT applications provide advantages in terms of both cost and time in studies such as the communication of machines, the processing of data from sensors and the observing of warehouses.

My second objective was to contribute on sustainable agricultural strategies with image processing techniques.

In summary, by monitoring the data received from the sensors in real time, optimum values for plant growth have been determined and a Machine Learning algorithm has been developed which shows whether the plant leaves are healthy or not. Thus, it is aimed to reduce the waste in the growing period of the plant to a minimum by combining the technological developments comprehensively in the field of agriculture.

5 EXPERIMENTS

In the first part, my project contributes with image processing techniques on sustainable agricultural strategies. It's observed that image processing techniques are already obtained in lots of agricultural projects. And disease detection is one of the major features on these contributions. So I applied to 'detection of plant leaf disease' and I selected lettuce for this. Because lettuce is one of the most useful plant in this area.

I respectively followed the steps as Image Acquisition, Image Preprocessing, Image Segmentation, Feature extraction, and classification. I investigate researches about this and found out many studies about this area. But they are not used widely yet. But in some years, using image processing technics in agriculture will be grow up and it will be necessary in agriculture to minimize the costs or to find out disease before it happens or to find out the reason of disease. Detection of plant diseases is important to detect the symptoms of diseases in early phases when they seem on the growing leaf. So I applied to MATLAB Where I focused on the lettuce and used image processing technique for exact detection and identification of plant diseases.

In the second part, the main aim was to determine the optimum humidity and temperature of the environment for the plant. So DHT11 sensor used to collect these data and used the NodeMCU ESP8266 development board to send the data to the Cloud to see the change of the environmental humidity and temperature in our platform as real time. In order to program the ESP8266, it was necessary to make the necessary card andlibrary definitions to the Arduino IDE. By the DHT11 sensor, the data was col- lected in real time and then collected data was sent to the Cloud. For the transmission between NodeMCU board and Google Cloud enabled with the MQTT protocol.

5.1 Experimental Setup

A) Experiment Setup- Step By Step- Disease Detecetion From Lettuce In Image Processing Using Matlab

In Figure [5.1] we can see the steps of the identification of the plant disease project.

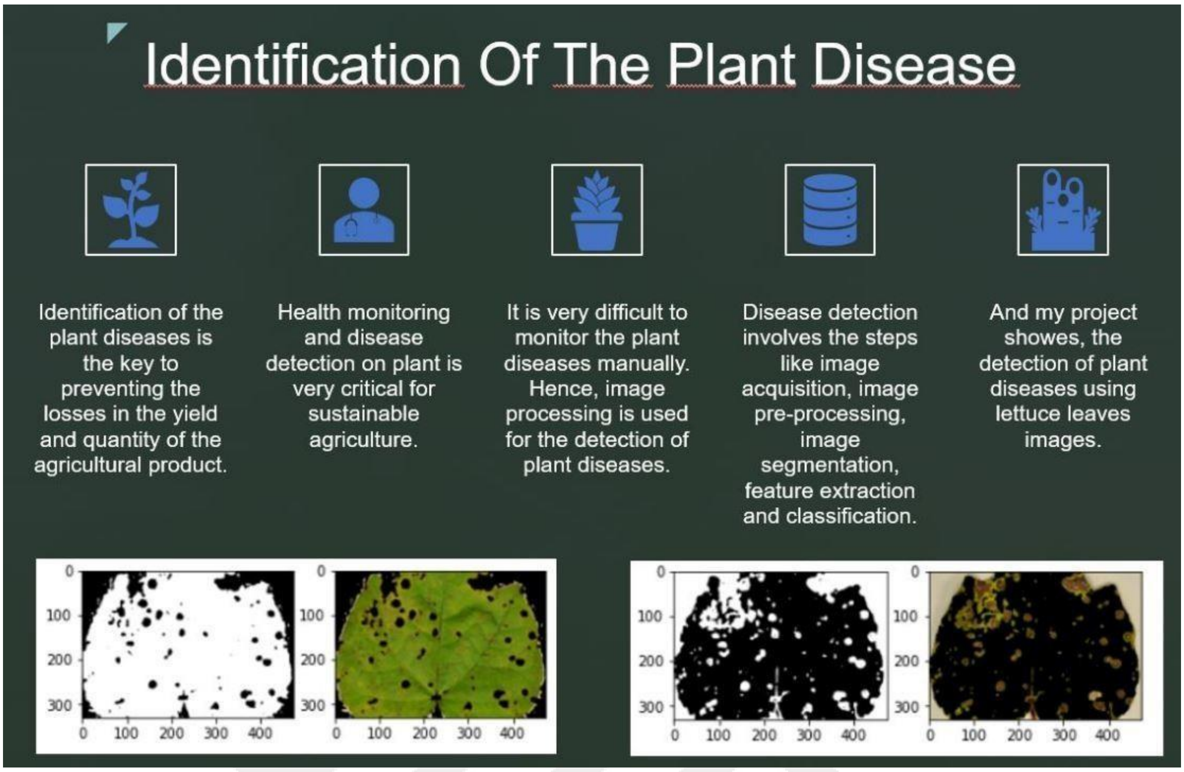


Figure 5.1 – Identification Of Plant Disease

1) We should load the original images. It will be loaded total 119 images for the class Diseased and 20 images for the Healthy and fed for the machine. And diseased category was classified as fungal, bacterial or viral illnesses as the below figure.

2) We should convert the image from RGB to BGR. Because open CV accepts images in RGB coloring format so firstly it is important to convert the original format, from RGB to BGR. We can see this steps respectively in Figure [5.4] and Figure [5.5].

3) We should convert the image from BGR to HSV format. HSV discretes the image intensity from the color information. Otherwise strange colors can be occur.

4) Image segmentation should be applied. This step is for extraction of colors and for the purpose of separate the picture of leaf from it's background. In this way, the color of the leaf can be withdrawed from the image as in the Figure [5.6].

