Project Deliverable D:
Conceptual Design

Submitted by:

Group 10

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Abstract

This report consists of a set of conceptual design sketches in relation to previous benchmarking and three chosen design criteria. Each member of the group will research and sketch concepts on temperature sensors, compactability, and attachability. The best suited sketches or combination of sketches will be saved as solutions to be developed in our future work.

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1.0 Introduction

In this deliverable, various conceptual designs were developed by each team member for three subsystems that will form a completed solution to the team's problem statement. The three subsystems are i) Temperature Sensor, ii) Sensor interfacing, and iii) Sensor Housing/Placement. Based on the problem statement, benchmarking and list of prioritized design criteria, the subsystem concepts will be analyzed and evaluated in order to identify multiple global concepts for further investigation.

1.1. Problem Statement

Safely delivering food to clients in the rural area, while continuously exchanging accurate data with the operator about the package's and the drone's climate. Ultimately determining the good standing of the buyer's package and the condition of the drone.

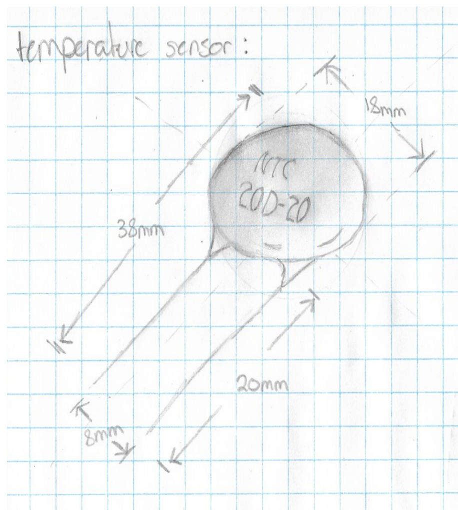
2.0 Temperature/Humidity Sensor Concepts

The temperature sensor subsystem will be responsible for the collection of temperature and/or humidity data. Data output should be accurate and continuous.

2.1. Benjamin Hotte - NTC thermistor

Thermistors are resistors that fluctuate depending on the temperature. As such, they are often used as temperature sensors: “ Thermistors are highly accurate (ranging from ± 0.05°C to ± 1.5°C) [...]”[1] They are also perfect temperature sensors for canadian summer: “The working temperature range for most thermistors is between 0°C and 100°C”[2]. NTC thermistors stands for negative temperature coefficient, simply meaning “the resistance decreases with increasing temperature”.[3]

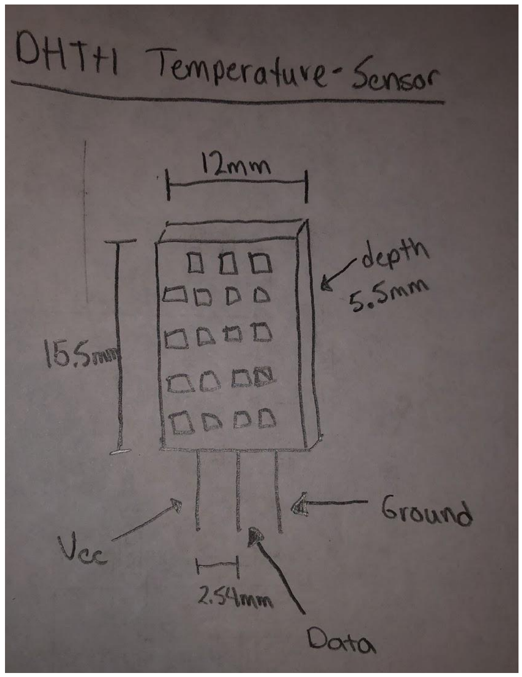
Specs : [4]



2.2.

2.3. Evan Lacroix - DHT11 temperature and humidity sensor

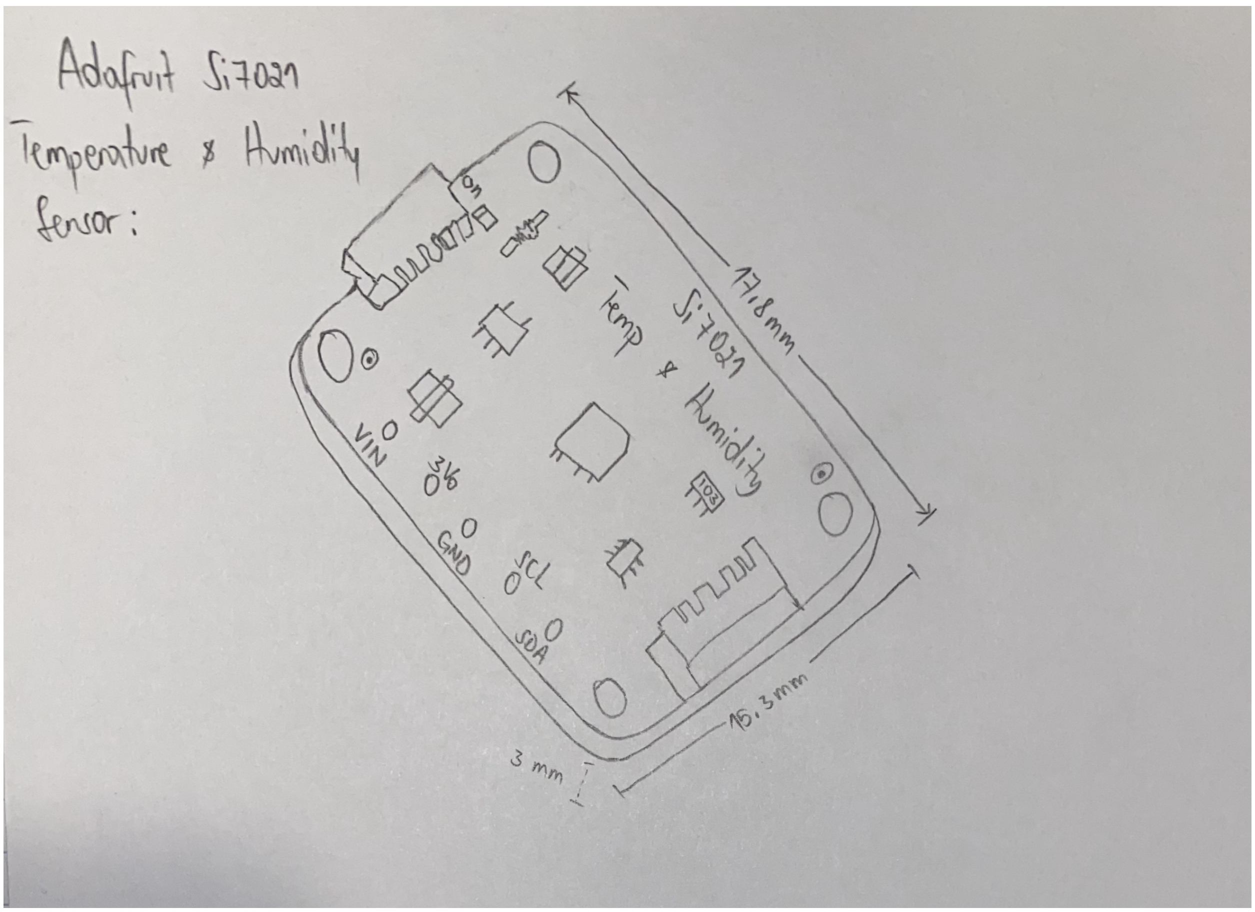
The DHT11 temperature and humidity is a very accurate and compact sensor perfect for the JAMZ drone. It can read temperatures from 0°C to 50°C and is accurate to within $\pm$ 1°C. It can also read humidity levels ranging from 20-80% with a 5% accuracy[5]. The sensor outputs serial data, and is very cheap and easy to set up.



