Computing Project: Proposal

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1. Working Title

Investigating an Automated Greenhouse Monitoring System for Temperature and Humidity, and Using Applied Machine Learning Techniques on the Data Tracked to for Training then Display Relevant Statistics on the Greenhouse Environment.

2. Research Question

The proposed project aims to monitor and record the temperature and humidity in a greenhouse environment, using applied machine learning techniques to analyse the collected data for training, then displaying relevant statistics on the environment being monitored. The goal is to ensure optimal conditions for crop growth by continuously tracking and displaying relevant statistics through an application, which in turn allows for the adjustment of the greenhouse climate, leading to better crop quality.

3. Proposed Project Artefact

The deliverables of this project are two files, one being the Arduino logic program that is used on the hardware for the monitoring of data which would be programmed on the Arduino IDE in C++, and the second file is the application that is responsible for the applied machine learning techniques that is used on the data recorded which used the data for training then displays and shares relevant statistics on said data which will be programmed in Python/R.

For the hardware that is to be used for the prototype, some components from the "ELEGOO UNO R3 Project The Most Complete Ultimate Starter Kit" would be used such as breadboard, power supply module, temperature and humidity module, and LCD display module. In addition to those components, a Micro SD Card Reader module will also be used in conjunction, which will be responsible for the storage of data being monitored by the Arduino.

Lastly, a report and several sprint reviews in the form of word documents would document the progress of the project. The sprint review documents act

as a systematic method to keep a record on the development cycle of the project, while the report would go in-depth on the project such as its capabilities, benefits and shortcomings, and the challenges that came with its development.

4. Rationale for Project Choice

My guardian tends to his greenhouse frequently during the day as his hobby, which I further noticed during the summer break. However, maintaining optimal conditions within a greenhouse such as temperature and humidity can be challenging and labour-intensive which he finds difficult with his advancing age, thus further exacerbating the inconvenience.

This problem gave me an idea in investigating the matter and applying the skills I have gained from the modules I have studied throughout my degree such as applied machine learning, agile development and application development with object orientated model using appropriate design patterns. Besides that, the application of an Arduino in projects have always piqued my interest, which is not part of any of the modules I studied so far. Thus, I decided to take this opportunity to learn about Arduino and to solve practical problems with it.

Moreover, this problem is relevant to the growing interest in sustainable agriculture and the increasing use of technology to enhance agricultural practices. As more individuals and communities seek to grow their own food, the demand for efficient and user-friendly solutions to manage home greenhouses is on the rise. By developing a system that automates temperature and humidity monitoring while also displaying relevant statistics on the data collected through applied machine learning. I aim to provide a practical solution that not only assists my guardian but can also benefit others in similar situations, or those who want something more than a simple greenhouse monitoring system.

In conclusion, this project will contribute to the advancement of smart gardening technologies, encouraging more people to engage in sustainable

practices while making greenhouse management more accessible for those with varying levels of experience and physical capability.

5. Background Research

On the hardware side, the ELEGOO Arduino Mega 2560 The Most Complete Starter Kit Tutorial (ELEGOO, 2024) was referenced to aid in me learning the nuances and capabilities of the Arduino platform and its various components. The tutorials provided cover essential elements for this project such as sensors, displays, and breadboards, which are vital for building a functional greenhouse monitoring system.

For the project topic, I have conducted extensive background research through various mediums such as articles, blogs, and books to gain a comprehensive understanding of the problem I am tackling such as the relationship between the variables I have chosen to record (Temperature and Humidity) and the importance of each variable and its effect on the environment and crop.

Additionally, I have reviewed some academic literature on automated greenhouses and its monitoring methods, and smart farming practices, which highlighted the importance of technology in enhancing crop yield and resource efficiency. This research not only helped me define the scope of my project but also informed me about the available resources and tools, ensuring that my approach is feasible.

6. Areas for Investigation

6.1 Arduino Platform and Components

Exploring the capabilities of the Arduino Mega 2560 including programming basics, wiring, and interfacing with various sensors and displays is crucial for the successful execution of this project. Since the system relies on the Arduino to gather and process data, understanding its functionalities will enable effective integration of applied machine learning techniques. Additionally, investigating the necessary libraries and resources available for Arduino will be

vital for streamlining data collection and enhancing the overall processing efficiency.

6.2 Understanding Temperature and Humidity Dynamics

Investigating how temperature and humidity levels impact plant growth and health is essential for understanding the significance of the variables being recorded. This research allows for a deeper focus on identifying the optimal ranges for various crops commonly grown in greenhouses, ensuring that the monitoring system is tailored to promote healthy plant development.

6.3 Data Collection and Analysis

As the project is required to gather data and use them for analysis, learning about methods for collecting, storing and analysing said data from the greenhouse environment is necessary to ensure an optimal code base for the program. Besides that, investigating how applied machine learning can be used to analyse the data collected to predict trends and make recommendations for environmental adjustments is also essential to ensure only relevant statistics would be used and displayed for the project.

