AR- GLASSHOUSE: SIMULATION OF AN IoT DRIVEN GREENHOUSE

Project ID: 19-097

Project Proposal Report

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DECLARATION

We declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

…… ……

Signature of the supervisor: Date

Dr. Pradeep Abeygunawardana

ABSTRACT

With the vast growth of population, increase production of produce is necessary. But lands are limited, People need good food. Organic food supply is scare; therefore, the retail prices are high. As a solution green houses are widely used all over the world to grow produce with minimal pesticides and weedicides including in Sri Lanka. Automated greenhouses can be used to increase the produce without expense of human labor. With less use of human hours, it will produce more harvest than conventional green houses with need constant human attention and care. Implementation of automated green houses are costly although the long-term benefits are high. So, introducing the concept to cultivators would be difficult, they are reluctant to invest money on unfamiliar technologies. There is a hesitance to embrace the technology since they don't have a firsthand experience. So, we are proposing a simulated model of automated greenhouse using Augmented reality which a client can experience it before hand to take an informed decision to invest money on automated green houses.

The simulated model proposed is known as "AR-Glasshouse" and clients can visually experience how environmental variables are controlled automatically inside an IoT based greenhouse. Furthermore, it includes a mobile application for the simulation purpose. Once the user selects a desired scenario, he/she can visualize how IOT sensors detect the changes and start their functions in order to keep the greenhouse in an optimal level.

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1. INTRODUCTION

1.1.Background & Literature Survey

Greenhouses form an integral part of agriculture. They are used to grow specific plants under specific controlled conditions for optimum results. They allow farmers to grow plants and yield a better production throughout the year regardless of climatic conditions. [1] In today's world greenhouses contribute to farming a lot due to the global warming and various climatic changes.

The next big thing in greenhouse is it being automated with the help of Internet of Things (IOT). Automated greenhouses are much better and more efficient in precision farming. Greenhouse automation and control works as many industrial applications. Several calibrated environmental sensors are used to control instrumentation devices to restrict climatic conditions. Each sensor and its response should be analysed separately for better results. [1]

Currently in Sri Lanka many organizations/companies are in the process of automating the greenhouses using IOT to yield maximum output in order to improve the agricultural activities and maintenance [2] [3]. Though several technological methods are used to improve the productivity it isn't that effective to yield the maximum output from it since there's a gap in agriculturalists understating and using the technological aspects. Due to this most of the agriculturalists are reluctant to use the advanced products and also the technological companies are finding it really hard to communicate/explain the final look and feel of automated greenhouses with them. Firsthand experience of an automated greenhouse and lack of understanding of technological enhancement or technological usage in improving the greenhouse are some of the major issues in marketing automated greenhouse solutions to several agriculturalists.

As a solution to the above-mentioned problem we propose a system to simulate an automated greenhouse using Augmented Reality (AR). Then agriculturalists /farmers can experience the real view of automated greenhouse and gain a better understanding of its workings without it being physically implemented. It also helps the technological companies to cut down the unnecessary costs of implementing an automated greenhouse to market their solutions. They also get a better way to express their ideas to the target audience. “A picture is worth a thousand words”.

There are mainly two fields which should be taken into consideration when building up the above-mentioned solution to the problem. Namely IOT based Automated greenhouses and Augmented reality. The proposed system will bind these two fields to provide the first-hand experience to the target audience in simulation of automated greenhouse

Augmented Reality

To build the 3D model of IOT based greenhouses augmented reality is used. 3D modeling is the main method that is used in order to give an idea about the place to the users.3D modeling is one of the most important tools used to give people the experience of greenhouses. Augmented reality (AR) methods and techniques are well-known since they contribute a lot to the representation process. In addition to various sectoral uses, the use of AR tools and methods is important to study and research with regards to their integration representation [4]

Slam technology and Wikitude sdk are the widely used technologies in AR. Importance of this technology is, it is well suited for tracking unknown environments, rooms and spaces. “The technology continuously scans and “learns” about the environment it is in allowing you to augment it with useful and value-adding digital content depending on your location within this space” [5] [6].

Automated Greenhouse

The main idea of an automated greenhouse is to help user to take better precautions inside a greenhouse or to reduce the time needed by a user to manually check the condition of a greenhouse with the help of technology. With the intelligent features in it the system will be able to give better maintenance details to user for better output in farming [7].