2.4. Alison Kamikazi - Adafruit Si7021 Temperature + Humidity Sensor

The Adafruit Si7021 is a highly reliable sensor which reads temperatures ranging from -10 to +85 ºC with a ± 0.4 ºC accuracy[6]. It is easy to use, light, has a voltage regulator and is compatible with the Arduino Uno among other microcontrollers.

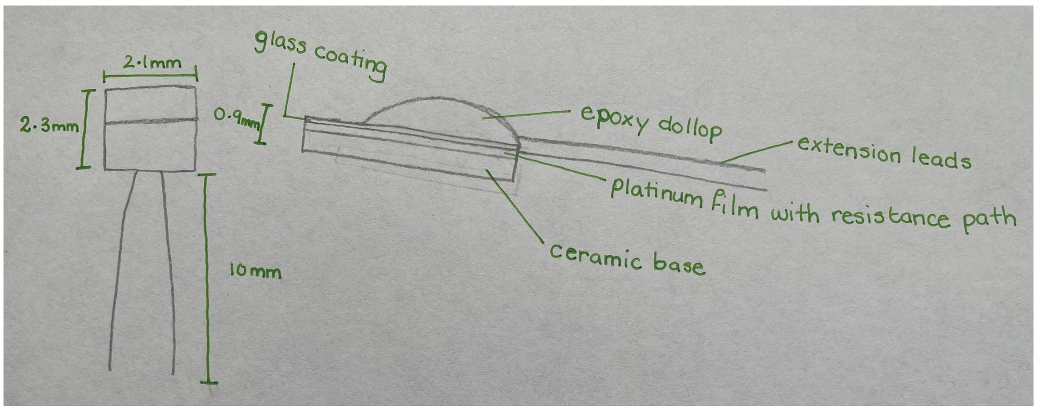
This sensor has “± 3% relative humidity measurements with a range of 0–80% RH”[7]. It can be used with 3.3V or 5V systems. An 86.18 grams Adafruit (PID 3251) Si7021 Temperature & Humidity Sensor Breakout Board can be bought on amazon for CDN$ 39.94 [8]



2.5.

2.6. Supathira Uthayakumar- Thin Film RTD Temperature Sensors

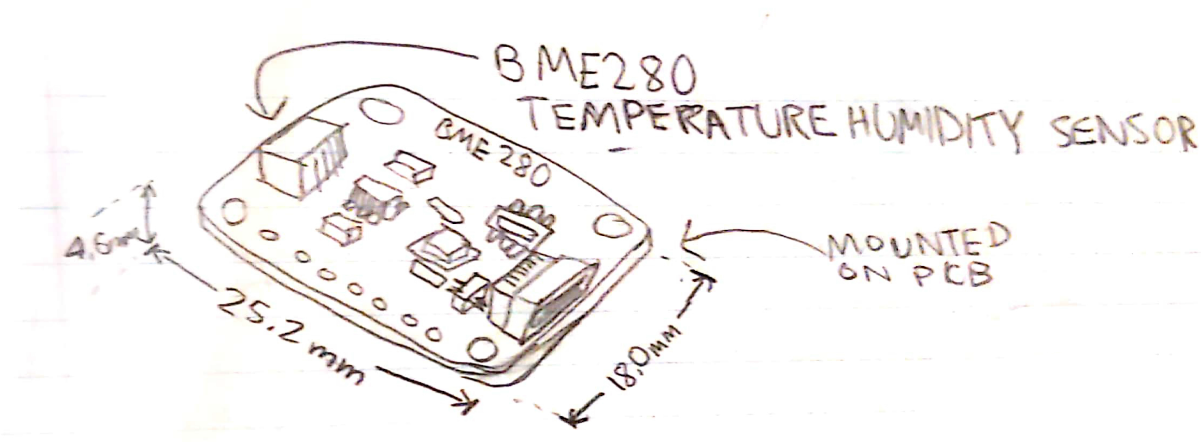
An RTD is a sensor whose resistance changes as its temperature changes; as the temperature of the sensor increases the resistance increases. The RTD temperature sensor provides precise data through proven design, ease-of-use, reliable performance, and quick availability[9]. The sensor uses this method to detect temperatures in the range -70℃ to 600℃[10]. While being able to detect the temperature at such a range the dimensions of the sensor is 2.1x0.9x12.3mm. The thin film allows for the resistor to be extremely flexible hence cost-effective[11].



2.7.

2.8. Gabriel Krausert - BME280

This concept uses a BME280 temperature and humidity sensor. This sensor can also measure pressure (not a part of target specifications). The BME280 can measure temperatures from -40 to +85 ºC with a ± 1.0 ºC accuracy, and humidity measurements of 0-100% and an accuracy of ± 3% relative humidity [12]. It can be purchased pre-mounted on a PCB which includes voltage regulators so can be used with 3.3V or 5V. It can be connected directly to many types of microcontrollers by either I2C or SPI. Compatible with Arduino IDE. The BME280 can be bought on Adafruit for $14.95 and weighs only 55 mg.