6.4 User Interface (UI) Development

For the application to provide a friendly user experience, further research into design principles would be undertaken as this program is used by a wide demographic and professions. These design principles could be on making the application UI simpler or the ideal method to display data such as using an LCD screen to display the temperature and humidity while using specialised graphs to display certain statistics.

6.5 Integration of Smart Farming Technologies

Researching other smart farming technologies such as Internet of Things (IoT) devices or remote monitoring solutions gives further context to the project's potential. Thus, investigating how the current project can integrate with existing smart home or agricultural platforms will enhance its functionality and

effectiveness. This exploration helps in displaying a more effective greenhouse management system by allowing different technologies to work together, optimizing overall user experience.

7. Research Ethics

In the proposed project, it will address several ethical considerations to ensure that responsible research practices will be taken. The aspects that would be considered includes data privacy, informed consent and the overall impact it has on the users.

Though the proposed project is mostly a personal work and does not involve others, it is paramount that some form of consent should be requested for a commercial release, especially for the data to be used for applied machine learning on the application. Measures that could be taken to ensure this is having a confirmation pop-up implemented at the start of the application, informing users that any data they provide is given voluntarily and may be used for the purposes of the application, including applied machine learning.

To further ensure data privacy, any collected information will be anonymized. Transparency will be maintained by clearly communicating what data is being collected, how it will be used, and the rights of users to withdraw consent or request data deletion at any time. Additionally, only the data necessary for the functionality of the system will be collected, minimizing the risk of misuse.

Regarding the application of machine learning, efforts will be made to ensure that models are trained responsibly, avoiding bias and inaccuracies. The system's suggestions will be designed to support informed decision-making rather than fostering dependency.

Lastly, the project will comply with all relevant legal and institutional guidelines, and an ethics review will be sought to confirm that all ethical standards are met following the General Data Protection Regulation (GDPR).

8. Review of Reference Materials

To assist in the development of the proposed project, gaining a further understanding on the Arduino platform by explaining the intricacies of different components that are used in many projects, the book “Exploring Arduino: Tools and Techniques for Engineering Wizardry” (Blum, 2019) is studied. In addition, to ensure that the code bases for the application are up to standard, the book “Head First Design Patterns: Building Extensible & Maintainable Object-Oriented Software” (Freeman and Robson, 2020) is referenced as it explains the concept of object-oriented designs in a digestible manner, thus making it easily accessible**.** Therefore, the two books in conjunction would ensure that the proposed project has a solid technical foundation, with well-structured code.

On the topic of automated greenhouse monitoring, an example of a similar project was referenced from an article. With this article, it further supports the validity, purpose and benefits of the proposed project, stating that the increase in production of crops in minimal time could be attributed to the successful design of the smart greenhouse control system while also can be commercialized for small-scale farmers and hobbyist (Saddiqui *et al*., 2017).

Besides that, to aid in research is the articles “Towards automated greenhouse: A state of the art review on greenhouse monitoring methods and technologies based on internet of things” (Li *et al*., 2021), which explains the effects of humidity on the environment in a greenhouse and the blog “Controlling greenhouse temperature for successful production” (Runkle, 2024) that explains how temperature manipulation impacts plant growth, are cited. With the combination of the two articles mentioned, it helps in justifying the reasoning and importance for the two variables (Temperature and Humidity) to be recoded and its influence on crop growth.

Moreover, to further support that temperature and humidity are important data points to be recorded, it was also noticed that warmer air has moisture-holding capacity than cooler air, which implies that with an increase in

temperature, the relative humidity decreases (University of Massachusetts Amherst, 2015). As such, it is essential to optimise the temperature and humidity in a greenhouse, with the article “Review of optimum temperature, humidity, and vapour pressure deficit for microclimate evaluation and control in greenhouse cultivation of tomato: a review” (Shamshiri *et al*., 2018) giving further elaboration on the effects of suboptimal temperature and humidity on greenhouse cultivation and how to optimise these two variables.

9. Methodology

The methodology that would be used for the development of the proposed project is a personal scrum agile methodology, which applies the scrum practices to an individual person project. I have decided to select this methodology as it gives a clear set of goals in each given scrum period/cycle, thus helping in self-motivation by promoting personal productivity through downsizing the project into parts and time-boxing. Besides that, this methodology allows for a more flexible development cycle as it promotes adaptability by allowing the changing of requirements due to unforeseen challenges. Moreover, review documentation on each scrum cycle would be taken at the end of each week, not only for organizational purposes but also to allow retrospective on the cycle and grant user satisfaction.

However, there are some disadvantages that should be mentioned by selecting this methodology. A worry that could be stated is that it prioritizes features over a more robust code base for the application. Due to its time-boxing nature, it incentivises completing a feature in a set amount of time while not allowing much time for the user to optimize the code after. In addition, managing the backlog of features may also prove to be a challenge, as it requires careful organization and prioritization to ensure that essential tasks are not overlooked. Without proper management, there is a risk of accumulating issues, which could affect the long-term sustainability and maintainability of the project.

Therefore, with the advantages and disadvantages stated, it could be said that the advantages outweigh the disadvantages with proper planning. As such to

mitigate these challenges, I plan to regularly review the backlog, reassess priorities, and allocate time for refactoring when necessary.