Also, there are several features of an automated greenhouse. Due to its closed model it's safeguard from pests and insects. Factors which are usually controlled and analyzed are Light Intensity, Humidity Soil Moisture, Temperature and devices which are usually used to control these factors are growth light, cooling fan, water pump, heating bulb, exhaust fan. Growing LED lights are switched on whenever light intensity is low to ensure proper plant growth. Humidity and temperature are measured by several sensors to maintain it in the optimum level, whenever temperature increases or moisture becomes ow foggers and fans will be used to control the environment. [8] Ph, Acidity levels of, soil moisture are also important in plant growth. They too will be measured using sensors to maintain them in an optimum level.

Augmented Reality in Agriculture

Several researches are being held to aid farming activities, but they seem to be out of reach for many. Generally farming is done by a large group of people around the world. It is a problem of scalability faced by industry which has few experts and very large base of people in their expert service need. Technology can play a major role here where AR can be used. [9]

"Augmented reality (AR) technology is growing in the past few years with a growing number of low-cost AR devices becoming available to the general public. AR techniques have demonstrated the capacity to optimize task efficiency in a broad range of industries and provide engaging entertainment and education experiences. One of the extremely underexplored areas is its application in broad agriculture sector". [10]

As per to the above literature review currently there are automated greenhouses and augmented reality products. There aren't any products which incorporates both to provide a simulation feature. Thus, the proposed system will be and efficient solution

for technological companies to express and market their greenhouse automation solutions to the target audience effectively. Rather than implementing and building an automated greenhouse the final look and feel of an automated greenhouse can be given to users/ agriculturalists through AR. The workings/outputs of several IOT sensors and other devices will be visually shown to users to get the real experience and feel through, the process of simulation via augmented reality.

1.2.Research Gap

Research Gap

There are no worldwide level researches going on based on the above simulation. The global smart greenhouse market was valued at approximately USD 680.3 million in 2016 and is expected to reach approximately USD 1.31 Billion by 2022 [11]. But in countries like Sri Lanka, India, Africa cannot be seen such an improvement as a result of high installation costs. Only few automated greenhouses can be seen in Sri Lanka.

Several researchers have been conducted on greenhouse automation. The proposed simulation is not about automation. Basically, it's about offering firsthand experience on automation or to visualize the concept of smart greenhouse before investing money.

Even though various simulations have been done using augmented reality they haven't used historical data to do the simulation.

1.3.Research Problem

In order to get a maximum yield, crops should be cultivated in a controlled environment. Traditional greenhouses fulfill the above requirement with the interaction of humans. But IoT driven smart greenhouse intelligently monitors as well as controls the climate, eliminating the need for manual intervention [12]. Various sensors are used to monitor the internal conditions of the greenhouse. Farmers who used to cultivate in ordinary greenhouses spend lots of money as the labor cost is sky high. As well as, farmers are reluctant to invest for an unfamiliar technology. In such scenarios it would become more complicated to convince them that the automation is the best solution to make more profits and save time. Furthermore, it's hard to obtain feedbacks on further enhancements since they don't have a visual sense. Describing this IoT driven greenhouse concept is useless because verbal explanations are less powerful than visuals.

Simulated IoT Green house is proposed to develop as our 4^{th} year research because it will be much effective for farmers and whoever in the field of agriculture. Temperature, light intensity, humidity and the moisture level of soil are the four main factors that should be monitored frequently. Through this simulation, the user can have a firsthand experience how it reacts when the above factors change.

While doing this, several research problems are identified such as,

- How to take most accurate data from sensors?
- How to build up 3D models with the gathered data set?
- How to do the sensor placement based on client's requirement with Augmented Reality?

To overcome above issues, both manual data and data from sensors are collected. Then those two sets of data will be compared before modeling

2. OBJECTIVES

2.1.Main Objectives

The main objective of this research is simulating an IoT based greenhouse which gives firsthand experience to the farmers who are having a greenhouse already and to motivate them to keep a step forward to make their existing greenhouse an automated one.

