

February 20, 2017

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 405W/440 Requirements Specification for Gaia

Dear Dr. Rawicz,

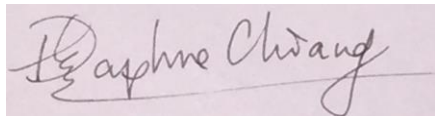
The enclosed document, Requirements Specification for Gaia, describes the features and functional specifications of our project for ENSC 405W/440. We anticipate a product that removes the difficulty of growing plants inside a house. Whether it is an exotic orchid or a plant that yields fresh produce, Gaia provides the necessary care and environment in order for all types of plants to thrive with minimal human dependency.

This document is meant to define the requirements for our system's functions to be achieved during the phases of development. It provides a more in depth view of the system and the system's requirements. Following these specifications, our project team will be working on the research and development of Gaia.

Applied Agricultural Innovations is an up and coming company composed of five engineering students: Daphne Chiang, Sunny Sun, Jenny Cheung, Philip Tang, and Jerry Hung.

Please feel free to contact us for any questions or concerns. We will be pleased to address any of your inquiries by email at mca123@sfu.ca or phone us at 778-875-668.

Sincerely,



Daphne Chiang

CEO
Applied Agricultural Innovations
Attachment: Requirements Specification for Gaia



Requirements Specification Applied Agricultural Innovations

Product - Gaia

February 20, 2017

Team Members:

Daphne Chiang

Philip Tang

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Jerry Hung

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Abstract

Gaia is capable of housing one plant and takes care of a plant's needs including watering, light, temperature, and humidity. This document is the requirements specification of Gaia made by Applied Agricultural Innovations. It outlines requirements for the overall system, individual systems, and user interface. For the overall system, it includes physical, electrical, environmental, standards, reliability, durability, safety, performance, usability, sustainability, microcontroller, and luxury requirements. Individual systems are separated by features: watering, lighting, humidity, and temperature control systems. Each system, including user interface, contains general and hardware requirements. The safety features, standards, and guidelines outlined by associations such as the CSA, IEC, and the National Fire Protection Association are referred to in the document.



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Glossary

CSA	Short for Canadian Standards Association
IEC	Short for International Electrotechnical Committee
LCD	Liquid crystal display
LED	Light-emitting diode, a semiconductor diode that emits light when a voltage is applied
Microcontroller	A computer present in a single integrated circuit, which is dedicated to perform one, task and execute one specific application. It contains memory, programmable input/output peripherals as well a processor
MTBF	Short for mean time before failure
NFPA	Short for National Fire Prevention Association
UI	Short for user interface
UV	Short for ultraviolet, an electromagnetic radiation with a wavelength from 10 nm (30 PHz) to 400 nm (750 THz)



1. Introduction

Gaia is an automated plant care device that will seamlessly control the temperature, humidity, lighting, and watering in its enclosed environment. It aims to provide maximum plant care to its input plant species while requiring the minimum amount of work from the users. Through the careful sensing of the internal elements such as temperature and moisture, Gaia will diligently adjust the environment to be suitable for its plant by means of its many actuators working in tandem. The requirements that best describe the necessary outcomes of Gaia, as proposed by Applied Agricultural Innovations, are described in this requirements specification.

1.1. Scope

This document outlines the requirements specifications for Gaia produced by Applied Agricultural Innovations. The listed requirements will be a guide for designing Gaia. It fully describes the prototype and production device.

1.2. Intended Audience

The requirements specification is intended for all staff of Applied Agricultural Innovations. These requirements are the standards and descriptions for engineers to design Gaia. This document will be referred to during design, implementation, and testing phases. The project manager shall refer to the requirements throughout the progress of the development phase. Design engineers shall refer to the requirements as they design and implement the product. Test engineers shall refer to this document to test if the functionalities meet the requirement.

1.3. Requirement Classification

Throughout every section in this document, the chosen convention for denoting the requirements will be as follows:

[Rn-p] Requirements Label

where 'n' represents the requirement number and 'p' upholds the priority designation divided into the three levels:

- I Applies to only the prototype system design
- II Applies to prototype system design and final production
- III Applies to final production system only

of which the lower the Roman numeral, the higher the priority.



2. System Requirements

2.1. System Overview

Gaia is built up as a rectangular prism that will house a potted plant and take care of its watering, lighting, humidity, and temperature needs. Figure 1 shows the concept design of Gaia describing the main dimensions of the prototype and its general appearance. Some of its main features includes the clear top where the plant will sit in, the control unit, and the water tank at the bottom of the device.