For the data usage aspect, a sample dataset “Daily climate in Delhi. ARIMA with TimeSeries” from Kaggle (Georgy Zubkov, 2017) would be used that includes the temperature and humidity of a given environment. If time permits, I will also create my own dataset using the project in my own greenhouse. This personalized dataset will not only validate the findings from using the Kaggle dataset but also provide valuable insights specific to the conditions of my greenhouse, ultimately contributing to a more effective monitoring solution.

10. Project Plan

10.1 Weekly Schedule

<table>
<tr><th></th><th>Mon</th><th>Tue</th><th>Wed</th><th>Thu</th><th>Fri</th><th>Sat</th><th>Sun</th></tr>
<tr><td>09:00</td><td>Break</td><td>Break</td><td>Break</td><td rowspan="3">Project</td><td rowspan="3">Project</td><td rowspan="3">Project</td><td rowspan="3">Project</td></tr>
<tr><td>10:00</td><td>Travel</td><td>Travel</td><td>Travel</td></tr>
<tr><td>11:00</td><td>Lecture</td><td rowspan="2">Tutorial</td><td rowspan="2">Tutorial</td></tr>
<tr><td>12:00</td><td>Lecture</td><td rowspan="2">Study</td><td rowspan="2">Study</td><td rowspan="2">Study</td><td rowspan="2">Study</td></tr>
<tr><td>13:00</td><td>Travel</td><td rowspan="2">Break</td><td>Travel</td></tr>
<tr><td>14:00</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td></tr>
<tr><td>15:00</td><td>Free</td><td>Tutorial</td><td>Free</td><td rowspan="5">Free</td><td>Free</td><td rowspan="5">Free</td><td rowspan="5">Free</td></tr>
<tr><td>16:00</td><td rowspan="3">Project</td><td>Travel</td><td rowspan="3">Project</td><td rowspan="3">Project</td></tr>
<tr><td>17:00</td><td rowspan="3">Project</td></tr>
<tr><td>18:00</td></tr>
<tr><td>19:00</td><td rowspan="2">Study</td><td rowspan="2">Study</td><td rowspan="2">Study</td></tr>
<tr><td>20:00</td><td>Study</td></tr>
<tr><td>21:00</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td><td>Break</td></tr>
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* Project takes a total of 24 hours a week with 15 hours of study a week. Study hours may also be used for project time and vice versa if needed.

10.2 Overview

18th September – 25th September 2024 (1 Week): Project Idea Planning

25th September – 2nd October 2024 (1 Week): Project Research

2nd October – 25th October 2024 (3 Weeks): Project Proposal and Ethics Approval

26th October – 2nd December 2024 (1 Month and 1 Week): Progress Review Poster Preparation and Presentation

3rd December 2024 – 14th March 2025 (3 Months and 1 Week): Project Artefact, Report and Walk-through Video

11. References

Blum, J. (2019) *Exploring Arduino: Tools and Techniques for Engineering Wizardry.* 2nd Edition. Indianapolis: Wiley.

ELEGOO (2024) *ELEGOO Mega 2560 the Most Complete Starter Kit Tutorial.* Available at: https://www.elegoo.com/en-gb/blogs/arduino-projects/elegoo-mega-2560-the-most-complete-starter-kit-tutorial?srsltid=AfmBOoqi5TNNmHabMT6Pf5ucZwCktYBKg3AazW6EX0sUU8CxF47Ux7P5 (Accessed: 18 October 2024)

Freeman, E. and Robson, E. (2020) *Head First Design Patterns: Building Extensible & Maintainable Object-Oriented Software.* 2nd Edition. Beijing: O'Reilly Media, Inc.

Georgy Zubkov (2017) *Daily climate in Delhi. ARIMA with TimeSeries.* Available at: https://www.kaggle.com/code/georgyzubkov/daily-climate-in-delhi-arima-with-timeseries/input (Accessed: 18 October 2024)

Li, H., Guo, Y., Zhao, H., Wang, Y. and Chow, D., 2021. Towards automated greenhouse: A state of the art review on greenhouse monitoring methods and technologies based on internet of things. *Computers and Electronics in Agriculture, 191,* p.106558.

Runkle, E. (2024) Controlling greenhouse temperature for successful production. Available at: https://www.canr.msu.edu/floriculture/uploads/files/Production%20temperature.pdf (Accessed: 18 October 2024)

Shamshiri, R.R., Jones, J.W., Thorp, K.R., Ahmad, D., Man, H.C. and Taheri, S., 2018. Review of optimum temperature, humidity, and vapour pressure deficit for microclimate evaluation and control in greenhouse cultivation of tomato: a review. *International agrophysics*, *32*(2), pp.287-302.

Siddiqui, M.F., Kanwal, N., Mehdi, H., Noor, A. and Khan, M.A., 2017, December. Automation and monitoring of greenhouse. In *2017 International Conference on Information and Communication Technologies (ICICT)* (pp. 197-201). IEEE.

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