2.2.Specific Objectives

In order to reach the main objectives, the specific objectives that needs to be attained is as follows,

1. Temperature related tasks

   Several 3D models will be created to simulate and experience the optimum temperature of an IOT controlled Greenhouse. To create accurate models to show the variation of the temperature inside the greenhouse; data which are gathered from temperature sensors will be used. Then various analysis algorithms will be used for data processing to get various output figures (ex-graphs). Based on those output figures aforementioned models will be created.

   Example: There is a previously determined optimal temperature for the plants. If a temperature change occurs in greenhouse, sensor will detect it and automatically activate the regulatory mechanism such as switch on the fan. The above scenario is modeled to visualize to a client by using the analyzed data.

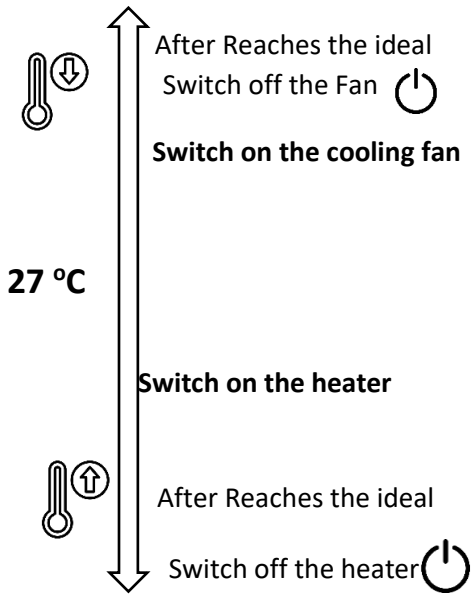


Figure 2.2.1. Temperature Diagram

2. Light Intensity related tasks

   Several 3D models will be created to simulate and experience the optimum light intensity of an IOT controlled Greenhouse. To create accurate models to show the variation of the light intensity inside the greenhouse; data which are gathered from light sensors will be used. Then various analysis algorithms will be used for data processing to get various output figures (ex-graphs). Based on those output figures aforementioned models will be created.

   Example: There is a previously determined optimal light intensity for the plants. If an intensity change occurs in greenhouse, sensor will detect it and automatically activate the regulatory mechanism such as switch on the lamp. The above scenario is modeled to visualize to a client by using the analyzed data.

