IoT Based Plantation System for Smart Home Farming

MAJOR 2 PROJECT DISSERTATION

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Submitted by

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CANDIDATES' DECLARATION

I, Vimal Rai (2K22/SWE/22), student pursuing Master of Technology in Software Engineering, hereby declare that my project, "IoT Based Plantation System for Smart Home Farming" in partial fulfilment of the requirement for being awarded the degree of Master of Technology in Software Engineering submitted in the Department of Software Engineering, Delhi Technological University is an authentic record of my work carried out during the period from January to May, 2024 under the supervision of Mr. Sanjay Patidar. I have cited all my references with proper credit.

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This is to certify that the student has incorporated all the corrections suggested by the examiners in the thesis and the statement made by the candidate is correct to the best of our knowledge.

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CERTIFICATE

I certify that the Project Dissertation titled **IoT Based Plantation System For Smart Home Farming** which is submiited by **Vimal Rai (Roll No. 2K22/SWE/22)**, Department of Software Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the Project Work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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DECLARATION & LIST OF PUBLICATIONS

I hereby certify that the work which is presented in the Major Project-II entitled **IoT Based Plantation System For Smart Home Farming** in fulfillment of the requirement for the award of the Degree of Master of Technology in Software Engineering and submitted to the Department of Software Engineering, Delhi Technological University, Delhi is an authentic record of my own, carried out during a period from January to May 2024, under the supervision of **Mr. Sanjay Patidar**. The matter presented in this report has not been submitted by me for the award of any other degree of this or any other Institute/University. The work has been published/accepted/communicated in SCI/SCI expanded/SSCI/Scopus indexed journal OR peer reviewed Scopus indexed conference with the following details:

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Abstract

The Internet of Things has transformed home automation and gardening systems with much ease and efficiency. This research would like to propose developing an automated system for the management of lighting at home and in gardens. The proposed system utilizes a low-cost LDR sensor for assessing the intensity of light, hence a cost- and energy-effective alternative for controlling lighting. The sensor data is then received by the IoT platform, accessible from a distance for regulating lighting. The system can be used to control lighting for both indoor and outdoor gardening, homes, streetlights, and more. The technology that has been suggested is likely to significantly reduce energy usage and promote eco-friendly living. The proposed system utilizes a low-cost PDL sensor for assessing the intensity of light, hence a cost- and energy-effective alternative for controlling lighting. This is also can be used to control lighting for both indoor and outdoor gardening, homes, streetlights, and more. The technology that has been suggested is likely to significantly reduce energy usage and promote eco-friendly living.

INDEX

LIST OF FIGURES

LIST OF ABBREVIATION

IoT	Internet of things
LDR	Light Density Sensor
PDL	Photodiode Light Sensor
ML	Machine Learning
AI	Artificial Intelligence

Chapter 1

Introduction

1.1 Overview

In fact, the monitoring and managing of the light level under which plantations grow is a very important aspect of gardening. The measurement of the exact quantity required for every plant may not be easy to quantify, but it is an important factor nonetheless. Real-time monitoring in a garden may be further made possible with an IoT-enabled measuring device featuring LDR sensing.

This has made it possible for the technology to provide an integrative solution towards the management of home automation and gardening systems in a smarter and more straightforward manner. Lighting control is one of the visible parts associated with home and gardening automation. The reason for that is it plays an important role in setting the safe and comfortable environment. For that reason, a proposed LDR sensor-based light measuring system features a low-cost means to sense light intensity and control the illumination, thus reducing power consumption. [1] The proposed device can be implemented over an Internet of things platform to develop a system for the automatic control of lighting in households and gardens, which can be remote-controlled. This project report has discussed the development of systems based on the suggested methodology, benefits of the system from currently used methods, proposed potential applications, and current research.

In this developed system, an LDR sensor is used in sensing light. It is connected to an IoT platform that sends the level of light to a smartphone or computer. The system allows the user to monitor the intensity of light and alerts them in the case of any change through their mail or phone after passing a certain point. By giving the user this knowledge, they may make the appropriatecorrections, such as moving the plants to a spot that receives more sunshine or adjusting the artificial lighting to make sure the plants get the right quantity of light. **[2]**

In my second research paper, I implemented the same device using other sensors which gives better results after dry run on the and also work on different plants and their need of sunlight accordingly. Further explaining about the work which I have done in this.

The latest phase in home automation and smart gardening has been ushered in by the advent of Internet of Things (IoT) technology, which presents unmatched prospects to improve resource management, ease, and efficiency. Precise monitoring and control of environmental parameters, such light intensity, is a vital component of these developments. This is because proper lighting conditions in residential settings and plant growth optimization depend on it. The goal of this project is to create an innovative light estimation device that integrates an IoT-capable photodiode light sensor (PDL).

This would be since this dictates the ideal light conditions in residential areas and the ideal for plant growth, respectively. This project is to invent a novel light estimation device equipped with an Internet of Things (IoT)-capable photodiode light sensor (PDL).

Photodiode sensors are semiconductor devices that record light intensity in an excellently precise and highly responsive mode by converting the light to electrical current. Such PDL sensors can be used to modulate the different disbursing conditions of light for various plant needs, hence being an important gardening tool. Moreover, the data collected by the sensors (PDL) photodiode may be sent to a central system with the use of the Internet of Things (IoT), and thus it allows for real-time monitoring via a computer or smartphone with control. This interconnection could send alerts to end users in case of a deviation from an intended range, automate lighting schedules, and change light intensity control according to prevailing conditions.

This is applicable to home automation for convenience and saving energy. The system shall maintain the indoor lighting level at its optimum, hence saving energy, and also give comfort day and night throughout the week, managing artificial light by detecting light from the sun to control artificial lights automatically. Functions like these allow easy booking and remote control through linking of IoT to enable homeowners to make arrangements with their lighting no matter where they are.

The main objective of the proposed project is to design, develop, and test the light measurement apparatus that uses the accuracy of photodiode sensors, coupled with the interconnectedness that Internet of Things technology provides. This system's ability to improve plant growth, energy efficiency, and user convenience will be evaluated in both gardening and home settings. By this project, we hope to improve user quality of life and promote sustainable living habits in the expanding fields of smart home and gardening technology.

The integration of thing's technology into a wide array of application domains has witnessed not just revolutionary changes in their hitherto state-of-the-art conventional systems but also paved the way for reaping the many benefits, like high automation, efficiency, and convenience. Among these star applications is home automation and the Internet of Things for gardening, environments that require precision and adaptive control over factors such as lighting. This project will develop an advanced light-measuring device with a photodiode light sensor, particularly designed for home automation and optimized gardening. The project envisioned designing a high precision device for measuring light intensity for control set lighting conditions in view of different plants specific requirements in a manner that improves energy efficiency and plant growth.