5) In this step we should apply to global feature descriptor as in Figure [5.7]. Global features are removed from the image by using three feature descriptors. These there features are :

Color : Color Channel Statistics (Mean, Standard eviation) and Color Histogram

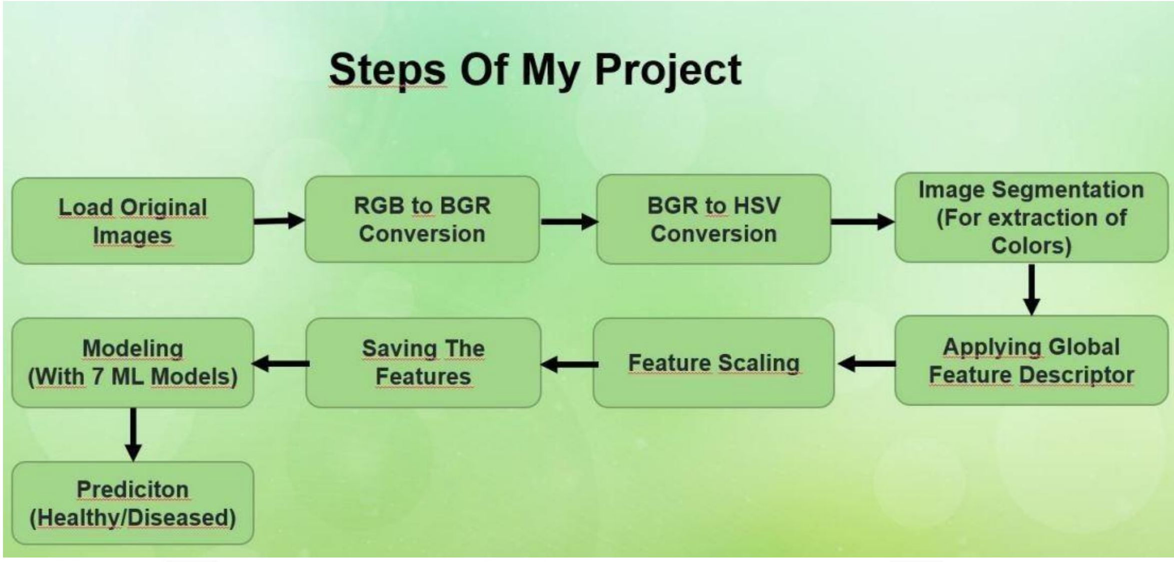


Figure 5.2 – Steps Of Plant Disease

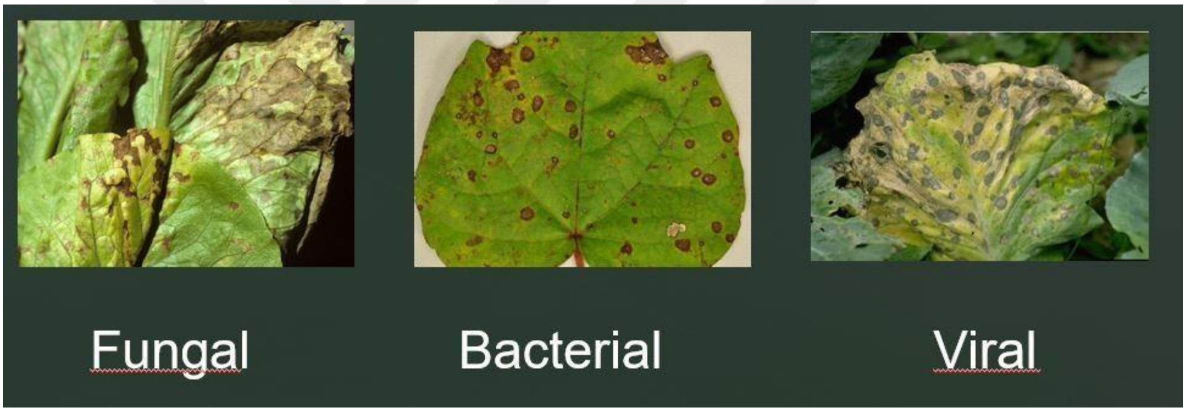


Figure 5.3 – Classification of Unhealthy Lettuce Leaves

Shape : Hu and Zernike Moments

Texture : Haralick and Local Binary Patterns (LBP)

After taking out the features of the images, the features gathering all together via the np.stack numpy function. According to the images which contained in the folder, the labels are encoded in numerical form for better understanding of the machine. The data divided into as training and testing dataset. The training dataset is composed of 80 visuals and the test set is composed of 20 visuals. It is important that the training dataset is diversified so that the machine can make accurate predictions according to this.

6) We should apply to the step of the feature scaling as in the Figure [5.8]. This is a technique in machine learning which is one of the most crucial step during the

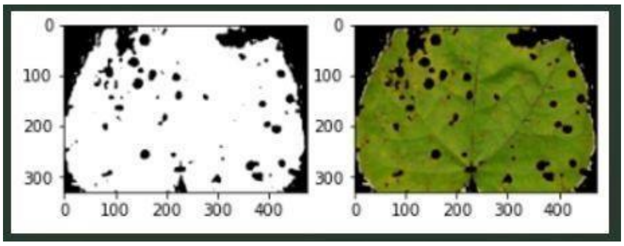


Figure 5.4 – RGB to BGR

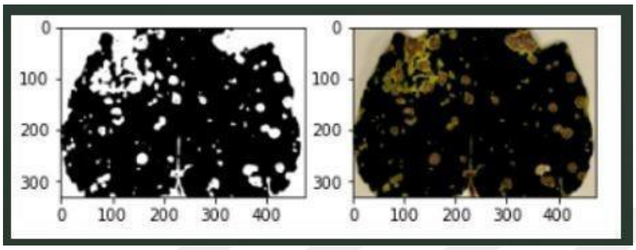


Figure 5.5 – BGR to HSV

preprocessing of data before creating a machine learning model. Scaling can make a difference between weak and better machine learning model. If we don't do feature scaling, the machine learning algorithm will prefer to weigh bigger values, higher and smaller values as the lower values. So here, I applied to Min-Max Scaler. With the scaling, value can be arranged between 0 and 1.

