Mars Shelter

—Let's Make Mars A-maize-ing

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Problem Statement

This project aims to design a Mars shelter, with the greenhouse as its core, to solve the food shortage in Mars exploration.

Needs

- A monitoring system to track the real-time environmental parameters.
- A light control system that can switch the tint film and LED lights ON/OFF according to the ambient brightness.
- A humidity control system to pump and atomize the proper amount of water into the greenhouse based on the detected humidity.

Design Description

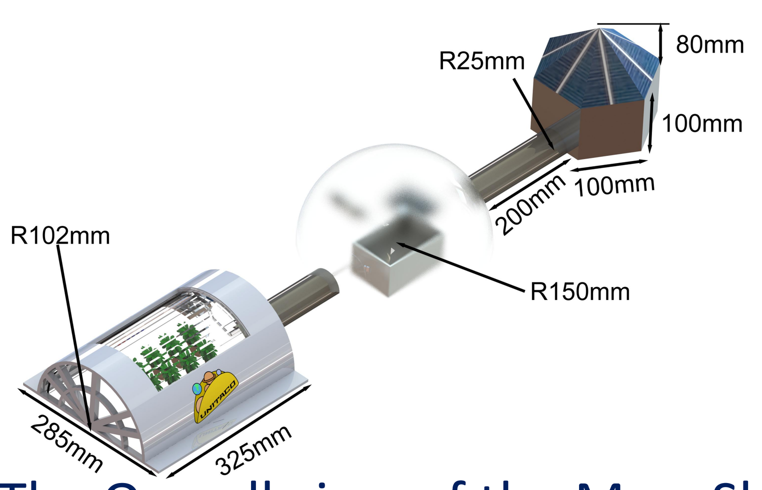

Fig. 1 The Overall view of the Mars Shelter

Mechanically, the Mars Shelter consists of three co-dependent structures: greenhouse, pump station and living district. The function implementation of each one includes four parts: sensors, regulators, microcontrollers and a computer.

For real time monitoring, the greenhouse is equipped with (i) DHT11, a digital temperature and humidity sensor, (ii) the photocell, a Light-Dependent Resistor (LDR). Once the Arduino Uno microcontrollers retrieve parameters from respective sensors, the current status will be transmitted to the dashboard.

To regulate brightness, the Arduino Uno first estimates brightness with data from the photocell. Then, (i) LED strips for artificial lighting, (ii) a liquid crystal tint film that could toggle the opacity, will react to adjust the brightness.

In humidity control, the humidity sensor in the greenhouse first transmits the status to Arduino Uno in the pump station. Then (i) a water pump, and (ii) a humidifier will add the hydration until a certain water level detected by the sensor is reached.

Significance of Solution

The data is visualized in a web browser, making it compatible for device upgrades, customizable, and perceivable. They also feature high precision and wide range.

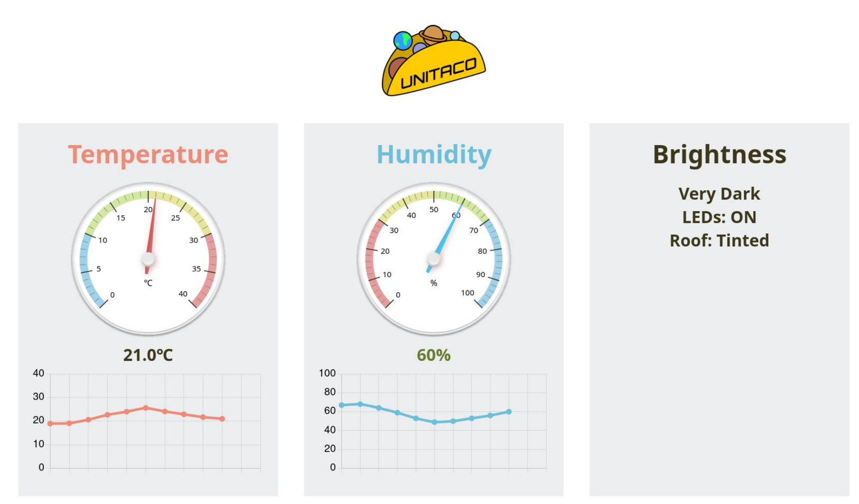

Fig. 2 Dashboard

The light wavelengths of the LED are optimized to red and blue according to the absorption spectrogram. Absorption by chlorophyll peaks at these wavelengths will increase efficiency of photosynthesis at night.