These are the types of automations we can apply with these sensors:

1. Smart Home Automation: The light measurement equipment using IoT and LDR sensors may also find application in automation systems of smart homes for regulating the conditions of lighting. For instance, in a scenario when the sensed ambient light level has gone below a predefined threshold,

this device can automatically carry out a step, such as switching on lights in a room.

2. Smart Farm: Environmental variables such as light intensity can be monitored and controlled using an LDR sensor integrated into the Internet of Things-based light measuring device for a smart farm. The data from the sensors would be used to optimize the growth of the plants and reduce water use.
3. Greenhouse Monitoring System: This system can include a light measurement device adopting IoT and LDR sensors for the control and regulation of various environmental parameters, not excluding light intensity.
4. Horticulture: Light measuring devices can also be employed in horticulture with the help of an IoT and the LDR sensor to monitor, regulate light intensity for best growth of a plant. Moreover, in this field, devices may move plants or sources of light to allow the most favored lighting conditions.
5. Plant Nurseries: To monitor and regulate light intensity for the best plant growth, lightmeasuring systems employing IoT and LDR sensors can be utilised in plant nurseries. To createthe best lighting conditions, the device can be used to move plants or light sources.

These are just a few instances of the many uses that light measuring tools made using IoT and LDRsensors may be put to use to support sustainable agriculture and improve environmental conditionsfor plant growth.

The photodiode light sensor is a semiconductor device that converts energy from light into electrical charges and is very sensitive with high speed. Unlike the common LDRs, the photodiodes will give very accurate measurements of light intensity, which luckily plays a pivotal role where the applications call for very keen control measures. It is pretty obvious in gardening, where each plant has a specific amount of light need: some will find it correct under direct sun, and others need shade or indirect sun. A photodiode sensor could be made to help this system capable of the accurate detection of light intensity and making the available condition of light as per requirements. This removes chances for plants to not receive optimum growth conditions, thereby reducing plant stress, while increasing yield and plant health significantly.

1.2 Home automations:

1. Smart Home Automation: The light measuring equipment developed using IoT with LDR sensors can be part of the smart home automation system for regulating lighting conditions. For instance, when the intensity of ambient light is reduced below a fixed threshold level, such a device may automatically turn on the lights in that room.
2. Smart Farm: Devices measuring light can be applied within a smart farm system, which continuously monitors and controls environmental variables using IoT and LDR sensors for light intensity. The data obtained from the sensors can be used to optimize plant growth and minimize water use.
3. Greenhouse Monitoring: A greenhouse monitoring system using IoT-

enabled devices and LDR sensors can measure the intensity of light, hence maintaining and controlling the environmental conditions of a greenhouse.

4. Horticulture: The horticulture applications include measuring light with the IoT and LDR sensors to control the intensity of light to the best of plant growth. This device will be used to move plants or light sources in order to create the best lighting conditions.
5. Plant Nurseries: Light measurement in plant nurseries, using the IoT and LDR sensors, can be used in controlling and monitoring the intensity of light for optimum growth of plants. The device could be used in moving the plants or light sources to create the best lighting conditions.These are just a few instances of the many uses that light measuring tools made using IoT and LDR sensors may be put to use to support sustainable agriculture and improve environmental conditions for plant growth.

1.3 Motivation:

These are just a few instances of the many uses that light measuring tools made using IoT and LDR sensors may be put to use to support sustainable agriculture and improve environmental conditions for plant growth.

In the home automation field, this photodiode-based lighting-measuring device will be interfaced with the IoT so as to control a lighting system seamlessly. The sensed data flows continually into an IoT platform to be analyzed and used in light automation according to the light prevailing in the environment. For instance, lights could switch off or reduce their brightness when there was enough preciously sun. Therefore less energy is conserved and lower electrical bills. This automated lighting system can be controlled and adjusted remotely via a smartphone or just about any other internet-enabled device, thus giving unprecedented levels of convenience and control over the home environment.

The applications for this technology are indoors and outdoors. Light conditions are of paramount importance in indoor gardening, such as with hydroponic systems inside the greenhouse. The photodiode sensor, by means of the IoT-enabled controls, is able to assist in ensuring that artificial light complements natural light in a most efficient manner, via the simulation of the photoperiod and the provision of all components of the light spectrum necessary for the plants to acquire during photosynthesis.

For outdoor gardens, the system can adjust garden lighting to provide better visibility and safety at night while ensuring that plants receive optimal light during the day.

The application of the IoT technology used with the light sensor photodiode offers a smart solution for managing lights in homes and gardens, supporting sustainability by lowering the burden of energy use to save it for future care. Moreover, this system can be scaled up and configured for wider usage in agriculture in controlling light, which would otherwise result in better productivity in large-scale commercial farming. In summary, with the development of a light measurement device implemented in a photodiode sensor and powered through IoT, a great step in home automation and gardening has been taken. Therefore, innovative solutions, bringing substantial improvement with respect to the possibilities of a precise controlling of light conditions according to plant needs, have been developed. As an interdisciplinary PhD student, I am convinced that this is the route by which technologies will be deployed in a smart, efficient, and sustainable way through this work on living systems and, therefore, horticulture in general. The future of automated light management greatly holds potential to enhance our interaction with living environments and act as stewards toward natural resources.

1.4 Limitations:

1. Wi-Fi Dependency: The device has to have good Wi-Fi in order to support sending out notifications. In most places where there is poor connectivity, the system will not be in a position to send out notifications on time.
2. Equipment Configuration: installing and making initial adjustments to the machine involves application of level of technological know how. A technologically incompetent user will therefore have problems in installation.
3. Power source: To work at their best, the devices need a constant source of power. Power shut down would inflect the monitoring and alerting systems.
4. Environmental Factors: Effects of environment such as dirt, humidity, and temperature changes may possibly affect the accuracy of the photodiode sensor.
5. Limited Range: Efficiency of the device is limited to Wi-Fi network range and sensor coverage region.Environmental Factors: Environmental variables including dust, humidity, and temperature variations can all have an impact on the photodiode sensor's accuracy.

Chapter 2

Related Work

In this chapter, we are going to talk about all the related works.
Several researchers put forward that with IoT, smart sensors and devices propose solutions for monitoring and regulating light intensity in gardening. For example, in the research done by:
M. T. Arshad and N. A. Azli have recorded the system of monitoring and control on environmental factors that affect plant growth by light intensity through an LDR sensor and forwarded it for processing to a central server via an IoT platform. According to the authors, the system has not only brought about control over artificial lighting but also effectively monitored light intensity in ways that ensure plants get the right quantity of light.
The other example has been done by F. Siddiqui et al., where they proposed an IoT-enabled monitoring and controlling system of the conditions for hydroponic gardens. Large numbers of sensors were installed, including the LDR sensor, to monitor the different variables for environmental conditions like temperature, humidity, and light intensity. The authors transmitted the data into an Internet of Things platform to get the data from the sensors as well as manage the garden effectively. Quality environmental conditions for plant growth are maintained, and less water is used; these claims were made by the authors.