7) Our last step is to save the features. We can save them in HDF5 file that we extracted from the images of the leaves. The Hierarchical Data Format version 5 isan open source file format which promotes wide, complicated and mixed data. HDF5 uses a "file directory" which allows us to organize data within the file in many diverse constructed ways.

B) Step By Step- Sending Data From DHT11 to Google Cloud By MQTT Protocol

The following diagram shows a high-level overview of the project which I built.

1) The DHT11 sensor is connected to ESP8266 to acquire the humidity and temperature information as the below figure.ESP8266 offers a complete and self-contained Wi-Fi networking solution.

2) Used Arduino IDE to write code for ESP8266 and ESP8266 pushes data to Google Cloud via MQTT protocol by using PubSubClient library for Arduino. And to read the temperature and humidity from the DHT sensor, we should apply to the DHT library from Adafruit. With this library we also require to set up the Adafruit Unified Sensor

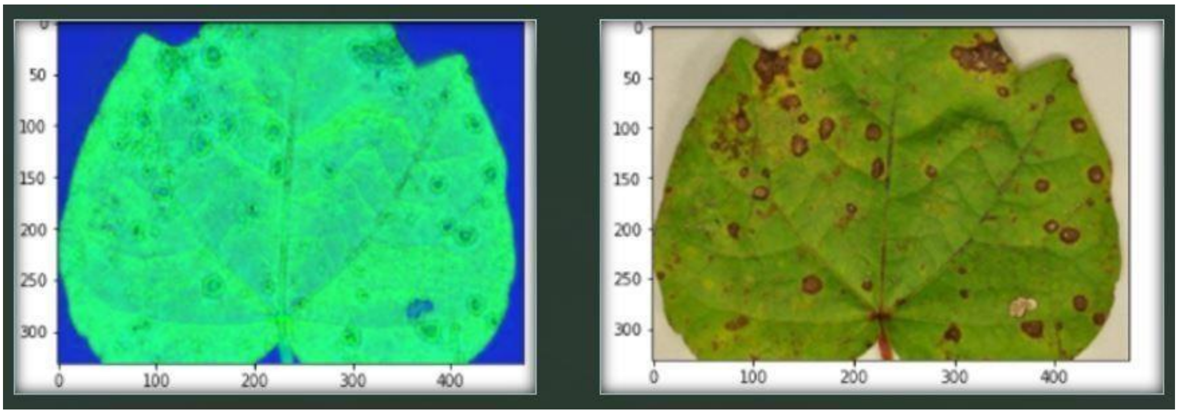


Figure 5.6 – Image Segmentation

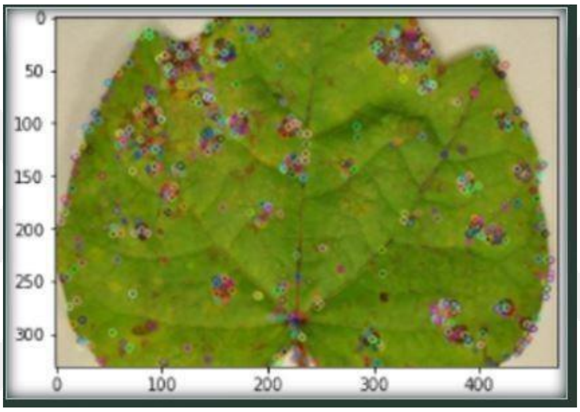


Figure 5.7 – Applying Global Feature Descriptor

library and also the other appropriate libraries.

3) ESP8266 can be programmed directly via Arduino IDE. After the connection, Google Cloud IoT and ESP8266 should be integrated. Our device send data from ESP8266 to Google IoT Platform through MQTT. And for this, Google Cloud Platform IoT console should configured.

4) To configure Google Cloud Platform IoT core for using with ESP8266 : We should create an account on the Google Platform and enable the IoT API using the console.

5) After we enabled the API, firstly we should create a project and after that we should do Google Cloud IoT Registry. To compose and configure our device is so important for connecting ESP8266 and Google Cloud to connect and transfer data.

6) Firstly we should create a registry. We can configure several general qualities when we use the registry. Many devices are included for the corresponding device record. We must ensure two information. if it is the recording ID which we use when growing the

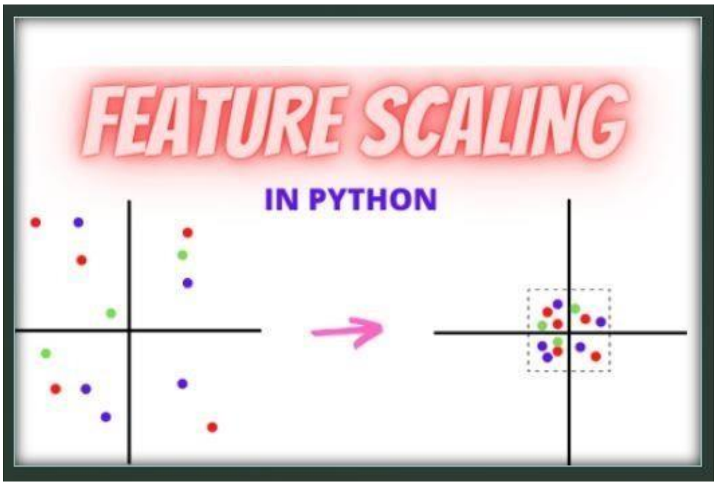


Figure 5.8 – Feature Scaling

ESP8266 that combines to Google IoT Cloud and the zone. On the other hand, we have to constitue a topic. This is the channel that we can disseminate the sensor data which is coming up to the sensors of ESP8266 and DHT11 :

7) To configure Cloud IoT Device : After we configure the registry, device can be created and configured. The device which we mean is our existing gadget and whole of the knowledge should ensure for connecting to the Google IoT. Google Cloud IoT Core needs several certificates for the connection to ESP8266. So we have to create a new certificate before.