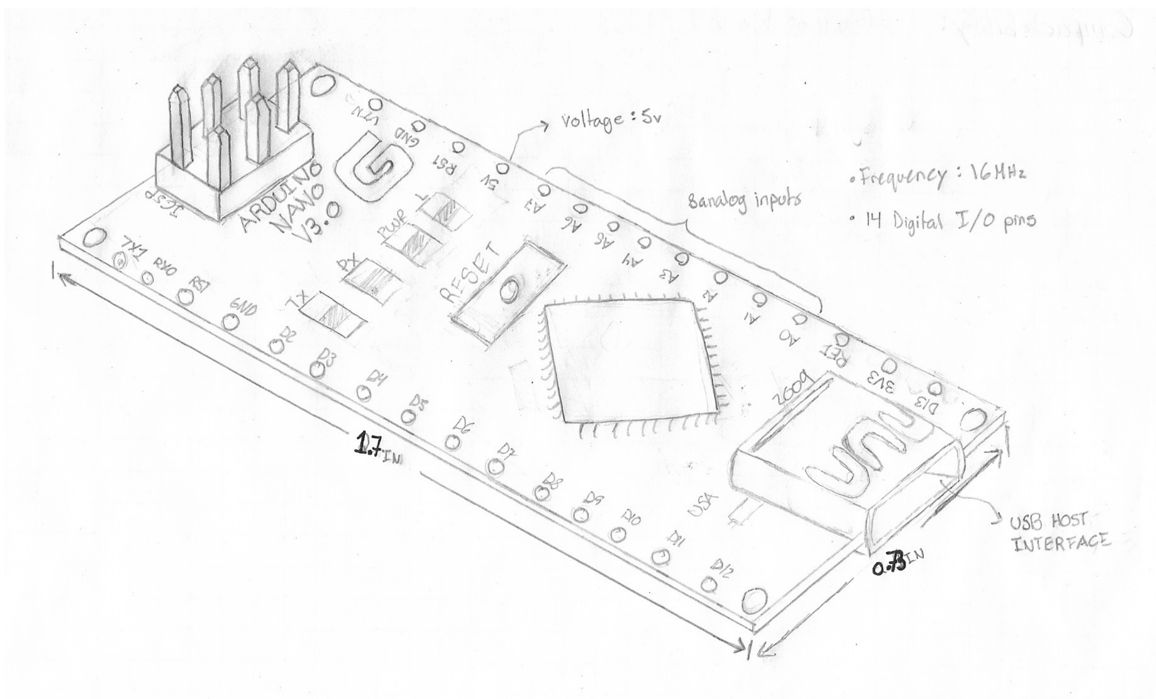
3.0

4.0 Sensor Interfacing Concepts

The sensor interfacing subsystem will be the interface between the environmental sensor and the drone's computational platform. This subsystem is responsible for powering the sensor and receiving the data from the sensor in serial communication.

4.1. Benjamin Hotte Arduino Nano

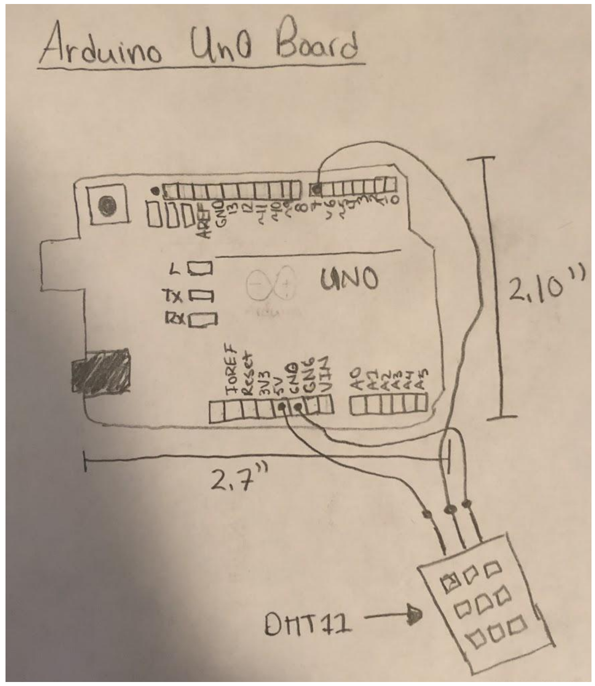
The arduino nano has a 5v input, 16Mhz clock speed, 14 digital I/O pins and 8 analog inputs. It has a USB host interface connection and is compatible with all the above mentioned temperature sensors.



4.2.

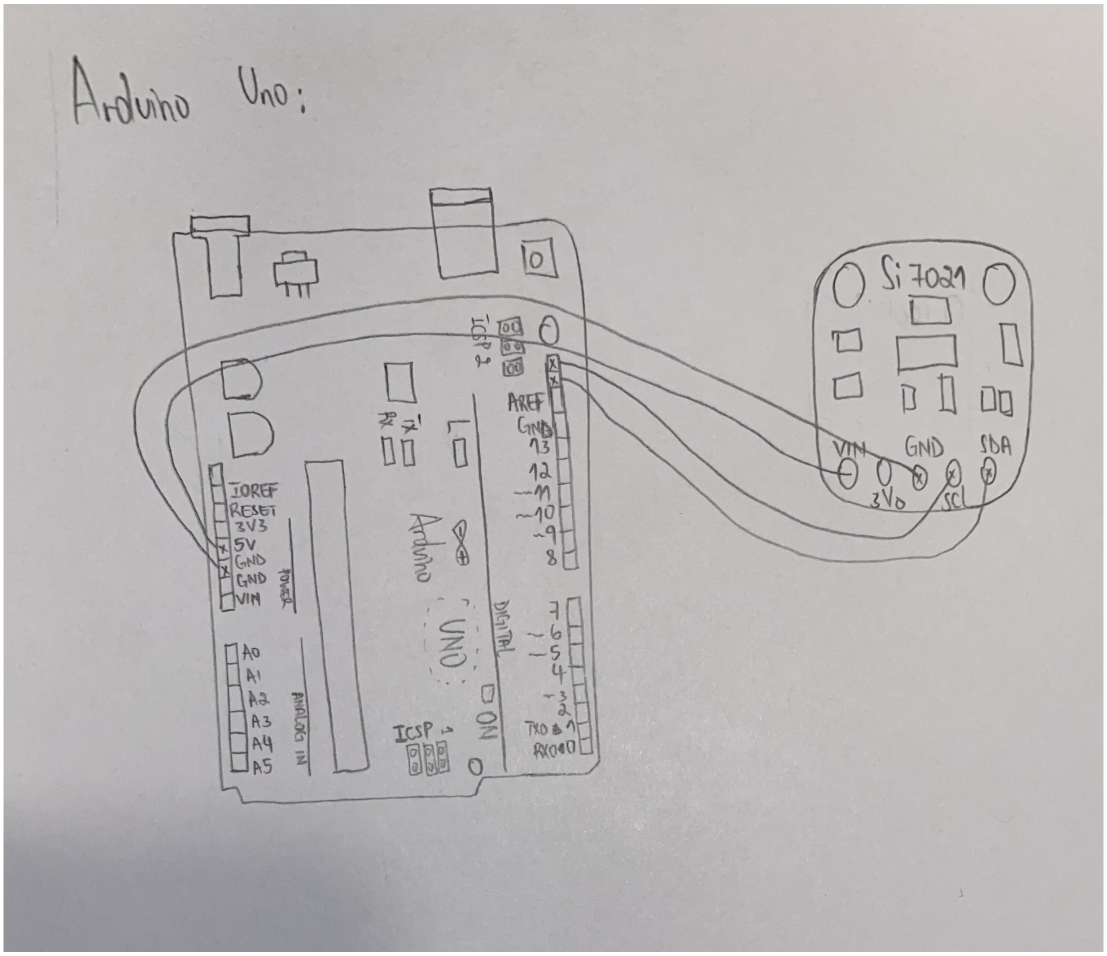
4.3. Evan Lacroix- Arduino Uno

The arduino uno which is compatible with the dht11 is again a very small and compact board required for the temperature sensor to run. We are trying to minimize the size of our sensor and the arduino uno board is definitely on to consider. It operates using 5V and will also transmit serial data.