In the same spirit, another system with IoT by A. Al-Saffar et al. [4] was proposed in the monitoring and control of environmental factors within a greenhouse. It had a range of sensors that were going to help measure a lot of varying environmental characteristics, such as light intensity, the temperature, and the level of humidity, among others. Sensor data were polled at an Internet of Things platform for remote greenhouse management. According to the authors, the device successfully conserved the ideal climatic condition for plant growth by consuming less energy. Research actually points out that with an increase in the number of IoT devices and sensors, general and specific, they will definitely have potential use in monitoring and managing changes in environmental conditions taking place in gardening. The proposed light-measuring gadget for monitoring light intensity in gardening incorporates LDR sensors plus IoT technology to come up with practical, cost-effective systems used in boosting the growth of healthy plants.

In the work of H. Singh and S. S. Bhadauria, "Design and Development of IoT-Based Smart Agriculture Monitoring System Using Raspberry Pi," it is outlined that an IoT-based system was designed for the purpose of monitoring and managing the environmental elements in agriculture applicable to light intensity [6]. The light intensity was measured with the use of the LDR sensor, part of the designated system, and then it was forwarded to the cloud IoT platform.

It is reported by the authors that this system was successful in preserving the optimal set of environmental conditions for plant growth, but with a reduced level of water usage.

Authors J. Ye et al. [proposed an article titled "An Internet of Things (IoT) Based Greenhouse Monitoring and Control System"] an IoT-based greenhouse monitoring and controlling system. It implemented many types of sensors, among which the LDR sensor was used for measuring environmental conditions, such as light intensity, temperature, and humidity. The data sensed by the sensors was uploaded into some Internet of Things platform from which one can monitor and manage, remotely, the smart greenhouse. According to the authors, the described device shows its efficiency in terms of maintaining desirable climatic conditions for growth with the help of low energy.

In their paper entitled "Smart Agriculture Monitoring and Control System Based on IoT", authors Y. Wu et al. [13] proposed an IoT-based system for monitoring and management of environmental variables in agriculture, such as light intensity. The sensors contributed to the system by measuring many gradations of various characteristics, including an LDR sensor that reportedly made the unit efficient in preserving the ideal conditions climatically for the growth of the plants, thus consuming less energy. The authors of this article, M. Alqudah et al., came up with a proposed IoT-based device for monitoring and analyzing environmental conditions in a garden, including light intensity, under "Smart Garden Using IoT and Image Processing for Plant Growth Analysis". For this purpose, an LDR sensor was employed. This system reported well in monitoring plant growth and continually maintaining it under the optimum environmental conditions for plant growth, according to the authors.

The authors N. S. Chavan and N.
In another related work by R. Kulkarni [10] entitled "Smart Irrigation System for Efficient Water Management in Agriculture," an IoT-based system was presented for monitoring and adjusting light intensity, among other environmental variables in agriculture. A light sensor, LDR, was used to measure the light intensity, and the data were sent to the IoT platform for processing and analysis.

The researchers have shown that the device decreased water use, and at the same time, maintained optimal environmental conditions for the plant. These studies bring on to the forefront: changing the control status of environmental growing conditions for agriculture and gardening; emboldening the IoT instruments and sensors, particularly the LDR sensors, to monitor 'on' and 'off'; and the proposed measuring gadget that may well be the further step toward enabling growth in healthily and sustainable agriculture through monitoring light intensity in gardening using an LDR sensor and Internet of Things technology.

Related work of my second research paper is mentioned below:

In the recent studies on this integration technology of the IoT with light sensors, the targets have majorly been home automation and gardening. Most researchers have provided proof of how beneficial these systems are for saving energy and making plant growth processes a lot easier.

There has been much research on the use of photodiode sensors and Light Dependent Resistors (LDRs) toward the monitoring and regulation of light intensity in different scenarios.
For instance, Rashid et al. designed an automated home-based smart lighting system with LDR sensors and Internet of Things technology. Indoor lighting in the proposed system dynamically changes based on the ambient light levels to ensure good energy savings apart from reducing the dependence on artificial cooling during theday. Gupta et al. proposed an IoT-based automated plant watering system, and the system was used in smart gardening.
The temperature, soil moisture, and the intensity of light were measured with the use of sensors such as photodiodes during installation. It works to increase the growth of the plants while maximizing water consumption and ensuring the plants get the right amount of light for photosynthesis.
In this sense, photodiode sensors have been applied practically in a precision agriculture system by Kim et al. with inputs from sensors being used to modulate the artificial lighting and shading systems to obtain optimal light conditions for various plant species.. Moreover, Singh et al. experimented in 2021, which then developed an intelligent greenhouse system with the help of a variety of photodiode sensors interfaced with an IoT platform to monitor and control various humidity, temperature, and light processes in real time for the development of a perfect microenvironment for different crops. The point was also brought out by this work that systems of this kind save huge amounts of energy and, thus, operating costs—while enhancing output and quality of produce.

Other studies have dealt with the technological challenges and development of sensor technologies together with IoT integration in real applications. For example, Zhang and Li (2019) [19] considered the accuracy and reliability of some light sensors within Internet of Things applications; interestingly, their study indicated useful information on network communication protocols, data fusion, and sensor calibration. All in all, so much literature has pointed out high effectiveness in adding photodiode light sensors onto IoT technology for home automation and smart gardening applications. A mere mixture of both technologies will oversee customer control and convenience along with more sustainable living and reduction in the use of energy. The work in question has been built on such a foundation to enhance the increased functionality of light-measuring sensors under an Internet of things context.