8) Adding a new device : It is important to ensure an unique device-id and a certificate for authenticating the ESP8266.And we should record all of the coming data. After the relevant developments, the gadget comes prepared and the knowledge we ensured should look like as the Figure[5.12] :

9) To connect ESP8266 to Google Cloud IoT : After the completion of our all configuration, we should connect the ESP8266 to Google Cloud. Even though the contact uses the protocol which calls MQTT, it is quite hard to connect throughly ESP8266 to Google IoT without any library use.

Moreover, we should verify the identity of ESP8266. As the authentication mechanism. Google IoT platform uses the private key, which is signed with JWT. As a result, by using MQTT for connection and sending data we have two distinct alternatives. These are Google SDK and Google Cloud IoT Ardunio. And I used the second option. Here firstly it is compulsory to import the library before we continue to our way.

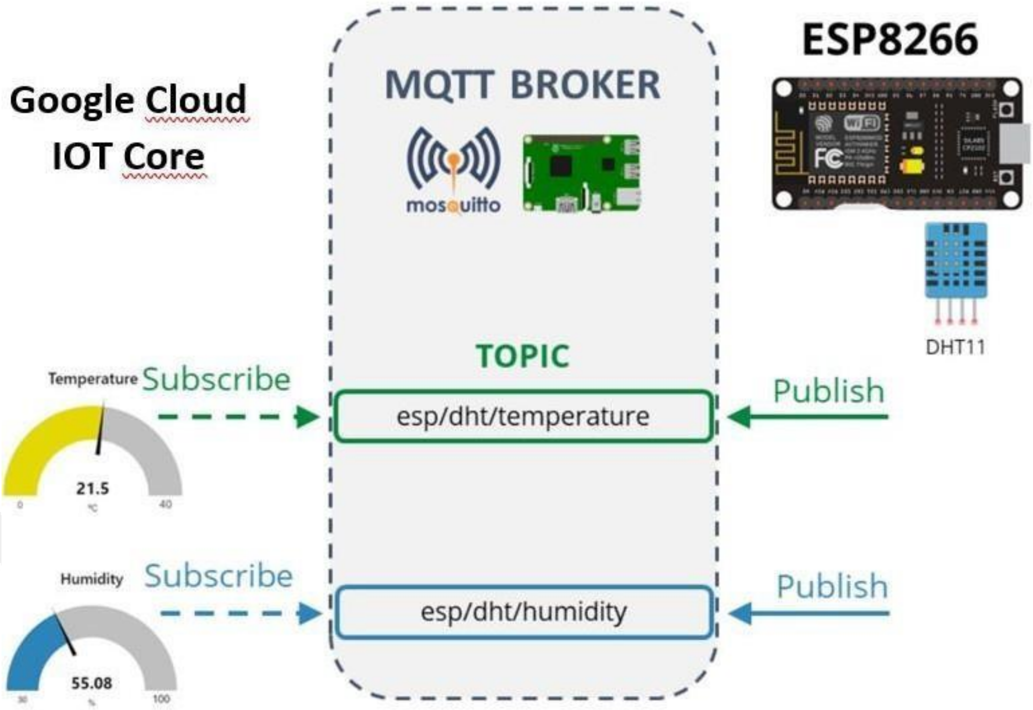


Figure 5.9 – The Diagram Of The System

10) Sending data to Google Cloud IoT from ESP8266 via MQTT : We acquire humidity and temperature using DHT11 in this step. My code is as below in Ardunio IDE to send the data to Google Cloud IoT from ESP8266 by MQTT usage.

In Figure [5.14], the DHT 11 connected to ESP8266 using PIN27 that reads the temperature and the humidity. Our code produces a JSON payload and via MQTT protocol, sends it to Cloud IoT Core.