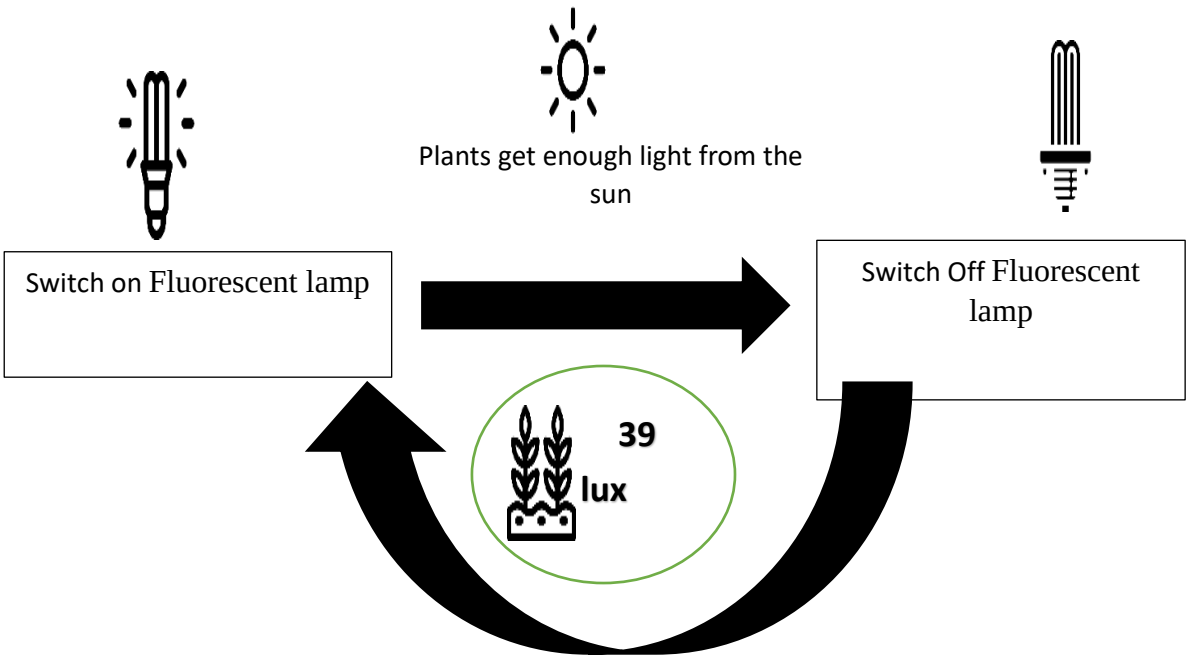


Figure 2.2.2. Light Intensity Diagram

3. Humidity related tasks

Several 3D models will be created to simulate and experience the optimum humidity of an IOT controlled Greenhouse. To create accurate models to show the variation of the humidity inside the greenhouse; data which are gathered from humidity sensors will be used. Then various analysis algorithms will be used for data processing to get various output figures (ex-graphs). Based on those output figures aforementioned models will be created.

Example: There is a previously determined optimal humidity for the plants. If a humidity change occurs in greenhouse, sensor will detect it and automatically activate the regulatory mechanism such as switch on the exhaust fan. The above scenario is modeled to visualize to a client by using the analyzed data.

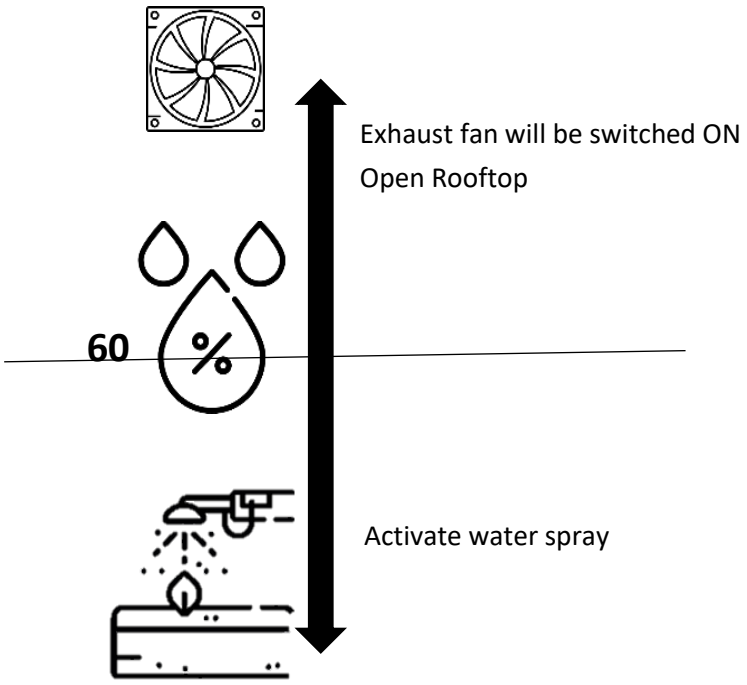


Figure 2.2.3. Humidity Diagram

4. Soil Moisture related tasks

Several 3D models will be created to simulate and experience the optimum soil moisture of an IOT controlled Greenhouse. To create accurate models to show the variation of the soil moisture inside the greenhouse; data which are gathered from moisture sensors will be used. Then various analysis algorithms will be used for data processing to get various output figures (ex-graphs). Based on those output figures aforementioned models will be created.

Example: There is a previously determined optimal soil moisture for the plants. If a soil moisture change occurs in greenhouse, sensor will detect it and automatically activate the regulatory mechanism such as turn on the water pump. The above scenario is modeled to visualize to a client by using the analyzed data.