Chapter 3

Methodology

Photodiode light sensors are integrated into some IoT technologies to ensure effective measurement and control of home automation and gardening. The approach followed in the research is systematic, involving sensor selection, calibration, data acquisition, and transmission to an Internet of Things platform together with an automated control algorithm that has been designed to optimize lighting conditions and respond to real-time data and plant requirements:

1. Smart Home Automation: The light measuring equipment developed using IoT with LDR sensors can be part of the smart home automation system for regulating lighting conditions. For instance, when the intensity of ambient light is reduced below a fixed threshold level, such a device may automatically turn on the lights in that room.
2. Smart Farm: Light measurement devices can be used in smart farm systems for monitoring and controlling environmental variables using IoT and LDR sensors for light intensity. The data obtained from the sensors can be used to optimize plant growth and minimize water use.
3. Greenhouse Monitoring: The monitoring system in a greenhouse can use IoT-based devices and LDR sensors to measure the intensity of light, thus maintaining and controlling the environmental conditions of a greenhouse.
4. Horticulture: In horticulture applications, the devices measuring light using IoT and LDR sensors help in controlling light intensity to the best of plant growth. The device will be used to move plants or light sources so as to create the best lighting conditions.
5. Plant Nurseries: To monitor and regulate light intensity for the best plant growth, lightmeasuring systems employing IoT and LDR sensors can be utilised in plant nurseries. To createthe best lighting conditions, the device can be used to move plants or light sources.

These are just a few instances of the many uses that light measuring tools made using IoT and LDRsensors may be put to use to support sustainable agriculture and improve environmental conditionsfor plant growth.

Table of plants and their corresponding sunlight requirements:

It is crucial to know the appropriate amount of sunshine that various plants require to survive and to maximize development.

The following table enumerates several plants together with the least amount of sunshine they require and the ideal range of sunlight in units of lumens.

Basically the below table give the over view of the plants and their optimal and minimum sunlight requirements (MSR):

Plant Name	Minimum Sunlight Requirement (lux)	Optimal Sunlight Range (lux)
Tomato	2000	5000-7000
Basil	1500	4000-6000
Lettuce	1000	2000-3000
Strawberry	2500	6000-8000
Spinach	1200	3000-5000
Orchid	500	1000-2000
Cucumber	2000	4000-6000
Pepper	2500	6000-8000
Rose	2000	4000-6000
Sunflower	3000	7000-10000
Aloe Vera	1000	2000-3000
Mint	1000	2500-3500
Geranium	2000	4000-6000
Peas	1500	3000-5000
Lavender	2000	4000-6000
Carrot	1500	4000-6000
Thyme	1500	3000-5000
Rosemary	2000	4000-6000

Fig. 1: Plant and their sunlight requirement [3].

3.3 Architecture

A photodiode light sensor, an Arduino or Raspberry Pi microcontroller, and a Wi-Fi module for internet access make up the suggested Internet of Things gadget. The microcontroller receives data from the photodiode sensor, which measures light intensity. After processing this data, the microcontroller sets off an alarm system in the event that the light intensity for a particular plant drops below a certain threshold. The user receives notifications via email or SMS from the notification system via a Wi-Fi module.

The flow of proposed methodology is as follows:

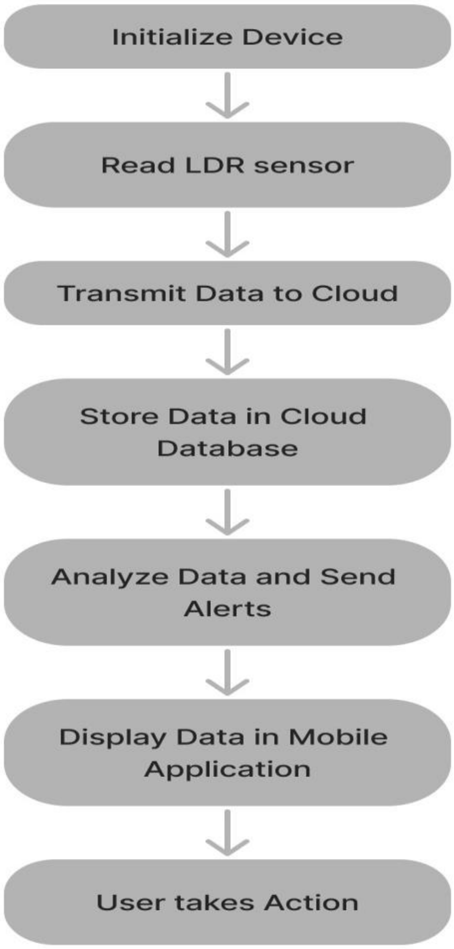

Fig 2: Methodology Flow [1]

In figure 2, the steps shown about how the proposed work flow takes action:

The proliferation of internet-of-things technology ushers in a new age of connected devices, and the transformation is in how the gadgets help interact with our environment. Today, all objects that surround an individual embed sensors, software, and connectivity ability that allows these gadgets to gather and share data, actually enabling them to act spontaneously on the given data. Applications of these devices range in wide categories, enabling each one of them to leverage the power of real-time data to impact improvement in processes and enhance the user experience.

On the other hand, IoT devices in smart homes have entirely changed the domestic life. Besides bringing comfort, security, and energy control to a user inside a home, these gadgets provide a level of control that is unparalleled with respect to their users through learning user preferences that evolve with time, setup features, and remote management using smartphones. For example, smart thermostats control heating and cooling according to occupancy patterns and weather forecasts, while smart lighting controls brightness in a manner that saves energy while optimizing.

Indeed it will make IIoT the most profound technological development in industry, driving automation, predictive maintenance, and optimization of supply chain. For instance, sensors on manufacturing equipment can track performance to predict an imminent failure, therefore reducing downtime and costs related to maintenance. Additionally, IoT-enabled supply chains provide enterprises real-time visibility of inventory levels, transit conditions, and demand forecasts, hence effectively running operations with minimum waste.

The impact is the same in healthcare; it is an enabler and disruptor through wearable health monitors, smart medical devices, and connected healthcare systems. It tracks vital signs, physical activity, and sleep patterns of users to provide critical data about fitness regimens and general health to both users and healthcare providers for improved treatment plans and general wellness. Smart medical devices, such as connected inhalers or insulin pumps, ensure accurate dosages and the timely administration of medication for improved care and better patient compliance.

Agriculture has jumped at embracing IoT through precision-farming techniques that use a large number of equipment devices, in the form of soil sensors, weather stations, and drones. Therefore, with data being availed on features like moisture and nutrient level and health of the crops, the farmer is well-placed to make decisions about irrigation, fertilizing, and pest control in a more informed way. Such a targeted approach would not only have superior produce and quality but also have sustainability promoted by saving valuable water, reducing chemicals, and pesticides.

In an urban setting, IT is the key that enhances developing a smart city, stoked with optimum infrastructures and services. The use of connected sensors for traffic lights, parking meters, and waste management systems in smart cities helps control urban resources economically. For example, a smart traffic management system incorporates, among other measures, adaptive signal timing based on real-time traffic flow to reduce congestion, while smart waste management solutions optimize collection routes and scheduling to achieve the best operational cost and minimum environmental impact.