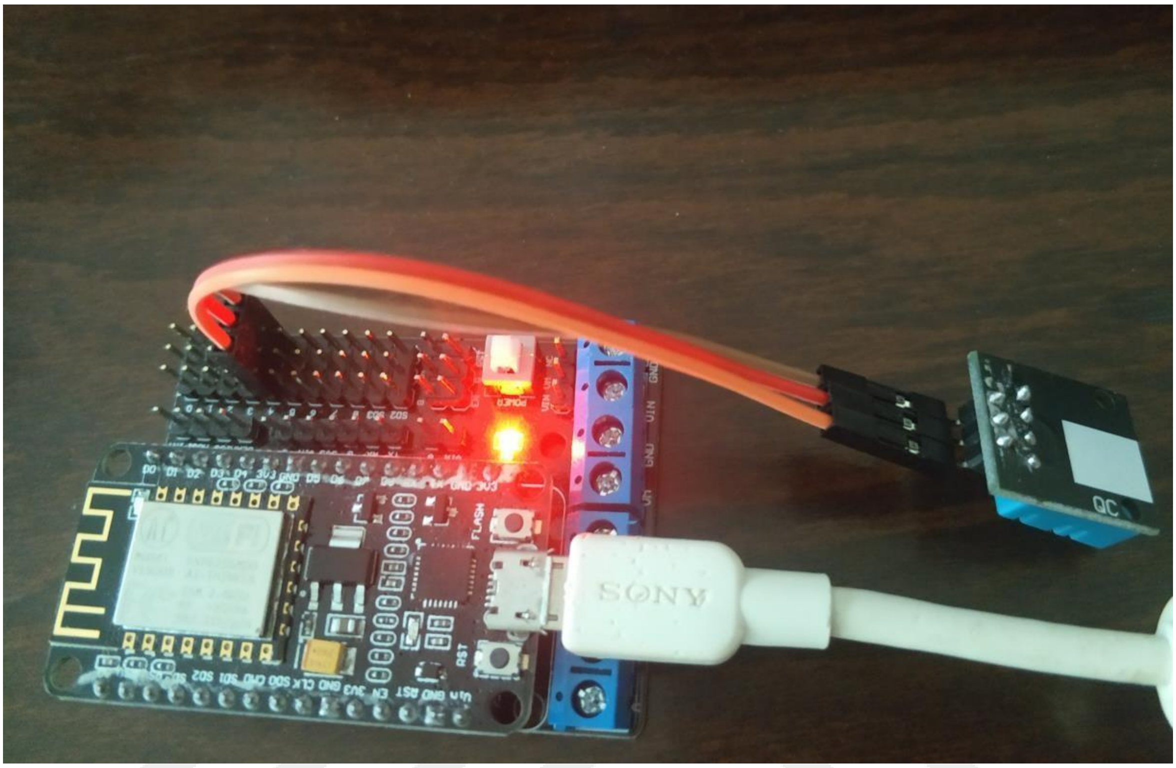


Figure 5.10 – The Connection Of ESP8266 and DHT11

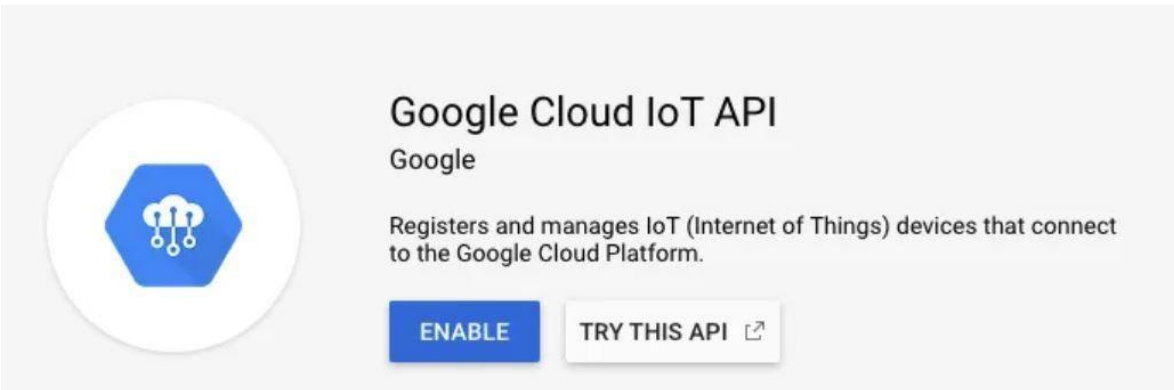


Figure 5.11 – Google Cloud IoT API

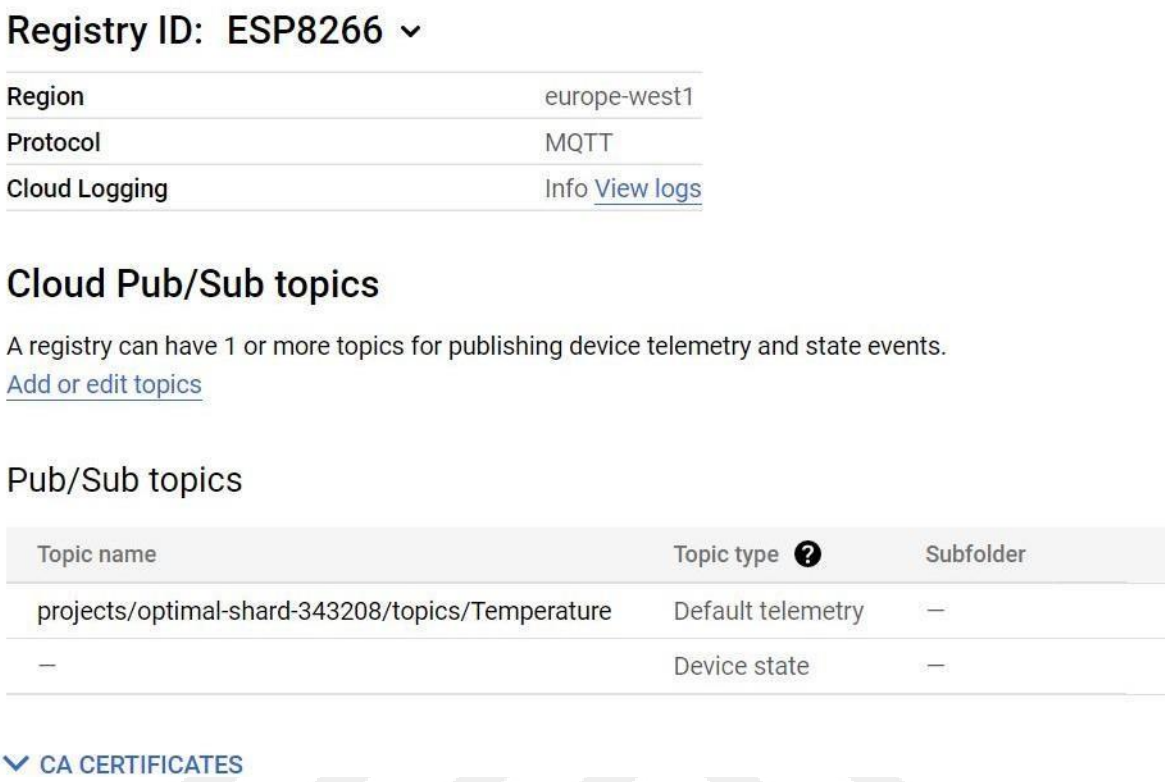


Figure 5.12 – Create a Registry

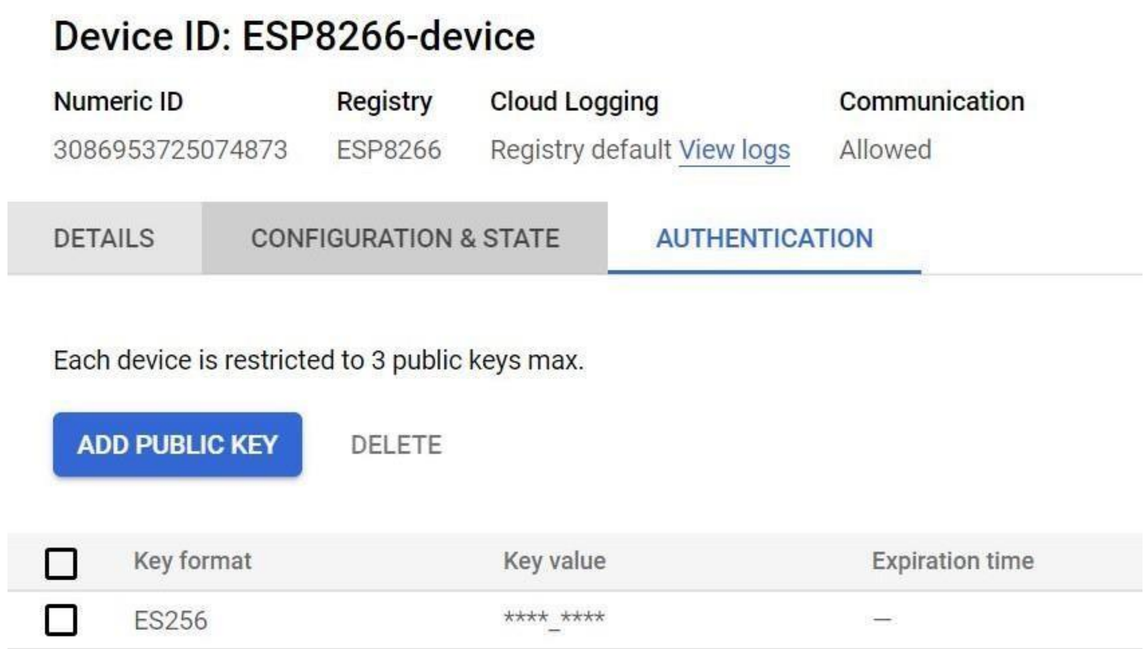


Figure 5.13 – Create a Registry

Part1

```
#include <Arduino.h>
#include <WiFiClientSecure.h>
#include "esP8266-mqtt.h"
#include <Adafruit-Sensor.h>
#include "DHT.h"
#include <ArduinoJson.h>
#define DHTTYPE DHT11
#define DHT-PIN 27
DHT dht(DHT-PIN,DHTTYPE);
char buffer[100];
void setup() {
Serial.begin(9600);
Serial.println("Setup.....");
```

Part2

```
dht.begin();
pinMode(LED_BUILTIN, OUTPUT);
setupCloudIoT();
}
unsigned long lastMillis = 0;
void loop() {
mqtt->loop();
delay(10);  // <- fixes some issues with WiF
stability
if (!mqttClient->connected()) {
connect();
}
if (millis() - lastMillis > 60000) {
Serial.println("Publishing value");
```

Part3

```
lastMillis = millis();
float temp = dht.readTemperature();
float hum = dht.readHumidity();
StaticJsonDocument<100> doc;
doc["temp"] = temp;
doc["humidity"] = hum;
serializeJson(doc, buffer);
publishTelemetry( buffer);
}
}
```

Figure 5.14 – The Code Of Reading Temperature and Humidity

5.2 Performed Experiments

For plant disease detection the model is educated over by 7 machine learning models which are as below :

1. Logistic Regression
2. Linear Discriminant Analysis
3. K Nearest Neighbours
4. Decision Trees
5. Random Forest
6. Naïve Bayes
7. Support Vector Machine