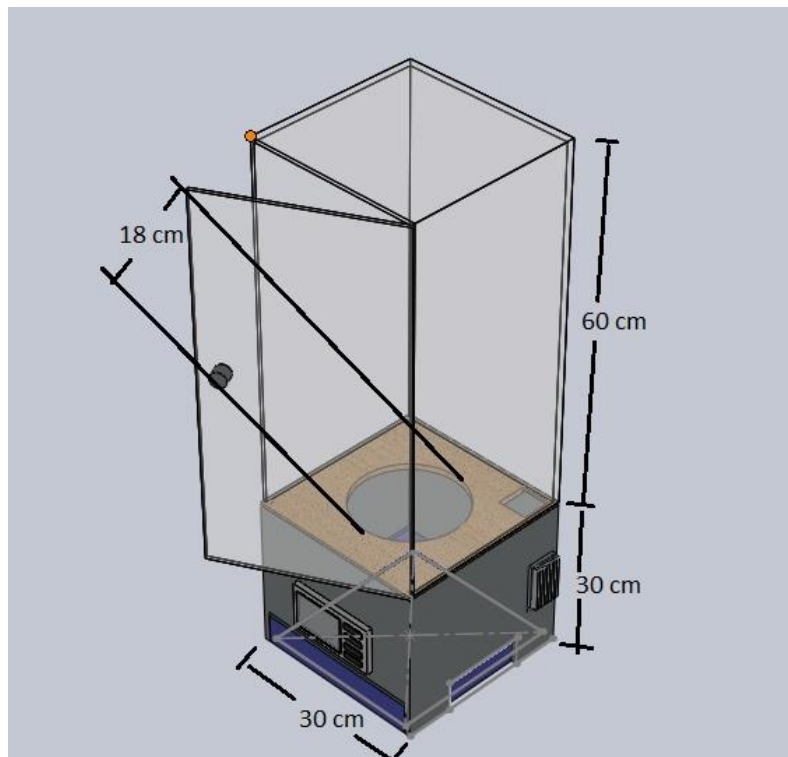


Figure 1: Conceptual Physical Design of Gaia

According to the diagram below, Figure 2, the UI and sensors will be providing input to the microcontroller. The UI will set the environment to the plant type as selected by the user while the sensors will be sending information on the temperature, humidity, and light of the plant's environment. Depending on this data the microcontroller will be activating the thermoelectric device and fan, the water pump, or the lights in response.