At large, multiple IoT devices, which have been integrated with the different sectors, underline a huge potential of change for the entire scenario of IoT technology. Such devices are harnessed with real-time data and connectivity in their breed to provide smarter decisions, efficient operations, and better living standards. As the Internet of Things becomes an ever-growing concept, its application will also increase, leading to more innovations and finally creating a more connected world of intelligence.

Chapter 4

Implementation

These are the implementation details about the project work with both the sensors:
Sensor Selection and Calibration:
The first step towards the implementation is to select a proper photodiode light sensor showing high sensitivity, accuracy, and fast response time. The chosen photodiode sensor can detect an extensive range of light intensity, which also makes it versatile for all indoor and outdoor usage. The sensor was calibrated according to measure light intensity adequately. In other words, calibration is that process by which the sensor must be exposed to known light sources and its output adjusted toward expected values, consequently it ensures great precision in making measurements under diverse lighting conditions.

Data Capture and Transmission:
When the photodiode sensor is calibrated, it is interfaced with an electronic circuit where a microcontroller (e.g. Arduino or Raspberry Pi) is applied. The applied microcontroller reads analog signals obtained from the photodiode sensor which correspond to the level of light intensity. The gained analog signals are through analog-to-digital conversion inbuilt in the microcontroller. Processing of the digital data is done to determine the current light intensity.

IoT Integration:
The microcontroller communicates with its IoT platform for remote control and monitoring through wireless communication modules, such as Wi-Fi or Bluetooth. This module is expected to report the readings to a cloud-based IoT platform where the data can be stored, analyzed, and visualized in real time. Examples of platforms for this part are AWS IoT, Google Cloud IoT, or ThingsBoard. Moreover, light conditions and the control of lighting systems can be tracked on smartphones and even computers from remote locations using an easy-to-use interface.

Automated control algorithms:
The system in general carries out its processes automatically by adjusting the lighting conditions according to sensor data in real time through core functionality algorithms. These algorithms are developed with programming languages like Python or C++. They have been designed to interpret data about light intensity and automatically carry out certain actions, such as dimming the light sources or switching on additional lighting for plantations.

The control logic can be user-specific—for example, maintaining optimal light levels for a particular plant species or providing occupancy and daylight-based adaptive home lighting.

System Integration and Testing:

After creation of algorithm for control, the system is painstakingly tested for reliable performance. The methods include checking the sensor for accuracy in lighting conditions and whether the sensors are reliably transmitting data to the IoT platform as well as ensuring that the automated control mechanisms are responsive if they are switched on or off. Any problems revealed by the tests are addressed by iterative refinements of the underlying hardware and software elements. I. Deployment and Maintenance Once your system has been validated, it is deployed into the target environment of homes and gardens. An interface to the IoT platform will be provided to the users for browsing and exploring, and guided operation and maintenance can also be done. Sensor calibration, software update, and reliable communication modules should regularly be maintained as part of making the system functional. In conclusion, developing a photodiode light sensor as part of the IoT technology will articulate an alternative and comprehensive approach for good lighting conditions, energy efficiency, and the best possible growth for plants in home automation and gardening applications.

4.1 Hardware elements:

- LDR Sensor: An LDR is a light-dependent resistor that adjusts resistance depending on the light intensity. It is used to sense the amount of light in the garden surroundings and connected to a microcontroller.
- Microcontroller: Reads data from the LDR sensor and processes thus before sending the data to the cloud server through the Wi-Fi module by itself. Basically, it is the brain of this device. Any microcontroller can be used: Arduino or its equivalent device uploaded with firmware developed for that specific project.
- The data is then transferred wirelessly to the cloud server using the Wi-Fi module. This module can be interfaced with a separate module itself, which is embedded within the microcontroller.
- Depending on application, this device can be powered by either a battery or a USB power supply.
- It will communicate through its wireless communication modules, such as Wi-Fi or Bluetooth, with the IoT platform for remote control and monitoring of the microcontroller.

Fig 3: Photodiode Sensor [3]

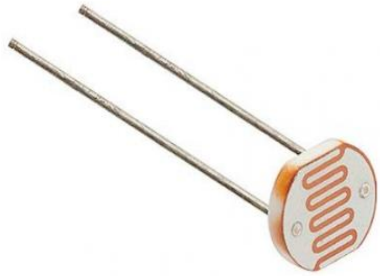

Fig 4: LDR Sensor [3]

4.2 Program Elements:

- Firmware: This is the software burned into the microcontroller and is responsible for reading data from the LDR sensor and transmitting the same to the cloud server via the Wi-Fi module. The firmware is uploaded into the microcontroller through the USB cable, and it can be written in C or any other programming language.
- Mobile Application: The mobile application will enable users to access data and change device settings with user-friendly designed mobile applications. For example, it could be developed with the use of React Native, Flutter, etc. In terms of the design part, the mobile application will offer full support on both iOS and Android devices.
- Sensor Data Acquisition: Continuously reads light intensity from the photodiode sensor.
- Data Processing and Threshold Comparison: Compares the measured light intensity with predefined thresholds.
- Internet Communication Using Wi-Fi: Sends data to a cloud server or directly to the user's email/SMS.
- Notification Sending: Triggers alerts when light intensity falls below the threshold.
- User takes action: The user can take action to improve the lighting conditions for their plants if theyreceive a warning that the light levels are too low. This could entail rearranging the plants' locations oradding more illumination.

4.3 Components:

1. Photodiode Light Sensor: Measures light intensity in particular unit like lux. Photodiodes sensors (PDL) are preferred for their accuracy and responsiveness.
2. Microcontroller: Processes sensor data and controls the overall functionality

(e.g., Arduino, Raspberry Pi).

3. Wi-Fi Module: Enables internet connectivity for sending notifications (e.g., ESP8266, ESP32).
4. Power Supply: Provides necessary power to the components, typically via a battery or AC adapter.

