



ESP32 Smart Farm Starter Kit Tutorial

Perface

Our Company

ACEBOTT STEM Education Tech Co.,Ltd

Founded in China's Silicon Valley in 2013, ACEBOTT is a STEM education solution leader. We have a team of 150 individuals, including members from research and development, sales, and logistics. Our goal is to provide high-quality STEM education products and services to our customers. We are working together with STEM education experts and our business partners to produce successful STE products together. Our self-owned factory also provides CEM services for our clients including logo customization on product packaging and PCB.

Our Tutorial

This course and Smart Farm Starter Kit is designed for 8+ children and teenagers to gain a deeper understanding of ESP32 controller board and smart farm knowledge, sensors and circuit components. If you want to learn about smart farms, this kit gives you the knowledge and steps to help you build your own smart farm with Lumi.

Through this kit, you can:

1. Learn how to use the ESP32 controller board effectively, including downloading the code, understanding its features, and coding in the Arduino IDE.
2. Build a solid foundation on top of the C language, as the ESP32 utilizes the simplified C/C++ programming language to control circuits and sensors.
3. Explore various electronic components such as LED, OLED screens, sensors, and solar panels, etc., and see how they work together in a real smart farm project.
4. Improve your maker skills by following step-by-step tutorials to build your own smart farm using the ACEBOTT suite.
5. Realize basic functions such as automatic response, Internet of things application and App control in the smart farm project.
6. Develop a comprehensive understanding of the concept of smart farms and prepare for more advanced learning in the future.

Overall, ACEBOTT Smart Farm is an ESP32-based starter kit specifically designed for beginners. Using this kit, the user can have a comprehensive understanding of the functions of the controller board and sensors in the smart farm. Through the tutorial operation provided in the suite, students of different ages can acquire valuable knowledge of smart farms and successfully build their own smart farm projects.

Customer service

ACEBOTT is a dynamic and fast-growing STEM education technology company that strives to offer excellent products and quality services that meet your expectations. We value your

feedback and encourage you to drop us a line at support@acebott.com with any comments or suggestions you may have.

Our experienced engineers are dedicated to promptly addressing any problems or questions you may have about our products. We guarantee a response within 24 hours during business days.

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Smart Farms for Earth Restoration

In the year 2540 AD, the earth was no longer habitable for humans, with vast stretches of barren land. Over five hundred years ago, the earth was characterized by clear skies, lush forests, fresh air, and pristine waters. However, with the advancement of technology, human-induced environmental degradation became increasingly severe, and the reckless exploitation of resources knew no bounds.

This situation lasted for nearly a hundred years, the the earth's resources have been exhausted, at this time some countries in order to compete for resources, even malicious war. Seeing that the the earth civilization is about to be destroyed, some pacifists formed the Guardian alliance, they secretly opened the human migration program, and finally 2.4 light-years away from the the earth in the universe, found a basic suitable for human habitation F Planet, so they resolutely will all join the pacifist alliance members sent to F Planet.

Until now, human beings have been living in F Planet for 300 years, in a peaceful environment, with unprecedented development of science and technology, but human beings still hope to return to the earth. Not long ago, the Guardians received a probe from the earth. They found that the earth's radiation seemed to be weakening, the oxygen level in the atmosphere increased, and predicted that in 400 years, the earth would be able to purify itself and recover. But this time is too long, they hope to

quickly improve the earth's ecology, shorten the time to return to earth, so the high-level issued an important project——Earth Restoration Project.

One day I received a mysterious letter. When I opened the letter, it said, "Hello, congratulations on your selection as a member of Earth Restoration Project. We have been looking for people to fit into this program since we launched the Earth Restoration Project. Through observation, we find that you have great talent in invention and creation, so we are looking forward to having you join the project.

You will be responsible for this project, and Lumi will act as your consultant. After entering the earth, your main task is to find a place called "Future Farm", which used to be the research base of Charles, a biology professor. According to the information, Charles used to study plants that can purify air super strongly there, but because of various reasons, the experiment was forced to stop, resulting in the experimental results have been unknown. And the seeds from the previous experiment may still be there. So after you find the farm, you need to repair and upgrade the farm, and eventually make the farm intelligent and transmit the environmental data of the farm to Planet F in real time for analysis.