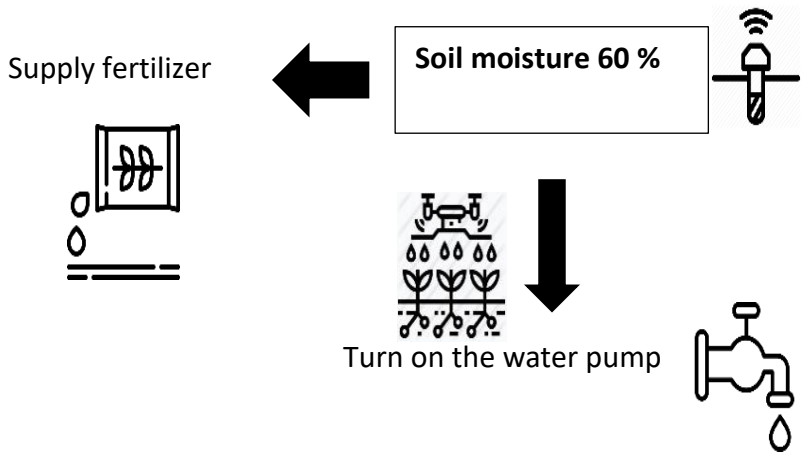


Figure 2.2.4. Soil Moisture Diagram

3. RESEARCH METHODOLOGY

3.1 Product overview

Final outcome of the research would be an augmented reality mobile application which provides user an interactive experience of a real-world smart greenhouse.

Moreover, Adjustment requirements on placements of devices can be fulfilled just after the first experience.

Firsthand experience would be given on four dominant environmental variables which should be controlled inside a greenhouse.

1. Temperature
2. Humidity
3. Light
4. Soil Moisture

3.2. The functionality of the project

3.2.1. simulation of reactions on environmental variables in an IoT driven greenhouse

Temperature is the primary factor that controls crop timing and plant development [3]. The temperature in a greenhouse is affected by the ventilation and the amount of sunshine it receives [4]. As an advantage of an IoT based greenhouse this primary factor will be monitored frequently by temperature sensors.

Intensity of the light is important as temperature to the process of production in a greenhouse. Intensity values will be measured in a given period of time by varying the distance.

When growing in a greenhouse, humidity can become a serious factor in the success of your crop [5]. Therefore, it should be monitored in different climates. The Last considering factor is soil moisture. Soil testing is the most common way of determining the nutritional status of plants used by greenhouse operators [6].

Number of sensors can be varied according to the size of the green house. Here the major aspect would be data analyzing where we have to gather a large dataset to avoid the inaccuracy. Both automated data obtained from sensors and the manual data which are collected by considering the time in a particular day will be compared before processing data. Data analyzing algorithms will be used for this and a few output figures like graphs can be plotted. Then 3D modeling software like 3DMaya and Blender will be used to model the effect.

3.3. Data Gathering

Large amount of data related to IOT based greenhouse is needed to process and know the variations and behavior of light intensity, temperature, humidity and soil condition. Continuous measurement of temperature, humidity, soil condition and light intensity with a wireless sensor network in greenhouses needs to be done. These measured data will be stored in database for analysis purposes. Then data collected for each factor will be analyzed separately to know each factor's behavior pattern.

3.4. 3D Model creation for AR Presentation

Gathered and processed data should be turned into AR viewable images and models for better interaction and meaningful insights. AR helps to achieve this by overlaying physical objects on real world. Adding 3D models makes it visually impressive.

Initially 3D models related to Greenhouse needs to be designed or downloaded if exists. Models can be generated using photogrammetry, 3D scanning, 3D modeling program. In our case the analyzed data will be visualized using photogrammetry and 3D modeling programming techniques. [17]

3.4.1. Photogrammetry

By using a series of pictures, photogrammetry software can generate high quality mesh of objects. The mesh is a group of triangles that define the shape. These photos are defined how light interacts with the objects. [18]

3.4.2. 3D modeling Programs

Modeling needs to started with blank space and create the model from the scratch. This is a time-consuming process, but still the models will be visually accurate and optimized for our purposes. [18]

3.5. Software Requirements & Technologies

- Android Studio
- Blender
- Unity
- Python
- RStudio

Technologies

- ZooBurst
- Augmented SDK
- Wikitude Augmented Reality SDK
- Vuforia SDK

3.6. Business Plan/ Business Potential

As per to several literature review and references there aren't any existing AR simulators for IOT based Greenhouse. There exist various other AR applications and IoT based Greenhouses, but not any for the combination of both the above-mentioned fields.