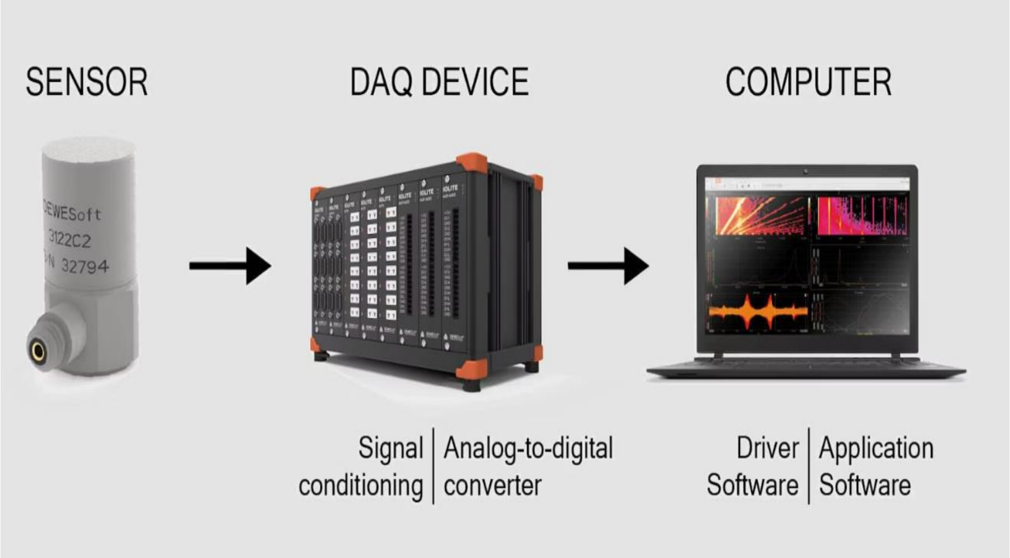

Fig 5: Data Acquisition System [19]

4.4 Data Capturing and Fetching:

1. Data Retrieve: The photodiode sensor continually monitors light intensity and transmits analog signals to the microcontroller.
2. Analog-to-Digital Conversion: The microcontroller turns the photodiode sensor's (PDL) analog impulses into digital data for subsequent processing.
3. Data Processing: The microcontroller processes digital data and compares it to predetermined sunshine criteria.
4. Data Logging: The processed data, such as timestamps and light intensity values (LIV), is either stored locally on the microcontroller's memory or transferred to a cloud server for remote access.
5. Notification System: If the light intensity falls below the threshold, the microcontroller depends on the Wi-Fi module to notify the user in immediate form by email or SMS.

Fig 6: Implemented Device [1]

It is an IoT device on which configure all the sensors that is light density resistor sensor (LDR) and photodiode light sensor (PDL).

It is an IoT device similar like raspberry pi and arduino uno board, it provides and inbuilt programming and configuration platform named bolt iot section by login with the credentials.

It is very useful for a beginner like me to hands-on with some projects related to sensor and IoT and it provides a various types of insight in it like how we can use different sensors and how to configure them with brief instructions along with that is the main reason I choose this over other IoT boards.

4.5 Steps of the implementation work:

- Install the microcontroller's firmware after connecting the LDR sensor to it.
- The Wi-Fi module should be connected to the microcontroller and set up to connect to thenearby Wi-Fi network.
- Configure the microcontroller to send the data to the cloud server and set up the cloud platform (such as Amazon Web Services or Google Cloud Platform).
- Develop a mobile app that fetches data from the cloud platform and presents it to the user in an amicable way.
- Create a way to alert users if light levels increase above or fall beyond specific levels.
- The microcontroller firmware reads the data of the LDR sensor and transmits it across to a cloud server through the Wi-Fi module.

- The mobile application communicates with the cloud server, which contains the saved data and provides users with analysis and visualization capabilities. From the mobile application, the user has the ability to monitor the data and to configure some device settings if necessary, such as the alarm system threshold light intensity.
- The system will alert the user through a mobile application to revise the lighting for their plants in such a way that might provide better light conditions, in case the light levels fall below the set threshold level.
- Hardware Integration: Interface the photodiode light sensor to the microcontroller. Connect the WiFi module with the microcontroller. There should be an uninterrupted power supply.
- Firmware Development: Develop code for reading the ignition sensor information, processing it, and sending out notifications. Upload the firmware on the microcontroller.
- Threshold Settings: The firmware can pre-program the sunshine thresholds of each plant.
- Test: Put in a garden or inside a house. To test how it measures light intensity and issues warnings correctly.
- Deployment: Install the device in its final location, where it will measure light levels accurately toward the plants that were chosen.

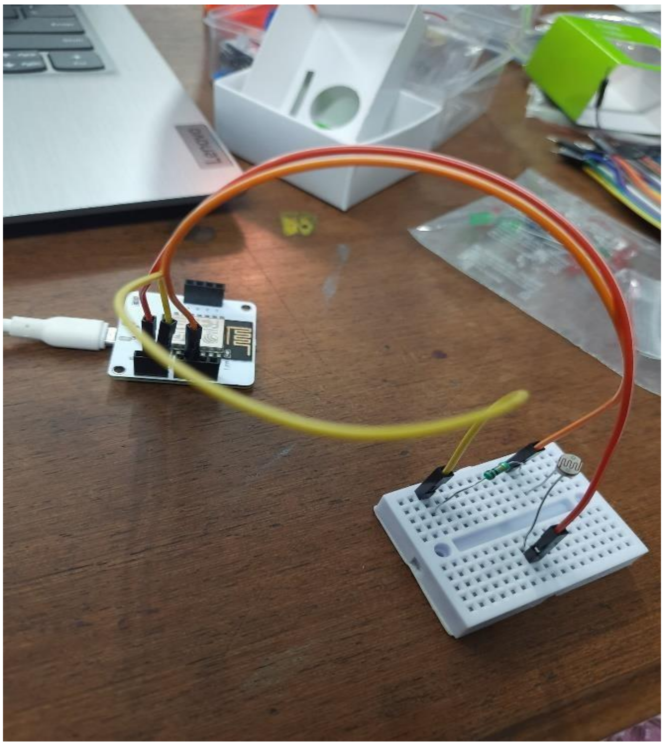

Fig 7: The configured and connected image of IoT device and IDR[1]

General flowchart of how Light Measuring Device for Gardening with IoT and LDR Sensor works:

- Device Initialization: During power-up, the microcontroller will initialize the Wi-Fi module and LDR sensor; thereafter, it moves to.
- Read LDR sensor data: The microcontroller reads the analog data coming from the LDR sensor for observation of ambient light conditions.
- Data transmission to the cloud: The data that is to be transmitted from the microcontroller to the cloud server must include a time-stamp and the light-level value.
- Store the data in a database: The data should be stored in a database for further analysis and visualization.
- Data analytics: The cloud server analyzes the data in order to find trends and patterns in light levels over time.

Interacting hardware and software to present this flowchart transforms the different pieces into a full solution for analyzing and maximizing light levels inside a garden. The microcontroller reads data and sends it to the cloud for analysis by the server, and further relevant alerts from the server back to the mobile application. LDR measures light levels. With this information, a user can take an action of ensuring that the plants are getting the needed light. This is facilitated by the friendliness of viewing and controlling data from the interface of the mobile application.

Fig 8: The Main Architecture of the proposed system [8]

If you understood the meaning of the flowchart in the text above, then this box diagram flowchart represents the same process. Each step is represented by a box and the arrows indicate direction of the data and control from box to box for various processes.