4.4. Alison Kamikazi- Arduino Uno

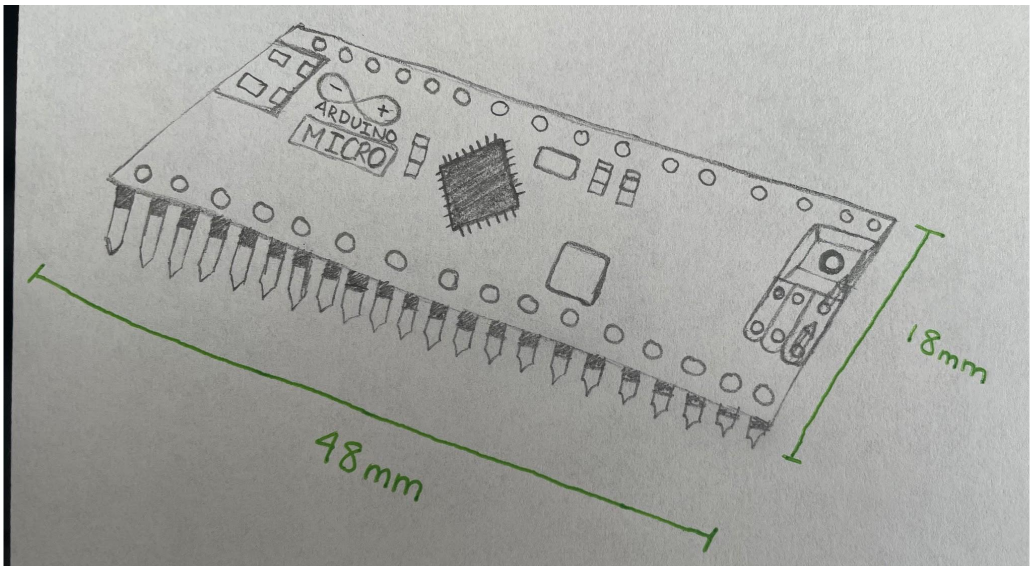
This microcontroller board uses I2C to communicate and transmit data, 2 pins are required to interface with the sensor. It has 14 digital and 6 analog input/output pins, a USB connection, a power jack and its operating voltage is 5V.



4.5.

4.6. Supathira Uthayakumar- Arduino Micro

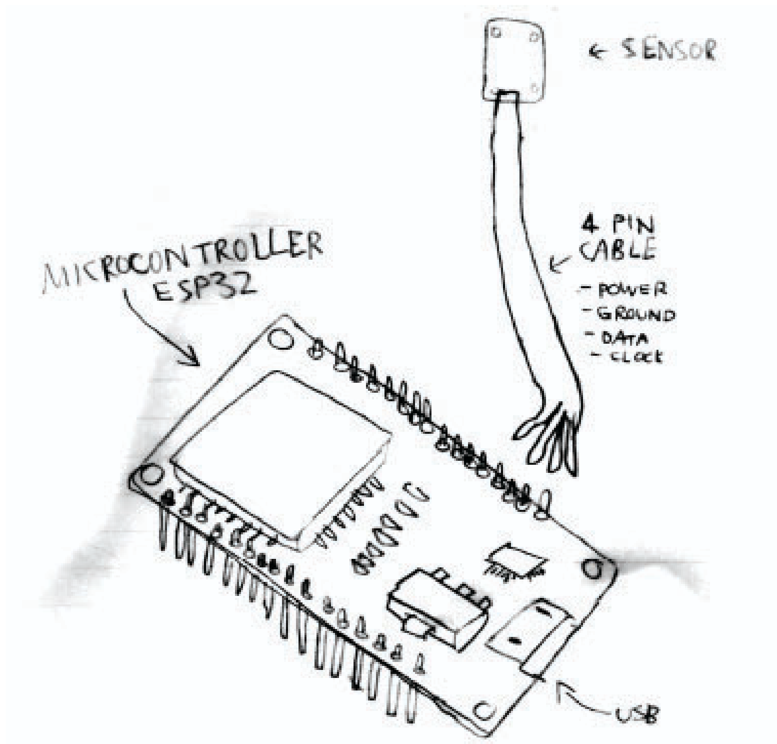
The micro comes with a built-in USB thus eliminating the need for a secondary processor, and allows it to appear as a mouse, keyboard in addition to a virtual (CDC) serial / COM port[13]. It has 20 digital input/output pins. It has an operating voltage of 5, allowing it to function with any shield. The Arduino also has a clock speed of 16 MHz. The Arduino has a length of 48 mm while having a width of 18mm. Above all the Arduino only weighs 13 g and has an average price of $20.70.



4.7.

4.8. Gabriel Krausert

The BME280 sensor can be connected to a microcontroller by 4 pin cable (power, ground, data, clock). Possible microcontroller: ESP32