And I used 10 k fold cross as validation technique for validating the model and connected DHT 11 and ESP8266 to the NodeMCU microcontroller for tracking the temperature and humidity. DHT 11 and the cloud services are interfaced by using the Arduino IDE. The end user Android application connects with Google cloud and displays the apprehended data and the pertinent information from the analysis of the data.

The proposed system use the MQTT protocol for sending the temperature and humidity values from the DHT11 sensor which exists in different locations with more than one mobile devices. These devices subscribe to the same MQTT topic and through NodeMCU the message gets published to that shared topic.

So I used the MQTT bridge. This points that my microcontroller code needs an MQTT client, and a method to create a JWT from an endowed private key. To accelerate and simplify the integration among Cloud IoT Core and device, lots o libraries and SDKs have been used.

The basic method connects a device to Google Cloud IoT Core is to use the Cloud IoT Device SDK, which comprise of client libraries written in Embedded C that enable developers to confidentally tie provision, and administer devices with Cloud IoT Core.

In my project, I used the google cloud iot arduino and the arduino-mqtt libraries for integrating Cloud IoT Core to an Arduino project.

After downloading the Ardunio libraries, we call the setupCloudIoT to setup the Wi-Fi, the device time, and to start an MQTT client.

In the main loop, we need to ensure the MQTT connection, and call publishTelemetry every minute to send humidity + temperature data to Cloud IoT Core :

5.3 Experiment Results

Disease detection models with the optimum efficiency is trained with the complete of the data and score for the set of testing is estimated by Predict function. We can see all the results in Figure [5.14]. An accuracy of 0.91 is achieved using Logistic Regression.