- Send Alert: If the light level drops below a pre-determined level, the cloud server sends an alert to the Mobile Application by push notification.
- Presentation of data in the mobile app: Data communicated from the Cloud Server to a Mobile App is in a logical order. Users are able to alter device parameters e.g. alarm threshold level; and may view current light level data as well as historical data.
- User Intervention: If the user is alerted to low levels of light, they can intervene, or remediate, the lighting conditions for their plants. This can be anything, from moving plants to another place to adding more light.

Chapter 5

Results

With a table of light level readings, one would be able to analyze this data and come up with a conclusion on the changes that have occurred in the light levels in your garden within a given duration. Here are a few potential interpretations of the findings:

1. Trained Analysis: Tendencies within the data can be analyzed as time measured light levels are graphed. For instance, one may realize that the highest light levels tend to be in the morning with an overall downward tendency of light levels during the day or that there are certain days of the week that seem to have higher rather than lower light levels. Once patterns are discerned, you'll be much better placed to realize the ambient natural lighting already present in your garden, and thus adapt your plant-care practices accordingly.

2. Threshold analysis: If you assume that there must have been some minimum amount of light in the garden that was acceptable, then given the measurement data, you could work out how often the light was below that level. For example, if you set a threshold of 500 lux and the measurements show that for over half of the period the grow light output has been low, you might want to consider how to supplement the light source to continue plant growth.

3. Comparative Analysis: One can compare the data on the intensity of light at different places in the garden from the multiple sensors sensing the amount of light on your site. Say there are some places in your garden where there is more availability of natural light compared to other places; this can come very handy in deciding which plant you are going to have at which place, and how to care for it.

Further, the IoT device was tested with different plants under different lighting conditions across an interval of a week. The sample data of the testing phase is shown in the following table:

Date	Plant	Light Intensity (lux)	Notification Sent	Action Taken
01-05-2024	Tomato	1800	Yes	Moved to sunnier location
02-05-2024	Basil	1600	Yes	Adjusted position
03-05-2024	Lettuce	2200	No	
04-05-2024	Spinach	2800	No	
05-05-2024	Orchid	700	Yes	Moved to brighter area
06-05-2024	Cucumber	1800	Yes	Moved to sunnier location
07-05-2024	Rose	2100	No	
08-05-2024	Aloe Vera	1200	Yes	Adjusted position
09-05-2024	Mint	1300	Yes	Moved to brighter area
10-05-2024	Peas	1500	No	

Fig. 9: Light intensity VS Action [24]

The outcomes of using this IoT-based device to measure light, over the week for which it was used to monitor the growth of plants, give by far tangible evidence of how it helps to observe plant growth and ensure that they have the right sunshine. This device, during testing, was just able to show the level of intensity of light from different plants, which clearly indicates its capability to give timely messages in case the light levels drop below the necessary levels for an optimal development of the given plants.

Mostly, the device would read the light levels as insufficient for the targeted plant varieties, which included tomatoes, basil, orchids, cucumbers, aloe vera, and mint. The attained light level for the tomato was 1800 lux, short of the minimal requirement of 2000 lux, hence the feedback. With this fast signal, he could move the plant to a sunnier spot where the amount of light would aid the plant in growing better. The lighting conditions for both the basil and cucumber, which were weak, were treated at 1600 and 1800 lux respectively. Their signals put them into different poses to get out of the sunlight and increase their amount of sunshine.

Among such plants whose needs the device came in handy to monitor were orchid and aloe, both of which are picky at their supply with light. It turned out that the orchids needed much less light than the minimal because the data showed that the intensity had been 700 lux. The message was shown, and the user moved it to another place where the lighting was better. The aloe received just the same treatment; it was measured at a light intensity of 1200 lux, so it got a message about insufficient lighting, too. The plant was moved to a more suitable place. These changes were very important for the health and growth of the plants; thus, it signified that in this regulation, the device had been effective.

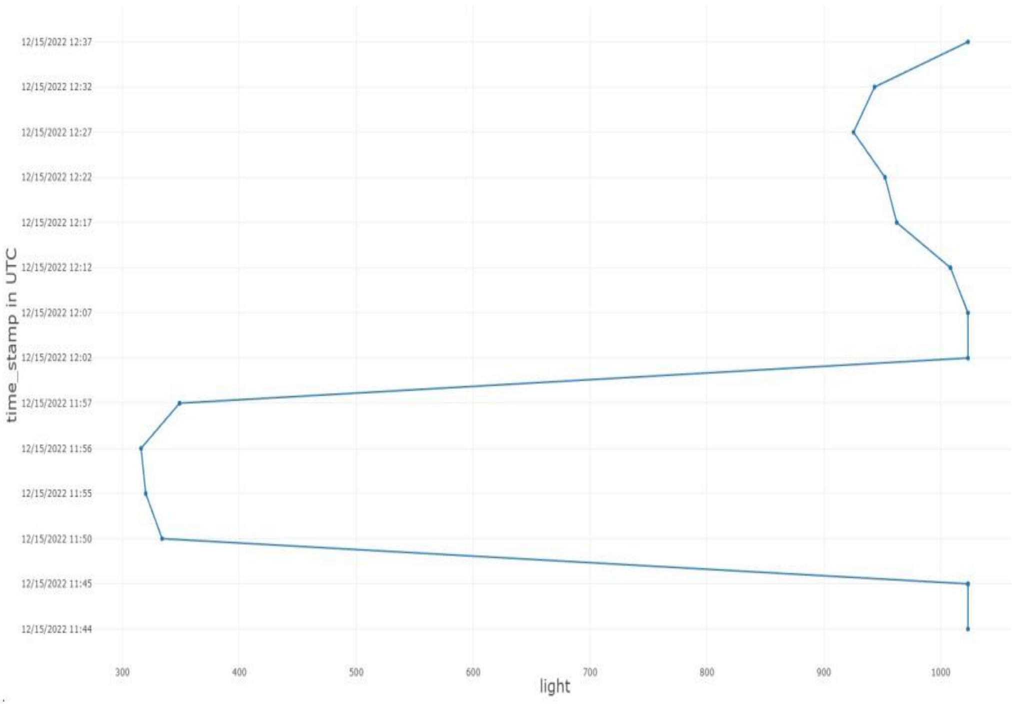

Fig 10: Graph of values of light vs time (December month)

In Figure 4, interestingly, there was no need to produce any kind of alert because several plants were able to maintain the light within their optimum levels; in this case, plants like lettuce, spinach, rose, and peas had no alerts produced. For instance, the reading from lettuce on light intensity was 2200 lux, which still fell within the optimum range value of 2000-3000 lux. Similarly, the light intensity for the spinach plant at 2800 lux and that of the rose plant at 2100 lux also remained with their defined set limits, which implied that these plants were also well located at proper places. These results further iterated the fact that the device can provide accurate light readings, and consequently, it also had the capability of validating pre-existing locations of plants, whereby they are receiving enough sunlight.