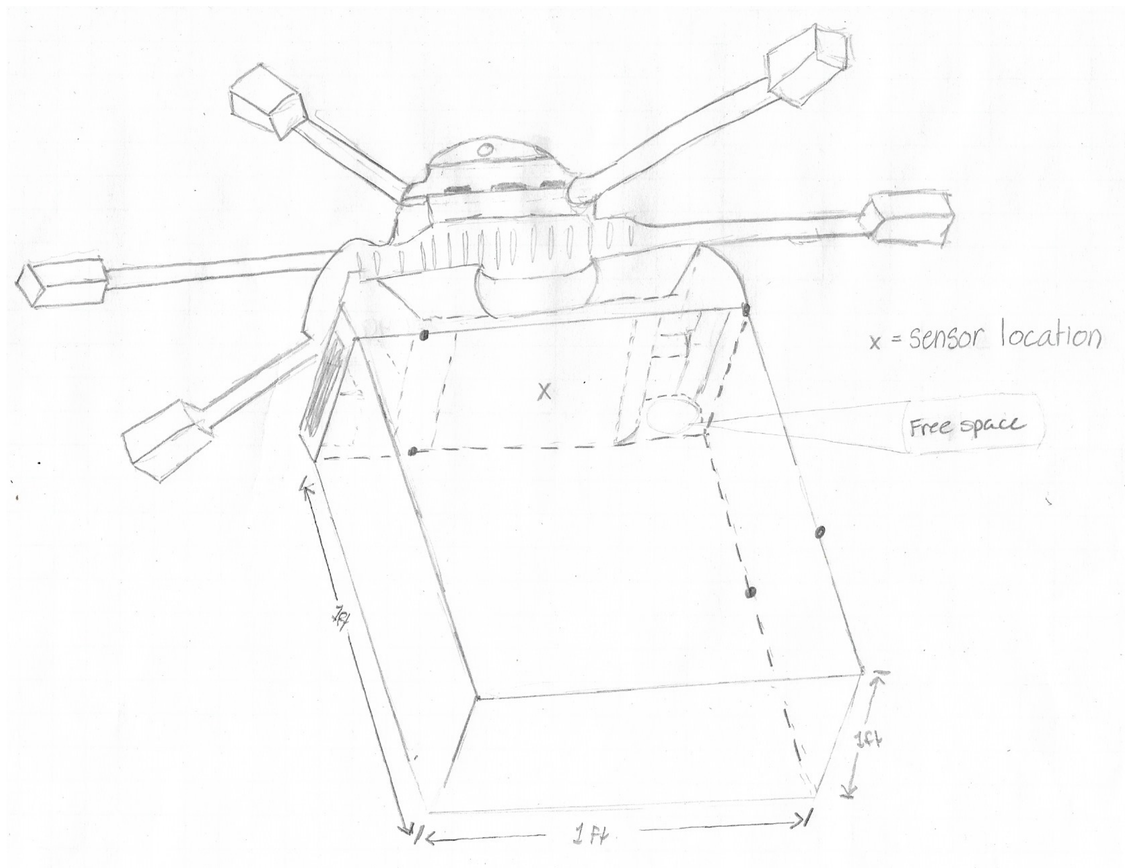


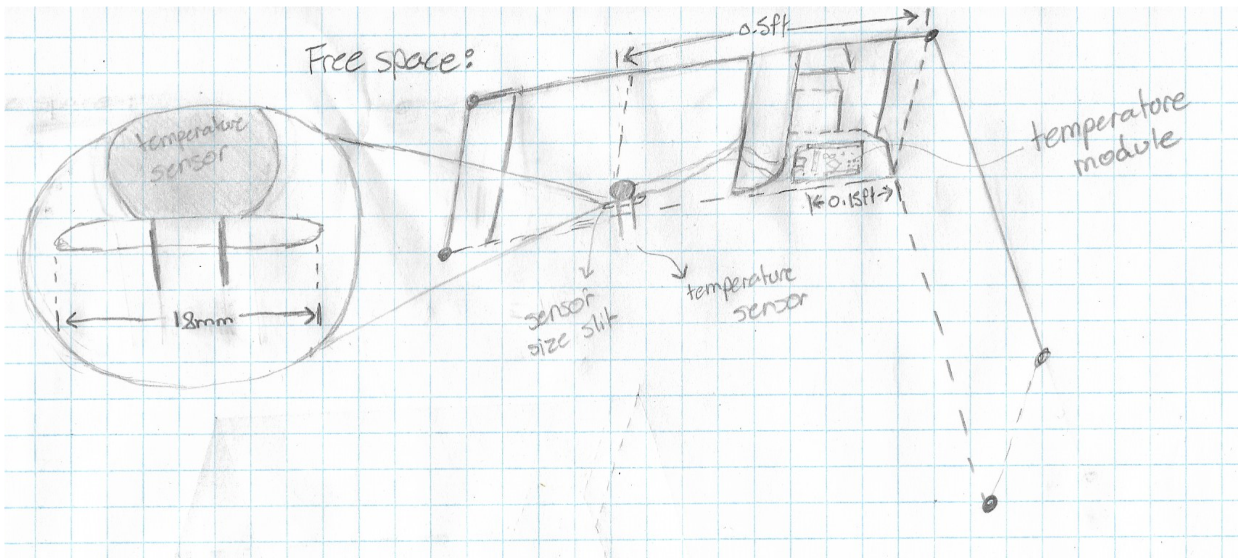
5.0

6.0 Sensor Housing/Placement Concepts

6.1. Benjamin Hotte

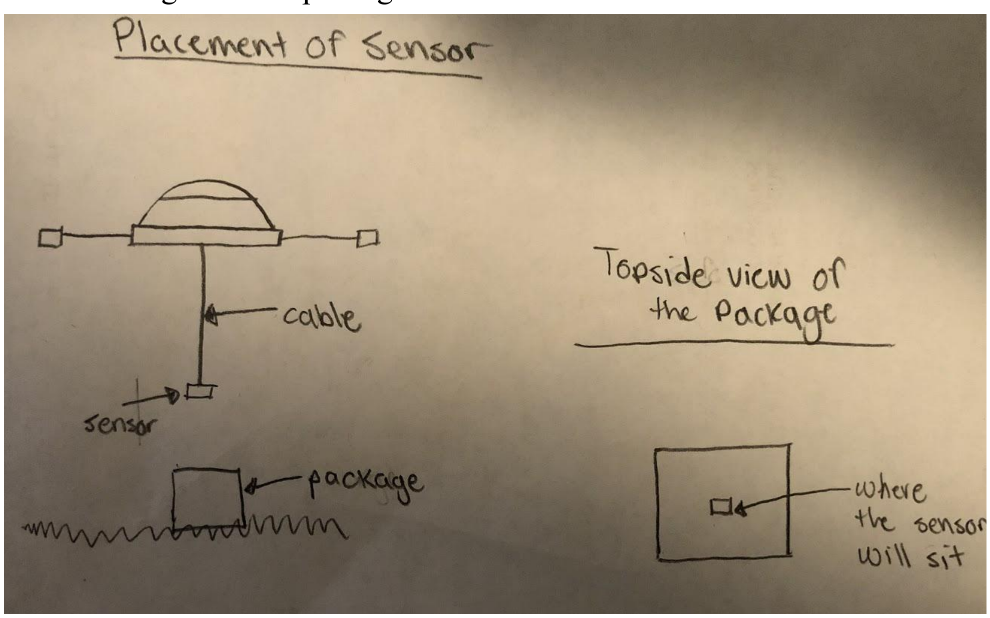
The sensor will be connected directly to the drone body, peeking through the box with a hole on at the top. The sensor hole will be of even size of the sensor. As such, the hole in the box will be limited to not affect the insulation of the box. Also, when the box is being dropped down, the sensor will simply slide out of the box. The downside of this, is that the temperature sensor will therefore not be used when arrived at the delivery location.