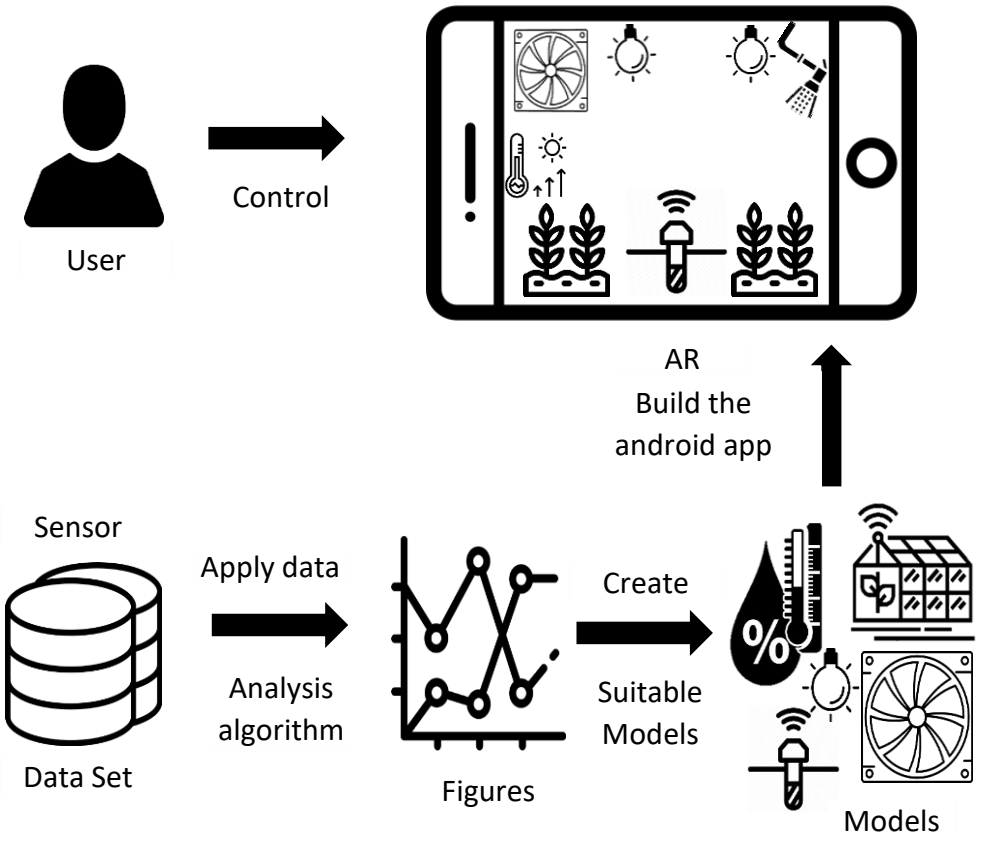
Our proposed system will ease many technological companies' automated solutions to reach various people with various literacy levels. The AR simulator can be used to visualize the real experience of automated greenhouse. This proposed system will give them a first-hand experience in the IoT based greenhouse through the process of Simulation.

In terms of cost this solution will be very cost effective. Physical implementation of IOT based greenhouse is very costly but leads to long term benefits. Due to this most of the agriculturalists are reluctant to use the technological solutions in greenhouses which is unfamiliar to them. Also, technological companies face difficulties and cost problems when marketing these products to agriculturalists. Also, it is mandatory for them to physically implement to market their solution to target customers.

But our proposed system will reduce all these issues to effectively and economically market the IOT based greenhouse products to target customers. We plan to release this to various IT solution providers. This product will be deployed to the Android world at a considerable low price to attract users from Sri Lanka. In future we plan to extend the AR simulation to various others fields apart from greenhouse.