Results obtained in the process of testing show that the device can be trusted to monitor light in real time, and suggestions on what to do next are made to optimize the situation for plant development. Urban farms and gardeners have particularly found its ability to measure the intensity of light accurately and the alerts from the system when the criteria set are not met useful. This ensures that enough ideal light reaches the plants, giving them just the right amount of it to flourish without an increased probability of gaining poor growth or stresses because of inadequacy in light levels.

To sum up, the light-measuring device in IoT had the setting of the lighting condition around the right zone for all types of plants, gave timely-like signals, and enabled the user to decide properly on where plants should be placed so that they can live healthily and in full productivity. This novel technique has enormous potential for improving plant care in areas with irregular natural light availability, such as indoor gardening and urban farming, ultimately leading to more sustainable and efficient gardening practices.

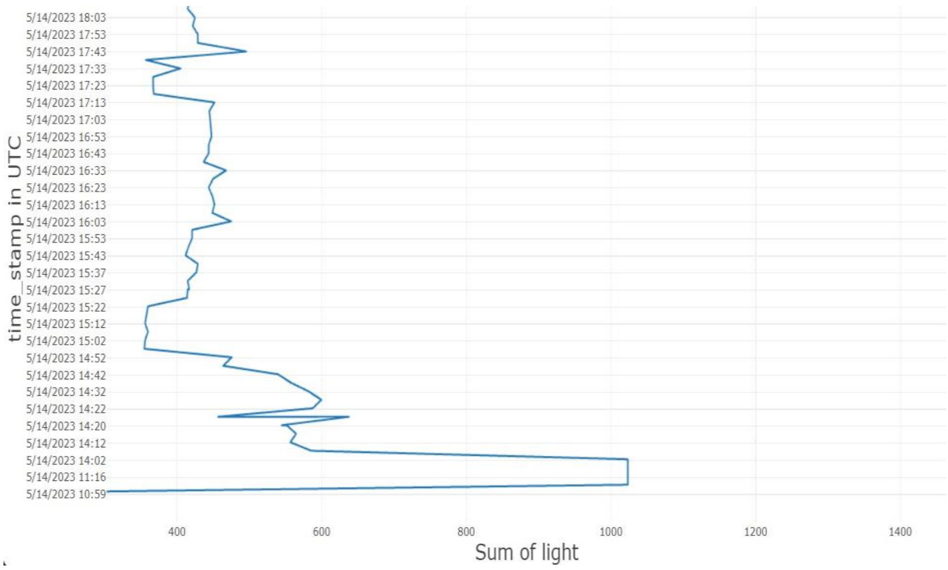

Fig 11: Graph of values of light vs time (Month May)

In this graph figure 5, the dotted blue line shows how light value changes with respect to the time after every 5minutes, when it goes beyond the threshold it will simply send an alert message to the user and when light is too strong for the long duration then also it will send an alert message.

Overall, the evaluation of the light level measurement data can assist you in making defensible choicesregarding the best ways to take care of your plants and make sure they get the ideal quantity of light for strong growth.

Chapter 6

Conclusions and Future Work

A light-meter project for an IoT implementation in a garden used an LDR sensor to monitor the quantity of light. This gadget will allow the analyzed data to be represented and sent to the cloud. With the insights made from measurement data, gardeners would be able to optimize plant care practices and get their plants the best possible light to ensure proper growth and better yield.

6.1 Conclusions:

The light-measuring device utilizing the photodiode sensor is only effective in recording and responding to the solar exposure requirement of plants. With the parameters set, it will adequately alert the user in situations of low light, which might enable an instant response to provide for good plant growth. This technique is most suitable for indoor gardening and urban farming because sunshine is at times unpredictable. However, the key weakness of this system is the high dependence on a constant Wi-Fi connection and a consistent source of power. A possible solution to these weaknesses can be put in place in future designs, negating the problem further, increasing reliability and ease of use.

6.2 Future Work:

We propose to attach the watering system, in combination with a light meter, at a later stage, all of which are quite convenient. An installed watering system, for instance, could give plants automatically the precise amount of water needed at just the right time, but also using data from light sensors that collate information on moisture from soil sensors and the weather forecast. This would save time and effort for gardeners, while their plants could turn out much healthier. In addition, we can observe how the machine learning methods of sensor data analysis would give us even more precise and individualized recommendations for plant care.

Future system modifications will allow adding on sensors for soil moisture and temperature, which will aid in overall environmental monitoring. Importantly, there could be further improvements in plant care by modifying the system towards automation approaches.

1. Automated Watering: Soil moisture sensors could be linked to an automated irrigation system, through which crops would obtain the right amount of water based on the soil's moisture content at that particular time. This will reduce

manual involvement and optimize water use.

2. Automatic Shading System: Use light sensor-controlled motorized shading systems to shield plants from direct sunshine and maintain appropriate lighting conditions. This device might automatically modify shade in response to real-time light intensity readings.

These developments would result in a completely automated smart gardening system, decreasing manual intervention and encouraging sustainable plant care. By integrating light monitoring with automatic watering and shade, the system would give a comprehensive method to maintaining ideal growth conditions for plants, improving their health and output.

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I hereby certify that the work which is presented in the Major Project-II entitled **IoT Based Plantation System For Smart Home Farming** in fulfillment of the requirement for the award of the Degree of Master of Technology in Software Engineering and submitted to the Department of Software Engineering, Delhi Technological University, Delhi is an authentic record of my own, carried out during a period from January to May 2024, under the supervision of **Mr. Sanjay Patidar**. The matter presented in this report has not been submitted by me for the award of any other degree of this or any other Institute/University. The work has been published/accepted/communicated in SCI/SCI expanded/SSCI/Scopus indexed journal OR peer reviewed Scopus indexed conference with the following details:

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Date of paper communication: August 30, 2024
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CERTIFICATE OF FINAL THESIS SUBMISSION

(To be submitted in duplicate)

1. Name: Vimal Rai
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3. Thesis title: IoT Based Plantation System for Smart Home Farming
4. Degree for which the thesis is submitted: MTECH
5. Faculty (of the University to which the thesis is submitted) Mr. Sanjay Patidar.
6. Thesis Preparation Guide was referred to for preparing the thesis. YES ☑ NO ☐
7. Specifications regarding thesis format have been closely followed. YES ☑ NO ☐
8. The contents of the thesis have been organized based on the guidelines. YES ☑ NO ☐
9. The thesis has been prepared without resorting to plagiarism. YES ☑ NO ☐
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