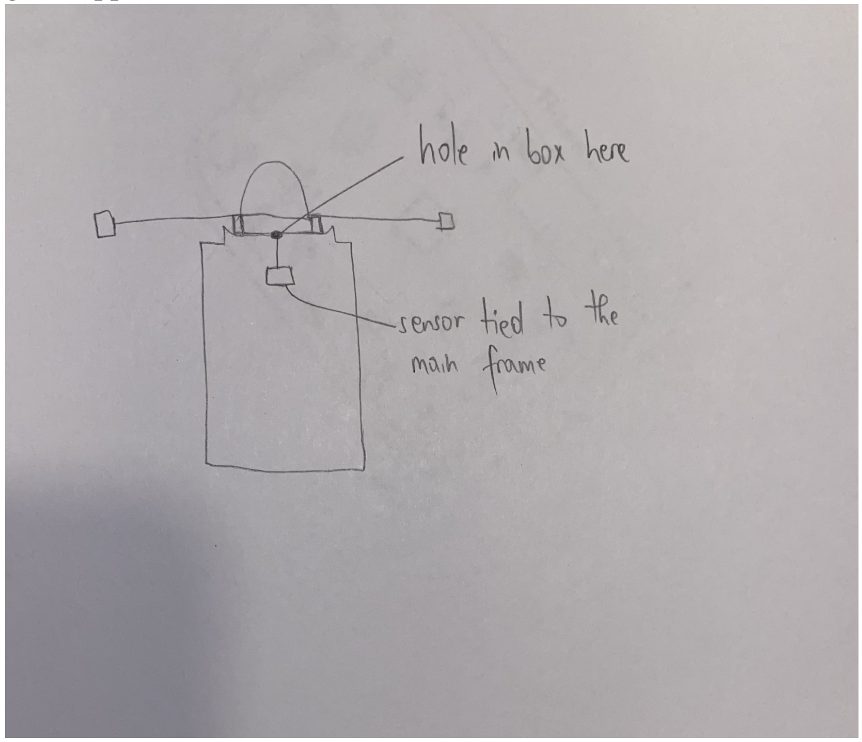
6.2. Evan Lacroix - Attached to the Winch System

By attaching the sensor to the winch, it will solve the problem of how to have the sensor inside the box but not have the customer take it as well. There can be a small hole in the box that is covered by the sensor until the package is finally delivered. Giving the most accurate reading from the package.

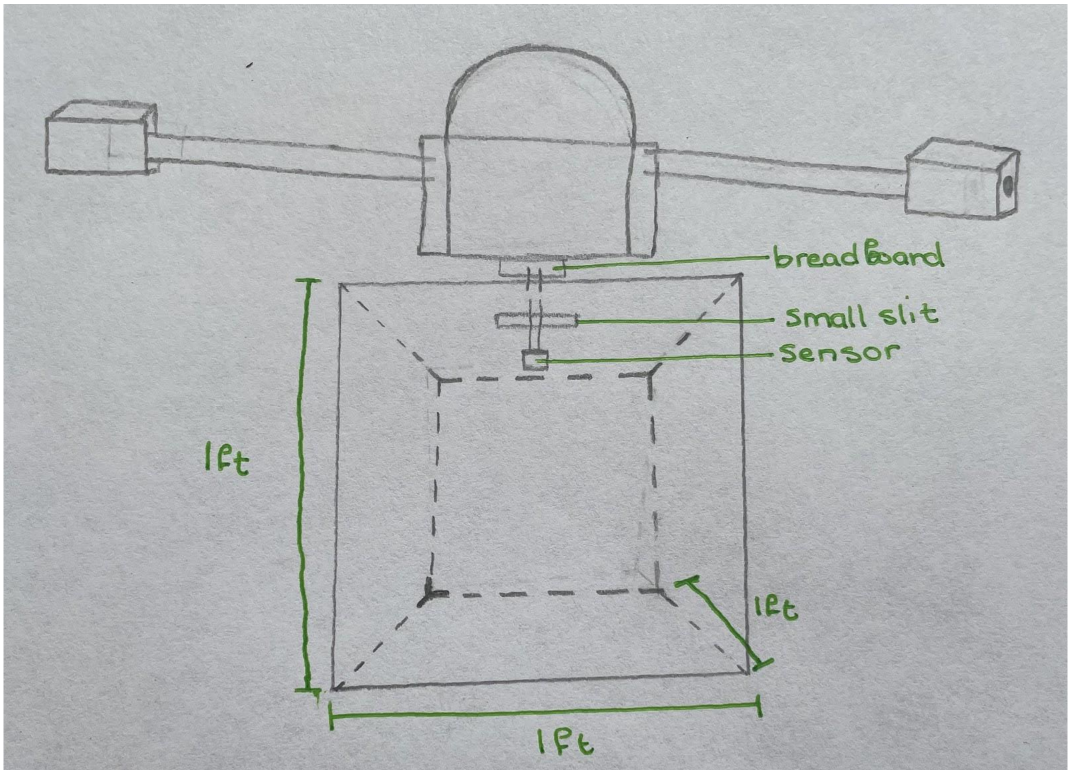


6.3. Alison Kamikazi

The sensor can be attached securely to the mainframe through a small hole in the box so that it does not get dropped with the food as well.