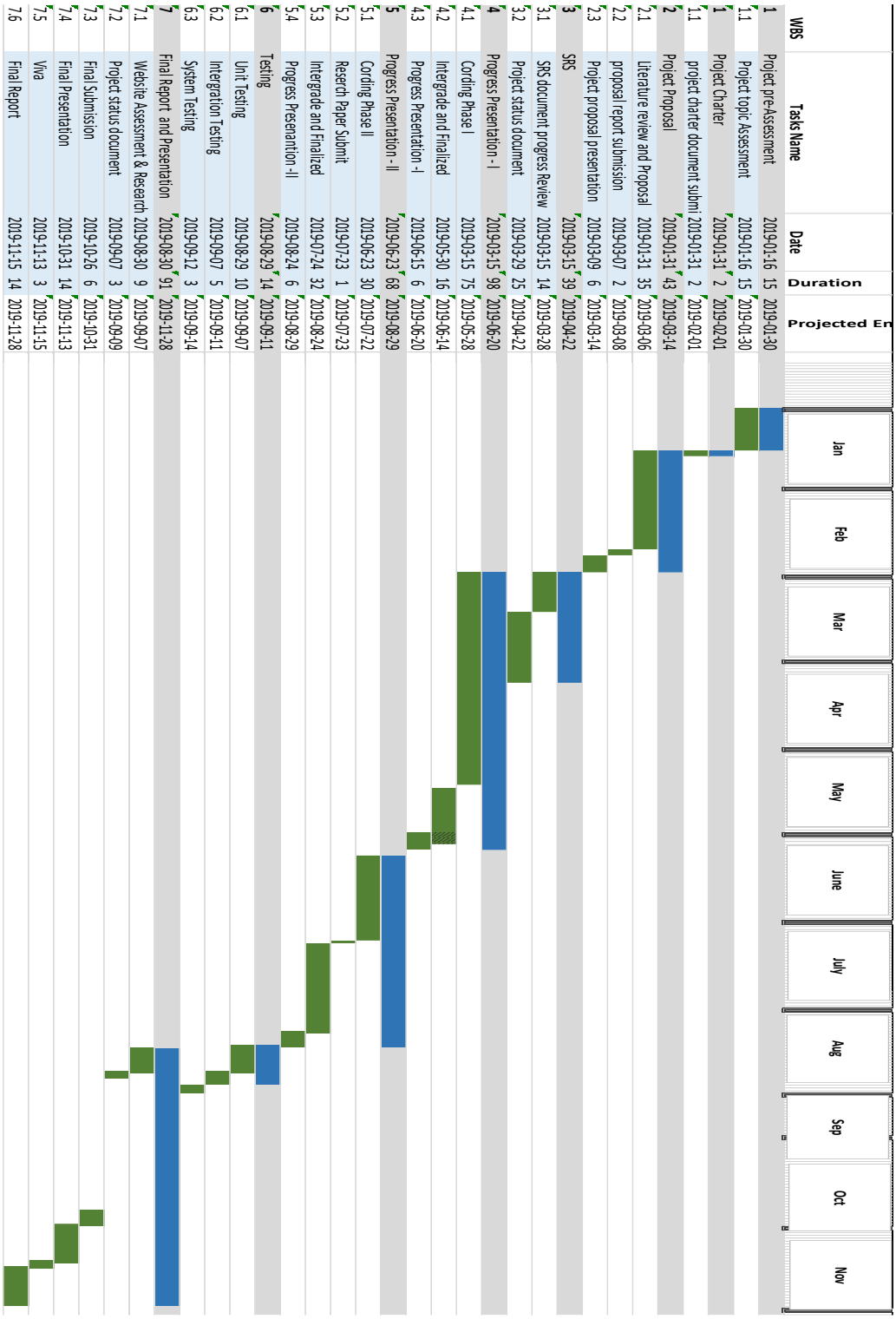
3.7 System Architecture

The system architecture is shown in the figure 3.7.1



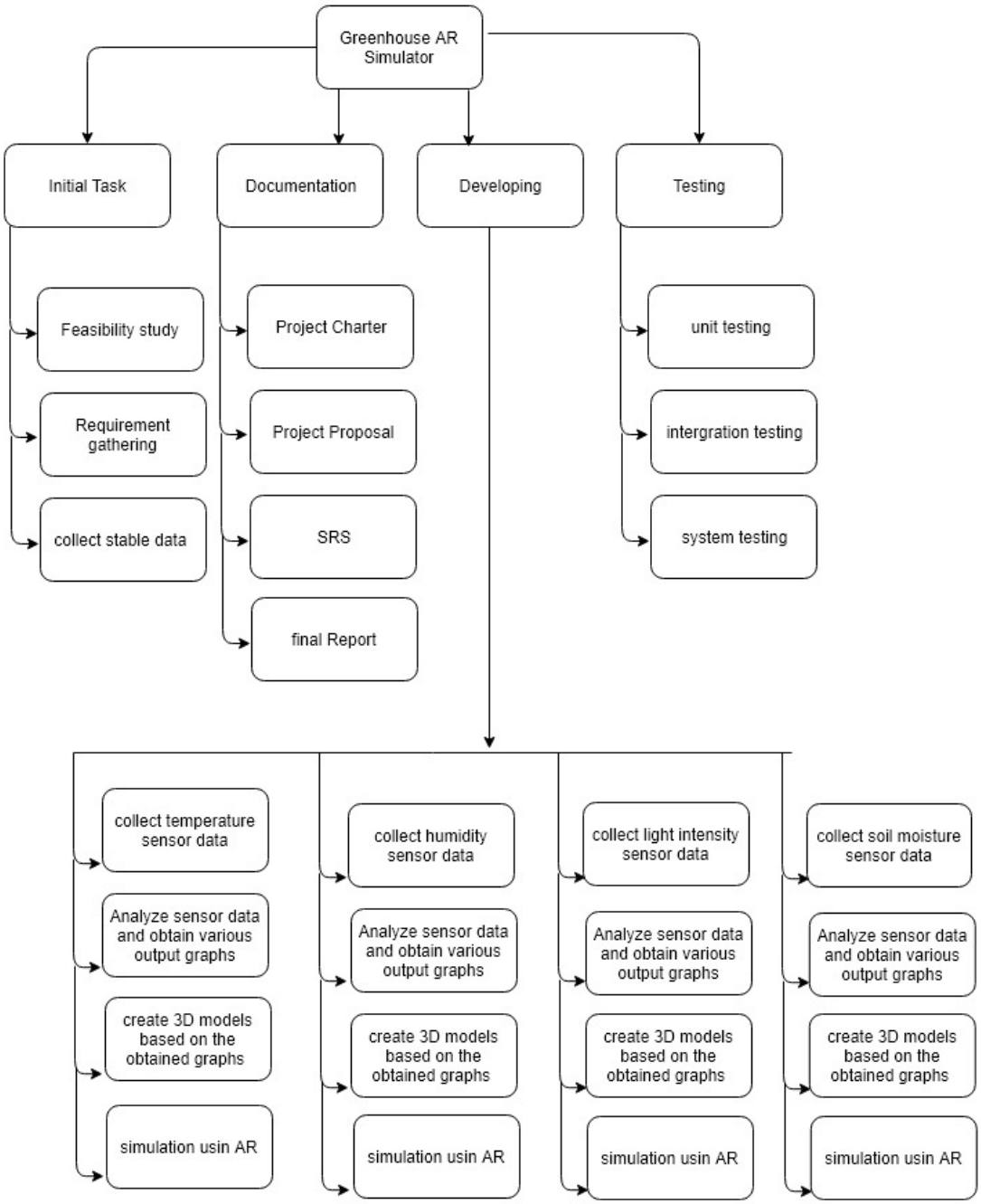
3.8 Gantt chart

Figure 3.8.1. Gantt chart



3.9 Work Breakdown structure

Figure 3.9.2. work breakdown structure



4. Description of Personal and Facilities

Table 1 Description of personal and facilities

Member	Component	Task
W.P.T.S. Weerasooriya	Light intensity related tasks	• Generate an algorithm using data obtained from the light sensor • Process data and create graphs/ figures. • Identify the way of controlling when the light intensity exceeds the desired level and when intensity goes down. • Create models based on the output figures. • An interface in the mobile application to visualize.
P.A.B.T. Wishvamali	Temperature related tasks	• Generate an algorithm using data obtained from the temperature sensor. • Process data and create graphs/ figures. • Identify the way of controlling when the temperature exceeds the desired level and when temperature goes down. • Create models based on the output figures. • An interface in the mobile application to visualize.

M.P.N.D. Gunarathne	Humidity related tasks	• Generate an algorithm using data obtained from the humidity sensor. • Process data and create graphs/ figures. • Identify the way of controlling when the humidity exceeds the desired level and when humidity goes down. • Create models based on the output figures. • An interface in the mobile application to visualize.
S. Hareendran	Soil moisture related tasks	• Generate an algorithm using data obtained from the soil moisture sensor. • Process data and create graphs/ figures. • Identify the way of controlling when the moisture level exceeds the desired level and when moisture level goes down. • Create models based on the output figures. • An interface in the mobile application to visualize.

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