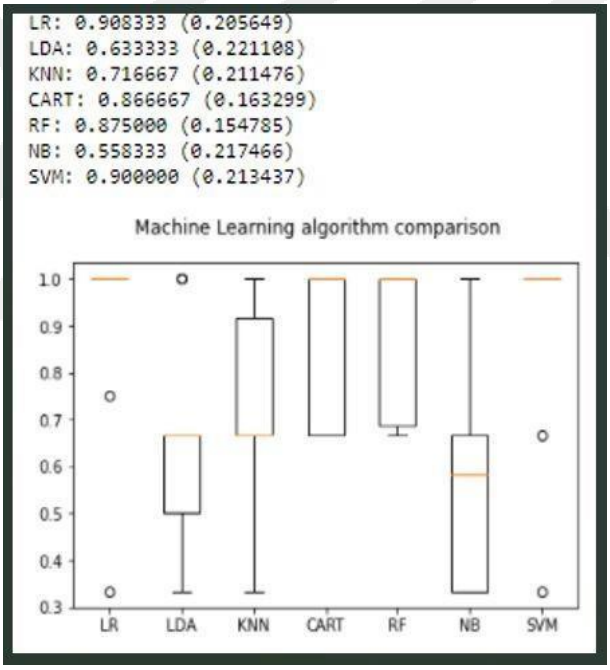
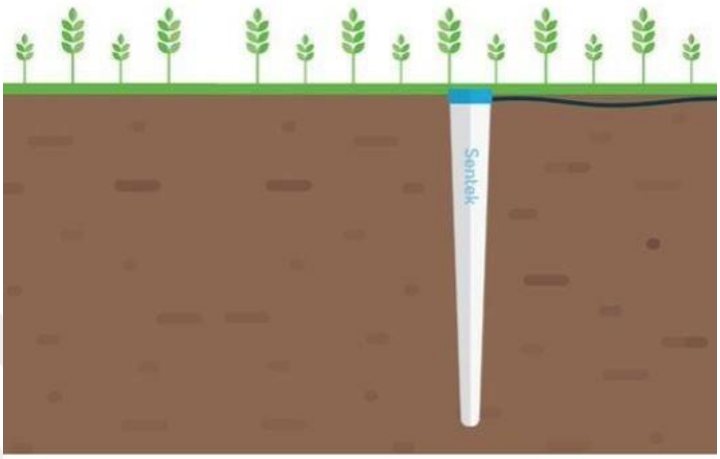


Figure 5.15 – Results Of Modeling

Moreover, if we speak about our IoT system, which was created in accordance with the prepared prototype, was made controllable with software by adding all the components. In order to control the humidity and temperature of the system, software control was provided with Arduino IDE.

An alarm system has been developed based on the values that the system receives from the sensors. It instantly reports when the environmental temperature and humidity exceed or fall below a certain value. Slow growth at low temperature is ideal for a good head formation in lettuce. It is known that the most suitable temperature for salad and lettuce cultivation is between 15.5 ^{o}C and 18.3 ^{o}C. Therefore, Arduino Ide gives an alarm when the temperature drops below 15.5 $^{\circ}$C and rises above 18.3 $^{\circ}$C. Thus, measures can be taken before it is too late, efficiency can be increased and extravagance can be prevented. And through the Google cloud, the humidity and temperature values of the system can be accessed from anywhere at any time.



Temperature – Humidity – Soil

Figure 5.16 – Observation By Sensors

To envision the data which is sent by the MQTT protocol, we should compose a subscriber which reads data from data topic channel. So we should form a subscriber as shown in the Figure [5.16].

It runs the code and control the dashboard on Cloud Core IoT : So

we can envision the MQTT messages sent by ESP8266.