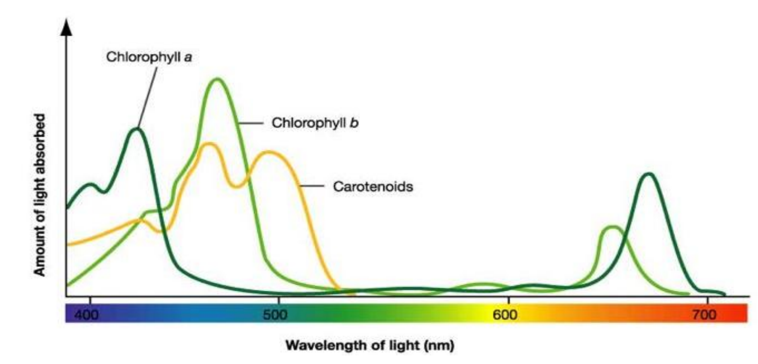

Fig. 3 Absorption Spectrogram[1]

Automatic and eco-friendly water pump, humidifier and tensiometer are installed to automate the humidity control process. As the water soaks the entire tensiometer, the system will cut off power supply automatically and enter the sleeping mode.

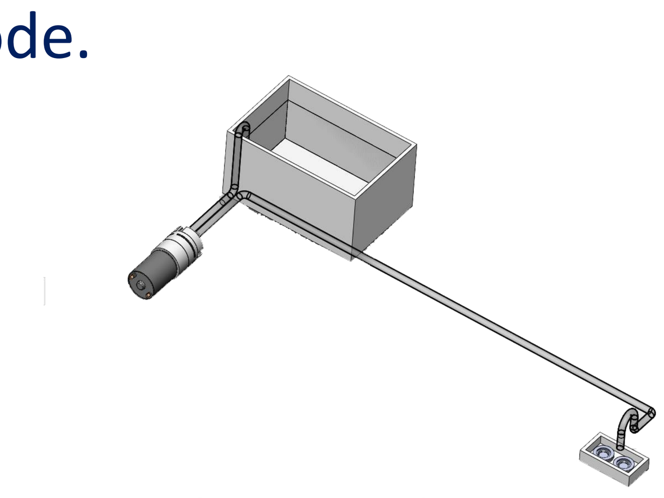

Fig. 4 The Humidity Control System

Validation

For the monitoring system, the precision and range of environmental parameters are checked with specifications as follows.

- ✓ The data precision is 0.1℃ for tempereture and 1% for humidity.
- ✓ The detected range cover temperature from -20℃ to 60℃ and humidity from 5% to 95%.

Below specification of energy consumption can be met in light control system.

- ✓ The power of red LED strip is 1.2W and 0.4W for the blue ones.
- ✓ The tint film requires 2 to 4 times less energy than the jalousie.

For the humidity control system, the energy efficiency, water volume and materials are checked.

- ✓ The humidifier's drive chip will automatically shut down after 4 hours of continuous work.
- ✓ The system could operate under 2W at 108 kHz.
- ✓ The water pump comes with 1.2KG water pressure, 25cm suction and 20cm lift, which guarantees the normal irrigation.

Conclusion

The Mars shelter offers monitoring, light control and humidity control functions. It provides a food self-sufficient and eco-friendly shelter for human through high-quality data, high efficiency and low energy cost.

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Reference

[1] Hillier, W., and Babcock, G. T., "Photosynthetic Reaction Centers," Plant Physiology, vol. 125, 2001, pp. 33–37.