Study of Intelligent Farm

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Abstract—In modern agricultural monitoring, self-powered systems are more and more recommended. However, there is no detailed research on the monitoring strategy of self-powered systems for different plants and different battery costs. Taking Dallas as an example, this paper studies and compares the trade-off between different duty cycles and batteries of self-powered systems by using the weather data of precipitation rate in Dallas. Finally, we explore a relationship between duty cycle, battery capacity, and precipitation threshold; that is, flowers with different temperature/humidity sensitivity can find the corresponding working mode switching strategy under different battery capacities.

Index Terms—self-powered, battery, duty cycle, precipitation threshold

I. Introduction

Nowadays, self-powered systems are popular in intelligent agricultural monitoring to reduce energy consumption. However, the biggest challenge is that many of the current monitoring systems do not have the right working strategy or system design, making it difficult for the system to keep working under different weather conditions. To this end, we will take the Dallas area as an example to design a self-powered system for monitoring. The system will work and switch different working modes according to the weather situation to maintain the monitoring.

II. Design and Model

A. System Design

This self-powered system includes solar cells, batteries, sensors, wireless transceivers, micro-controller (MCU).We will select appropriate solar panels to capture solar energy to power the system. The captured energy is then stored in a battery. Battery capacity is an important metric to consider because it is positively correlated with cost. In the model in this paper, we will take 7Ah, 10Ah and 14.5ah as examples to explore how battery capacity will affect the final working strategy in different duty cycle schemes. For transceivers, we will use LoRa Transceivers [1]. LoRa has a longer transmission range than wifi, but its power consumption is similar to that of wifi, which is very suitable for agricultural monitoring application scenario.For sensors [2], the system we designed has a certain versatility, that is, it can be matched with different types of sensors. In this paper, we will use temperature sensors [3]

as an example to further study the working strategy.MCU will control the overall system and enable the monitoring and communication components to operate smoothly. The system will have three working modes, low, medium and high. We will further elaborate on the details of the modes later.

B. Weather Model

We found that Dallas's annual precipitation rate distribution approximates a sin function, and we analyzed it using Python and found that it approximates the function:

$$y = \left(\sin \left(x - \frac{4}{5}\pi \right) + 3 \right) \div 10 \times 100\% \qquad (1)$$

when the curvature=1. For easy calculation, we will use equation (1) as our weather model.

C. Precipitation Threshold

The timing of the switch between these three modes should be determined by the weather. Based on the weather model, when the precipitation rate is low, we consider it sunny; When the precipitation rate is high, we will consider it rainy, and in between is the weather of rain and sunshine. The threshold value of precipitation rate between rainy day and uncertain rain is called rainy value. The threshold value of precipitation rate that determines the weather as sunny or sunny and uncertain is called sunny value.

In order to ensure the continuous operation of the existing system throughout the year, we need to have a good working mode switching strategy.

III. Approach

Based on the weather data, we believe that the efficiency of solar panels can be judged by the precipitation rate data in the weather data. We wanted to adjust the system to three different modes of operation: high power mode, medium power mode, and low power mode, so that the system can continue to work in different weather conditions.

Low power mode: In rainy weather, the total amount of energy captured by the solar panels and contained by the batteries is not enough for the entire system monitoring operation. Therefore, the system enters the low-power mode, which reduces the monitoring frequency to the minimum to

ensure that the system can continue to work without shutdown and continuously consume the energy stored in the battery.

Medium power mode: In this mode, an adaptive monitoring frequency is used to ensure that the energy obtained by the solar panel is exactly equal to the energy consumed by the system, but it cannot charge the battery.

High power mode: In sunny weather, when the solar panel can obtain more energy than the battery capacity and the system's highest monitoring frequency, the solar panel will charge the battery and power the whole system.

A. Sunny Value

To know the the sunny value, the key is to know the battery charging time. According to the equation(2), we can calculate the charging time during the sunny days. To ensure that the battery can be fully charged during the charging time, we multiplied the charging time calculated by the formula by 1.5 times as the final required charging time.

$$\text{Charging time(min)} = \text{Battery Capacity} \times 1.2 / \text{Current (m}A) \times 60 \quad (2)$$

B. Rainy Value

The key to knowing the minimum rainy value is to find the point that total system energy equals to zero.

$$E_{\text{Harvest}} + E_{\text{Battery}} - E_{\text{Load}} = 0 \quad (3)$$

C. Adaptive Duty Cycle

For medium mode, we make an adaptive duty cycle. Therefore, the energy harvested by the solar cell can always cover the whole system's power consumption, but not charge the battery at all. Finally, We build the adaptive duty cycle model based on the linear function.

IV. RESULT AND CONCLUSION

A. Result

For the result of the model, we use 10Ah Battery with 0.1667 duty cycle as an example. We can find that the rainy value is 36.7856% and sunny value is 24.6285%. Between this two value, the adaptive duty cycle in medium power mode has the relationship with precipitation which shows in figure.
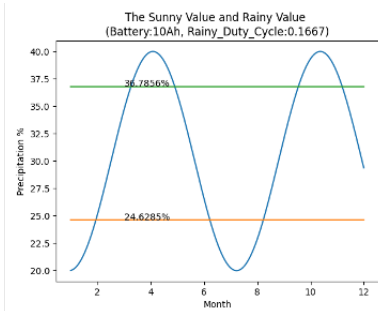

Fig. 1. Final Result

We combine different duty cycles and battery capacities to explore their relationship with rainy value. Finally, we can obtain the following 3D graph, which shows the trade-off
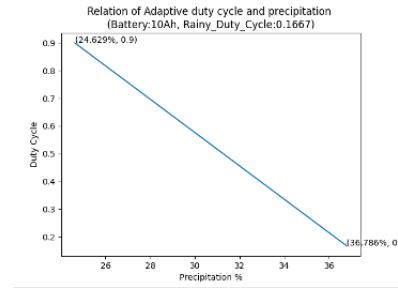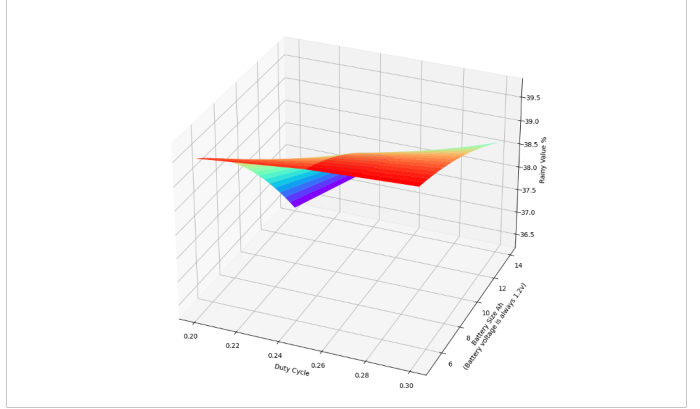

Fig. 2. Final Result2

Fig. 3. Final Result3

of battery capacity, duty cycle and precipitation rate threshold.The precipitation data of Dallas is always similar every year. Therefore, based on this model, you can take different strategies to meet different situation.

B. Conclusion

We developed a model of an agricultural monitoring system for the Dallas area, which can be used as a reference for monitoring strategies for different plant types. Also, we found a trade off among duty cycle, precipitation threshold and battery capacity, and demonstrated its relationship with a 3D graph Final, we think the SPS is highly flexible and can be adapted to a variety of scenarios by adjusting the working mode.

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