6.4. Supathira Uthayakumar

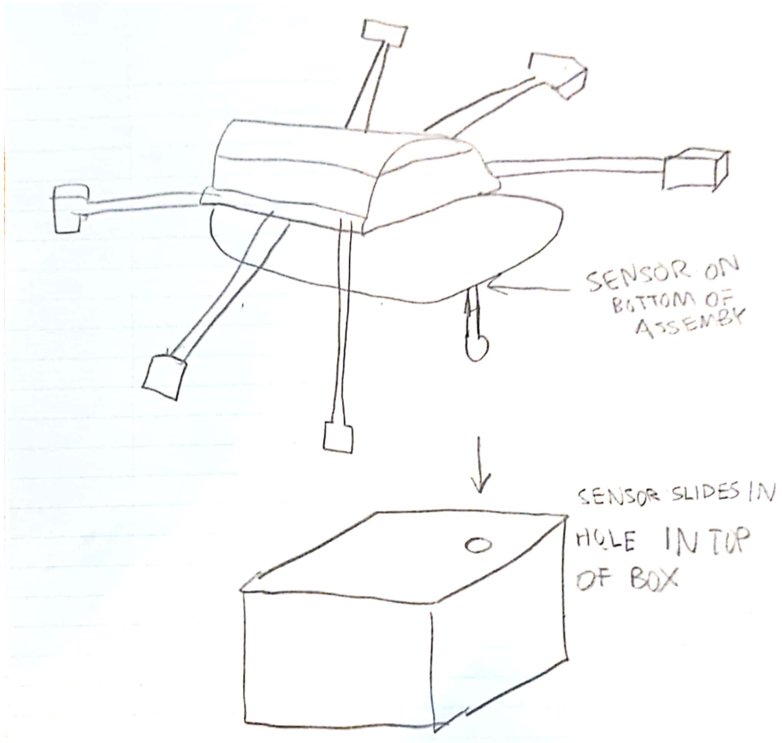


The module will be attached to the bottom of the drone while the sensor will be slid into the box with the package through a slit. This slit should be of a perfect size which allows for the sensor to slide out as the package is being lowered and not too big that it falters the sensor's temperature reading.

6.5.

6.6. Gabriel Krausert

The sensor can be placed inside the drone housing with cable and sensor on the end of the cable. A hole can be drilled into the package containing the food so the sensor attached by cable can be inserted directly in the box. When the drone detaches from the package, the sensor and cable can freely slide out of the hole and stay with the drone.

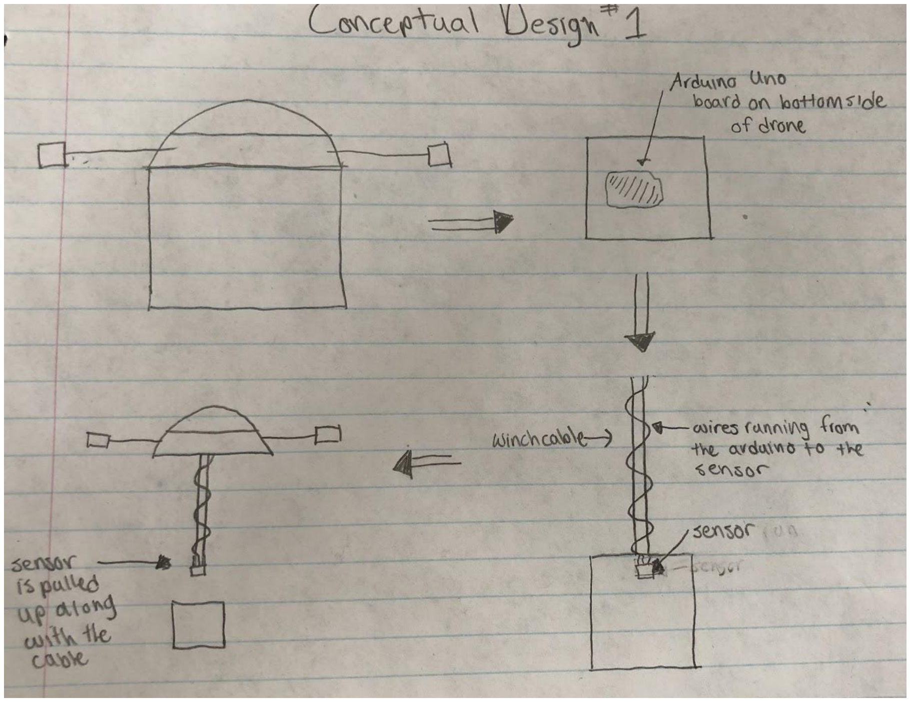


7.0

8.0 Selected Conceptual Designs

8.1. Conceptual Design One

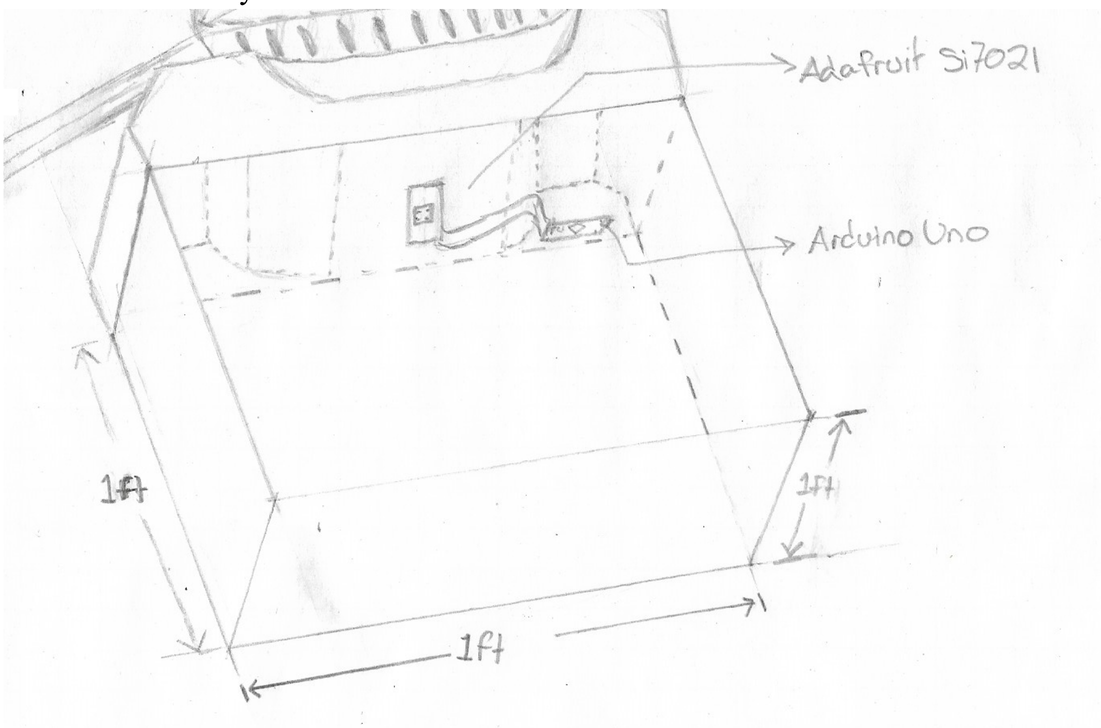
- DHT11 Sensor
- Arduino Uno
- System attached to the cable



The concept requires the arduino uno board to be bolted etc. to the bottom side of the drone near the winch system. When the package sits alongside the drone the sensor will be inside to hole on the top of the drone. Once the cable starts to lower the sensor being attached to the cable as well. Wires will run down the cable to keep the sensor hooked up to the arduino. When the cable releases the package and begins to retract the sensor will come up with it.