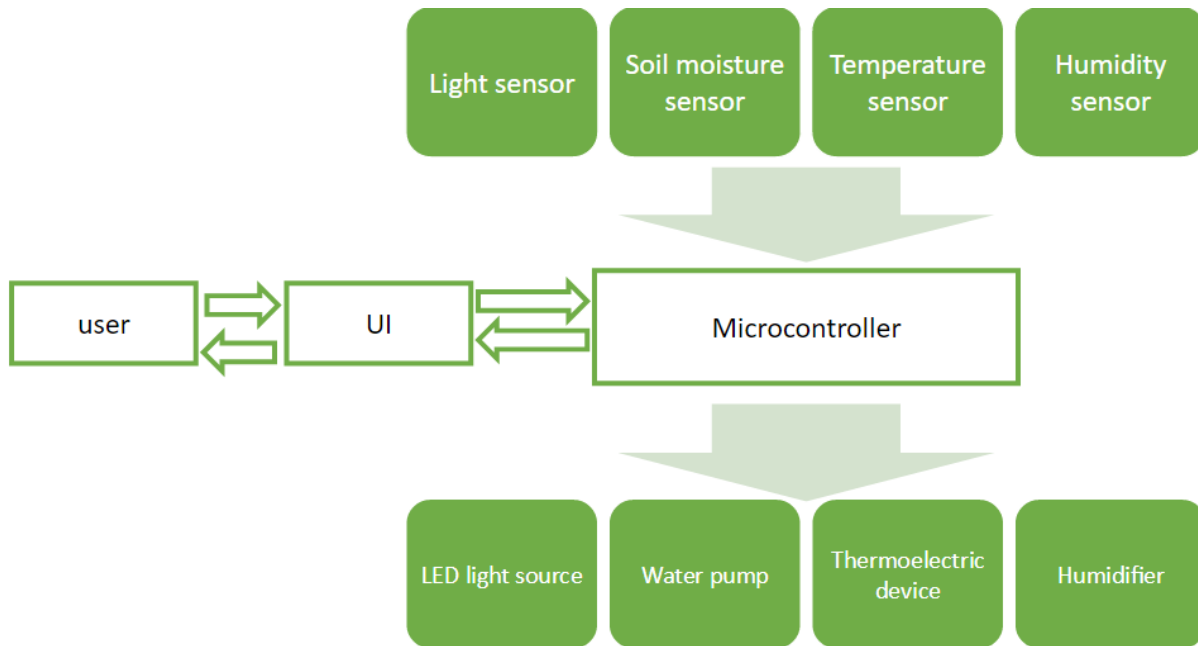


Figure 2: High-Level System Diagram

Figure 3 is the updated flowchart that describes the process of Gaia. When using Gaia, the first step is to pick the type of plant that the device is to care for. The microcontroller will be receiving data on the amount of light, moisture, and temperature the plant is exposed to. If the condition of the plant is not ideal then the microcontroller will activate the related devices and adjust the light, moisture or temperature levels until the factors are back to the ideal condition. The devices will be switched off again and the microcontroller goes back to analyzing the data the sensors are sending until there is a change in the environment or until the settings of the plant type is changed. If the plant type is changed then Gaia will immediately adjust the current factors until it is at the optimum environment for the new plant selected.



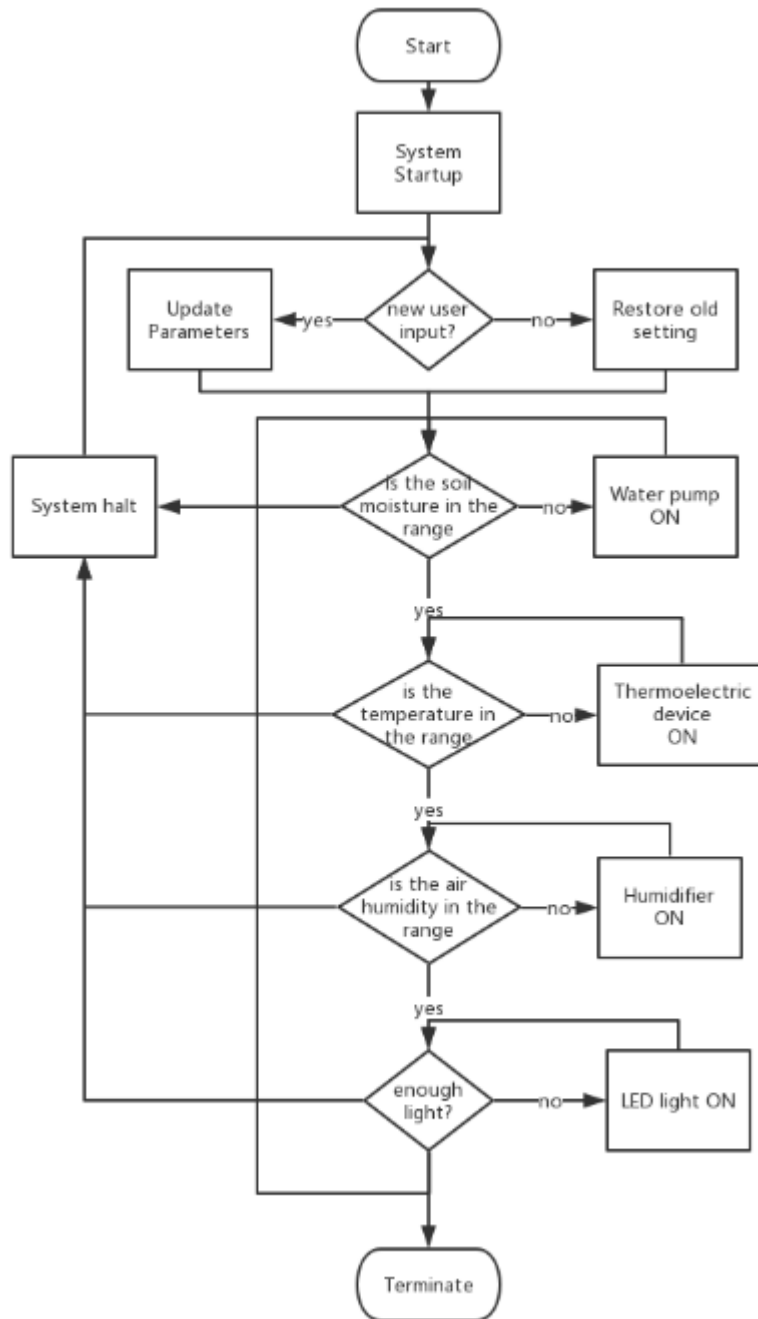


Figure 3: Flow Chart of Gaia



2.2. General Requirements

- [R1-III] The retail price of the final product shall not exceed \$350.
- [R2-II] Flowerpots shall be replaceable.
- [R3-II] Flowerpots shall be provided by users.
- [R4-I] The device shall support no less than 8 species of plants.