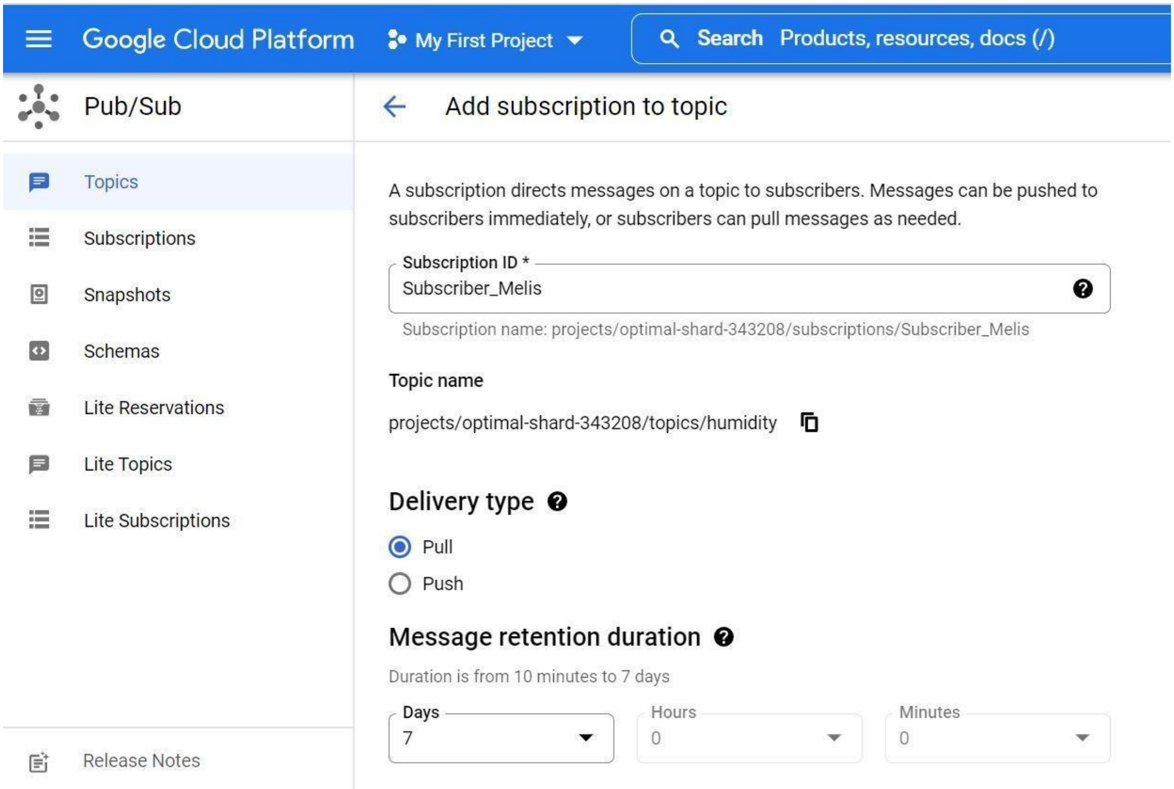


Figure 5.17 – Add Subscription To Topic

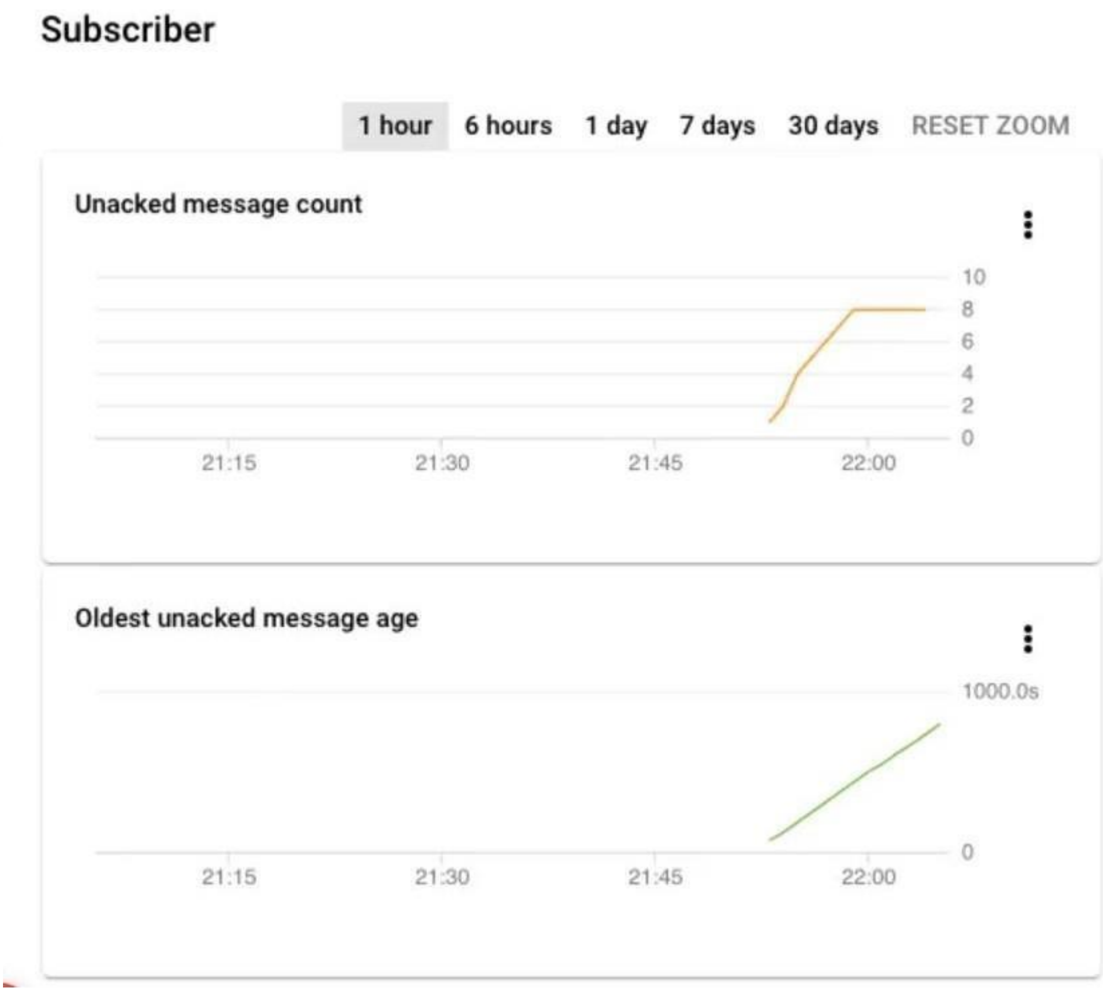


Figure 5.18 – Result

6 CONCLUSION AND DISCUSSION

In my research I saw that identification of the plant diseases is so crucial to prevent the losses in the harvest and quantity of the agricultural crop. So I used respectively Image Acquisition, Image Preprocessing, Image Segmentation, Feature extraction, and classification methods. By these, we could ensure minimize the costs or to find out disease before it happens or to find out the reason of disease.

Image processing techniques, especially irrigation, fertilization, pesticides, agricultural with the opportunity to increase the efficiency in inputs and its successful applica- tions in other fields. It has been seen that it contributes significantly to sustainable agriculture.

And secondly the most effective way to increase agricultural productivity is using real time IoT based environmental monitoring systems. So DHT11 temperature and humidity sensor used to collect the data and pursue the optimum values to lettuce growth.

So we can say that sensors are building blocks of smart farming. They ensure data which help farmers to follow and optimize products by adapting to changes in the environmental conditions. These sensors are installed on weather stations, drones and robots used in the agriculture industry.

This system can be widened as various areas, based on temperature and humidity monitoring through the assistance of the mobile application.

My study is a basic key step to understand the machine learning usage in agriculture and IoT applications development and implementation. The Environmental Sensor Monitoring system provides a good paradigm for any Automation System based on Internet of Things.

Agriculture is a necessary and strategic activity for the continuity of life, as well as having an important economic return. The target in agricultural production ; Increa- sing productivity and quality of the product in agriculture by using minimum inputs, food safety, protecting natural resources and the environment, and providing economic, sustainable and productive management.

As conclusion, due to climate change, high demand for higher crop yield, and need to use natural resources efficiently, smart farming has become a necessity nowadays. Including big data, machine learning technologies, the cloud and the internet of things– for tracking, monitoring, automating and analyzing operations. Moreover precision agriculture and smart farming is software managed and sensor monitored. By making ageicultural activities more connected and smart, we can dicrease all costs and develope the quality and quantity of the crops and the development of agriculture.

When we examine the past and see the emerging problems of the future from now, digitalization of agriculture seems inevitable. Although digitalization in agriculture has developed slowly until now, it is predicted that the developments in this field will increase logarithmically as of today.

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