8.2. Conceptual Design Two

- Adafruit Si7021
- Arduino Nano
- System attached to the bottom of the drone

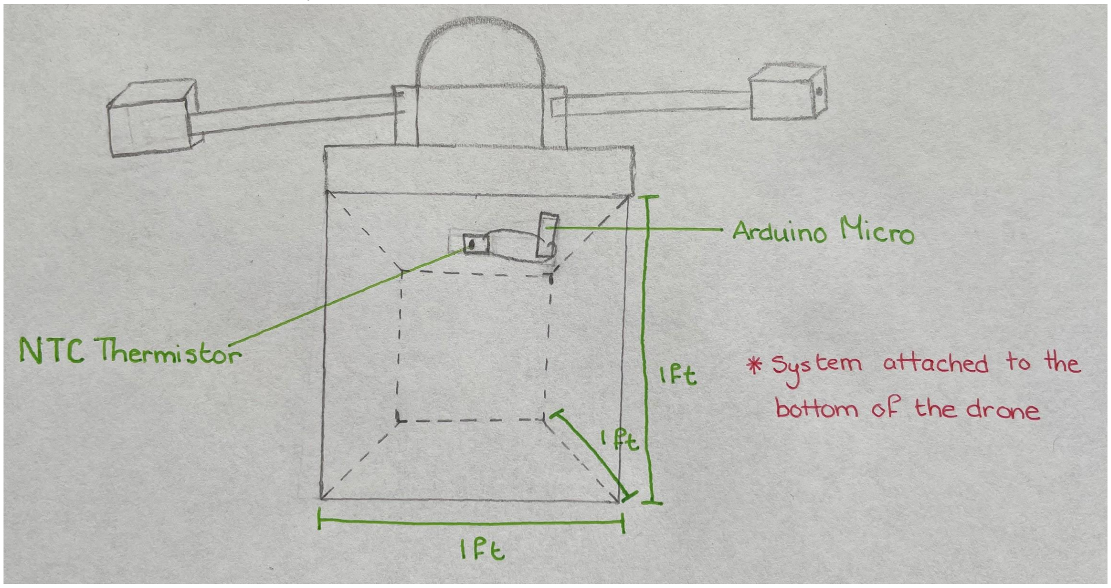


This concept design suggests the placement of the arduino uno board under the drone body, but outside of the box and places the Adafruit Si7021 right over the box. As such, the idea is to make a hole in the box so the sensor can be in the box while the box is attached to the drone, thus relaying accurate temperature information. However, when the box will be lowered using a cable, the sensor will stay attached to the drone body, making information captured by the sensor inaccurate as the box descends.

8.3.

8.4. Conceptual Design Three

- NTC thermistor
- Arduino micro
- System attached to the bottom of the drone



*Scale when drawn (4cm=1ft)

This concept design suggests the system be attached to the bottom of the drone and have the breadboard with the NTC thermistor lowered into the box to read the temperature of the package. As the package is lowered the breadboard will slide out of the hole.

8.5.

8.6. Comparison of selected conceptual designs

	Target Specification	Importance	Design 1	Design 2	Design 3
1	Constant data output	5	1	2	2
2	Sense package humidity	5	2	2	1
3	Sense package temperature	5	1	2	1
4	Power requirements	1	3	3	3
5	Device size	4	2	2	3
6	Operating conditions: temperature	2	3	3	3
7	Device weight	4	1	3	2
8	Cost	3	2	3	3
9	Safety	3	3	3	3
10	Aesthetics	1	3	2	3
	Total Score		61	79	70

The temperature targeted for the sensor to read is between -20 to +40 ºC and among all the sensor concepts designed only the Adafruit, the Thin Film RTD and the BME280 sensors are the only ones to measure below zero temperatures. The Thin Film RTD provides a way larger than needed range and the Adafruit has ± 0.4 ºC accuracy which is better than the accuracy of the BME280 sensor at ± 1.0 ºC. Though the BME280 sensor also provides a good range of temperatures it can measure, -40 to +85 ºC, the Adafruit Si7021's range of -10 to +85 ºC falls closer to the target temperature specified.

When comparing the humidity levels that each design concept can detect, we based it on RH levels. To begin with design 3 uses the NTC Thermistor which can not detect humidity levels. The DHT11 sensor used for design 1 is great for humidity readings between 20-80%, whereas the Adafruit Si7021 is great for humidity readings between 0-80%. Since both sensors detect similar RH levels the accuracy was referenced to determine the best sensor. The Adafruit Si7021 has a ±3% accuracy while the DHT11 sensor has a ±5% accuracy, thus making Adafruit Si7021 a better humidity sensor.

Evaluating the speed of constant data output differs on the amperage of the current, the length of the corde connections, the radius of the corde connection, the temperature, the processor speed of the drone cpu, the processor speed of the microcontroller and the refresh rate of the code. However, all these design concepts will be used in the same environment with the same relative refresh rate and they also all use arduino boards with 16 MHz clock speed which are connected to the same drone raspberry pi. As such, they all have the same relative relay speed before looking at their physical connectivity. Concept 2 and 3 have the same connectivity idea, thus were both given the ranking 2 . However looking at concept 1, the cable runs along the drone delivery cable, thus slowing down the relay speed which is why it has a 1.

The concept size rating was assigned depending on the microcontroller size and the sensor size. As such, the concept 3 got a 3 rating because it uses the smallest microcontroller (arduino micro) and the smallest sensor (NTC thermistor). Furthermore, the concept 2 was given a 2 because it uses a small microcontroller (arduino nano) and a medium size sensor (Adafruit Si7021) and the concept 1 was given a 2 because it uses the arduino uno (biggest microcontroller of the 3) but a small sensor (DHT-11).

9.0 Conclusions and Recommendations for Future Work

Based on the importance of target specifications generated and a careful analysis of the data present, Design 2 was chosen to be the best concept. This concept, compared with the two others, was chosen because of it's reliable sensor, a very compact arduino board and suitable positioning of the sensor on the overall system.

The Adafruit Si7021 sensor provides better and accurate readings and can be used to measure, not only temperature but humidity. It has better temperature and humidity ranges and is compatible with most microcontrollers. It is going to be connected to the Arduino Nano which was chosen because of its small size and ability to interface with the sensor without difficulty. This system will then be attached to the bottom of the drone so as to allow the box to be dropped while the sensor is securely held in place. This will ensure that there is no interference from the customer since the white mechanism will retract after each delivery and this will only allow the box containing the food to be lowered.

For future work, this concept will be further developed and cost estimates will be put together. Prototypes will also be created to test the functionality of the chosen concept, Design 2. From there, it will then be decided if it's best to continue forward with it or make adjustments accordingly in order to fulfil the clients and customers' needs.

10.0 References

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