2.3. Physical Requirements

- [R5-II] The shape of the device shall look like a rectangular prism.
- [R6-II] The base of the device shall be under 50 x 50 cm in area.
- [R7-II] The height of the device shall not exceed 100 cm.
- [R8-II] The device shall be visually appealing.
- [R9-II] The device shall have a transparent enclosure.
- [R10-III] The enclosure shall be resistant to condensation.
- [R11-II] The water tank will hold a minimum of 2 L in water.
- [R12-II] The upper enclosure shall have ventilation gaps to provide air circulation.
- [R13-II] The material of the base shall be rigid and 8-12 mm thick.
- [R14-I] Supported flowerpots shall not exceed 180 mm in width and depth.
- [R15-II] The base structure with electrical components shall be opaque.

2.4. Electrical Requirements

- [R16-I] The power consumption shall be no greater than 100 W.
- [R17-II] The system shall run on 120 V AC 60 Hz from standard wall outlets.
- [R18-I] The system shall use 12 V DC or lower to power internal components.
- [R19-II] All electrical components shall be grounded.
- [R20-II] None waterproof electrical components shall be sealed to prevent possible damage.

2.5. Environment Requirements

- [R21-II] The system shall operate in temperatures between 15 °C and 30 °C.
- [R22-II] The system shall be running with minimal noise.
- [R23-II] The device shall operate on a flat, indoor surface.
- [R24-II] The system shall be operational in typical indoor humidity 40%-50%.^[1]

2.6. Standards Requirements

- [R25-III] All electrical installation shall follow the IEC 60634-1: Low-voltage electrical installations.^[2]



- [R26-III] All electrical installation shall follow IEC 61558-1: Safety of power transformers, power supplies, reactors, and similar products. [3]
- [R27-III] Plugs and socket-outlets for domestic and similar general shall follow IEC 60083. [4]
- [R28-III] All electrical connections shall follow Canadian Standards Association. [5]
- [R29-III] The device shall pass the UV test for photovoltaic (PV) modules IEC 61345. [6]
- [R30-III] The device shall follow the NFPA 70: National Electrical Code. [7]

2.7. Reliability and Durability Requirements

- [R31-III] Device shall be able to withstand UV light on all visible surfaces for at least 3 years.
- [R32-II] Device shall be able to support the weight of a plant and soil up to at least 8 Kg with a safety factor of 2.
- [R33-II] Device shall be sturdy and shatter-resistant.
- [R34-II] All systems shall be serviceable by trained technician.
- [R35-III] The MTBF of Gaia shall be no less than 25,000 hours.

2.8. Safety Requirements

- [R36-II] All interconnects shall be insulated.
- [R37-II] The electronic components shall be protected from contact with water.
- [R38-II] In the event of detected errors, the system shall stop all functions.
- [R39-II] All electrical components shall be grounded.
- [R40-III] Most of the electrical components shall not be exposed to physical contact.
- [R41-II] Water flow shall be designed to avoid most of the electronic parts.
- [R42-II] No external component shall be above 45 °C to the touch.
- [R43-II] Device shall not spontaneously combust.
- [R44-II] The device should not have sharp, exposed edges.
- [R45-III] When the door is open, all automatic functions should be suspended.

2.9. Performance Requirements

- [R46-II] The system shall respond to user input within 1 second.
- [R47-II] All features shall respond to internal environment within 5 minutes.
- [R48-II] Device shall indicate that it is ready for use within 30 seconds of activation.

2.10. Usability Requirements

- [R49-II] The overall weight and bulk of the device shall be low enough to be comfortably carried by an adult for at least 10 m. [8]
- [R50-II] Waste heat shall have minimal influence on its operating environment.



[R51-II] Interior of enclosure shall be easily accessible for cleaning and replacing plants.

2.11. Sustainability Requirements

[R52-I] As many of the components shall be from reused parts if available.

[R53-III] The construction material of Gaia shall be from at least 25% recycled material.

[R54-III] The device shall be recyclable at electronics recycling facilities.

[R55-I] The disassembly of the device shall not hinder usability of electrical components.

2.12. Luxury Requirements

[R56-III] The system shall have Wi-Fi support.

[R57-III] The UI shall be implemented as a phone application.

[R58-III] Fertilizer will be incorporated into the features.

3. Watering Requirements

3.1. General Requirements

[R59-II] Watering shall be powered by an electric pump.

[R60-II] Watering shall be triggered by a soil moisture sensor and timing.

[R61-II] Water shall be drawn from the water tank and reach a height of at least 30 cm.

[R62-II] Water in housing section shall drain back to water tank.

[R63-II] Water LED indicator shall be on when feature is operating.

[R64-II] Low water level LED shall be on when the water level is low.

[R65-II] Empty water tank LED shall be on when the water tank is empty.

[R66-II] Water system will be disabled when the water tank is empty.

3.2. Hardware Requirements

[R67-II] Watering system shall be interconnected with microcontroller and a power source.

[R68-II] Water tank shall be refillable by users.

[R69-III] Water tank shall be easily removable for cleaning.

[R70-II] Sensors for moisture shall be waterproof.

4. Lighting Requirements

4.1. General Requirements

[R71-II] Lighting system shall provide blue, red, natural, and UV lighting.

[R72-II] Lighting system shall supplement or replace external lighting if external lighting is insufficient for plant.



- [R73-II] Lighting system shall provide multiple levels of intensities of lighting.
- [R74-II] Lighting LED indicator shall be on when feature is operating.

4.2. Hardware Requirements

- [R75-II] Lighting system shall be interconnected with microcontroller and power source.
- [R76-II] The sensors shall be waterproof.
- [R77-II] The light sources shall be waterproof in case of humid conditions.

5. Humidity Requirements

5.1. General Requirements

- [R78-II] Humidity control system shall increase humidity if air is too dry.
- [R79-II] Humidity control shall be triggered by humidity sensors.
- [R80-II] Humidity increase shall be at least 15% humidity in working conditions.
- [R81-II] Humidity LED indicator shall be on when feature is operating.
- [R82-II] Humidity system will be disabled when the water tank is empty.

5.2. Hardware Requirements

- [R83-II] Humidity control system shall be interconnected with microcontroller and power source.
- [R84-II] Humidity sensors shall be waterproof.

6. Temperature Requirements

6.1. General Requirements

- [R85-II] Temperature control system shall be capable of heating up enclosure to +10 °C of ambient temperature.
- [R86-II] Temperature control system shall be capable of cooling down enclosure to -5 °C of ambient temperature.
- [R87-II] Temperature control functions shall be triggered by temperature sensors.
- [R88-II] Temperature control system shall keep the internal temperature within the thresholds dictated by plant species otherwise a warning will be issued.
- [R89-II] The heat output during regular operation will not greatly affect the temperature outside of the enclosure.
- [R90-II] Temperature LED indicator shall be on when feature is operating.



6.2. Hardware Requirements

- [R91-II] Temperature control system shall be interconnected with microcontroller and power source.
- [R92-II] The power consumption shall be no greater than 60 W.
- [R93-II] The waste heat shall dissipate outside the enclosure as evenly as possible during cooling.

7. User Interface Requirements

7.1. General Requirements

- [R94-III] The interface shall have a time of day selection.

7.2. Hardware Requirements

- [R95-II] Interface shall have 3 buttons for plant selection.
- [R96-II] Interface shall have 1 on/off switch.
- [R97-II] There shall be an LCD display for plant selection and info.

8. Arduino Requirements

- [R98-II] The main board shall have a form of non-volatile memory. ^[9]
- [R99-I] The main board shall run on 12 V. ^[9]
- [R100-II] The main board shall support both analog and digital I/O. ^[9]
- [R101-III] The main board shall support Wi-Fi/Bluetooth. ^[9]
- [R102-II] The main board shall have an LCD screen connector. ^[9]

9. User Documentation

The user documentation for Gaia will be a comprehensive manual in Chinese, English and French. It shall have the company logo and contact information in an easy to find location. The manual should cover the instructions for operating Gaia in a simple, step-by-step format targeted for an audience with minimal knowledge of plants or technical background. The manual must provide information on how to maintain the device for optimal performance. Also included should be the limitations of Gaia and all relevant safety information.



10. Conclusion

The requirements specification gives clear definitions and expectations of the capabilities and requirements of Gaia. The design of Gaia consists of the environmental control systems: watering, lighting, humidity, temperature, and the UI. Additional specifications for Gaia include the general, physical, electrical, environment, standards, reliability, durability, safety, performance, usability, sustainability, luxury, and Arduino requirements of the device. All of Gaia's requirements have been numbered and given a rank in priority for development. The watering, lighting, humidity, temperature, and user interface requirements are further split into general and hardware requirements. The development of all models from proof-of-concept to production shall follow all the requirements and be implemented with the best designs described in the Design Specification.



References

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