In five days, please get your package ready and gather at the air base for three months of training preparation. At that time, we will use the Voyager spacecraft to send you to the earth farm for actual modification. In this process, there may be unpredictable dangers, but this project is

related to the future of mankind, and we look forward to your successful completion of the project. -- The Alliance of Guardians."

Lesson 1: Rebuild the farm

Five days later, I packed up early and after three hours, I finally arrived at the gate of the Guardian Alliance air base. After checking my identity, the guard said, "Hello, please get in this drone. It will take you to the command center."

"Yes, thank you!" After that, I took the unmanned aircraft curiously observed the aviation base, here parked a lot of advanced aircraft, the air plane dense and regular flight, the ground personnel also come and go busy.



It took about ten minutes for the drone to arrive at the gate of the command center. Lumi had arrived and greeted me.

At this time, a man in military uniform came to the door and said to you, "Welcome to the center of the base, I am Instructor Luca, I believe you already know the purpose of here, you are all selected excellent personnel, is going to the earth to participate in restoration project, I hope that with your efforts, one day we can return to the earth. Now you are about to embark on three months of intensive training to prepare you for your mission here on the earth."

Instructor Luca will take you to the training base, physical training, aircraft operation skills, first aid knowledge, space knowledge, field survival and other subjects.

Three months have passed, and everyone has grown a lot through this time of training. Today is the day to start. The spacecraft carrying you to the earth is the Voyager, it is the latest starship, loaded with the space curvature engine, the speed is extremely fast, can travel through the space continuously, in theory, seven days can reach the earth, and there are enough materials on the Voyager to guarantee your mission on the earth.

"Roar! A loud noise, the spacecraft slowly take off, and then the speed is faster and faster, after breaking through the atmosphere, the spacecraft will be in the universe for a continuous space jump.

Fortunately, we have been trained to adapt to this sense of space jump speed, otherwise we would have passed out. Seven days later, the spacecraft made its final jump to rest in outer space. I was curious to observe the earth in front of me, and found that it was very different from the picture, the picture of the earth is a blue planet, but at this time, the earth is a gray piece.



Confused, I asked, "Is this the earth?"

"The coordinates are right," Lumi said. "It's blue, but it's broken. According to the records, the location of the farm is in Eurasia."

When we piloted the spacecraft into the earth, ten minutes later, when the spacecraft was still 1 km above the ground, the spacecraft turned on the landing recoil device. The landing speed of the spaceship began to slow down, when a huge bird as big as a truck was hurrying toward the spacecraft, leaving 500 meters above the ground when suddenly "boom!" There was a loud crash, which shook the ship violently, and then the ship sounded an alarm: "Danger! Damage to the ship's warehouse!" The ship was out of balance and falling fast.



Lumi shouted for me to calm down, and then tried to control the balance of the ship, I immediately calm down and controlled the balance of the ship together, but the warehouse position had broken a hole, and the strong air flow had made the ship unable to keep the balance, and the ship might hit the ground if it went on like this, Lumi decisively started the warehouse separation button. Let the warehouse directly off the ship, at 200 meters above the ground, the ship finally stopped spinning, and then after a jolt, the ship finally reached the ground, and we exhaled.

I looked around and saw that it was a forest. The sky was shrouded in gray haze and there was an unusual silence.

"How did the ship suddenly lose control?"

"A huge bird just hit the ship."

"We've only got a small amount of food and spare batteries left. Most of our stuff is in the ship's storage. What now?"

"The spaceship warehouse should fall in the south position, may not find for a while, and I feel some danger here, we first go to the farm to complete the repair, from here to the west four kilometers should be the future farm," Lumi said after holding the map to confirm the location.

I nodded and went with Lumi to the future farm. About ten minutes later, we finally arrived at our destination.

Looking at the future farm in front of them, they sighed. After more than 300 years of wind and rain, it has been ruined. Only a half of the gate

was left alone on the ground, the roof of the farm house collapsed, and the farm wall collapsed.



It was nine o'clock in the morning, so Lumi pulled out the drawings of the farm and said, "We must finish rebuilding the farm before dark, otherwise there may be unknown dangers after dark." Then, with our cooperation, the task of rebuilding the farm quickly began.

[【Click to get the farm setup steps】](#)

Lesson 2: Light up the farm

After a long period of restoration, the farm structure was finally rebuilt. The current farm is initially divided into three important areas: farm plantation, farm hut and farm warehouse.



Lumi looked up at the sky, because of the haze, the light is seriously blocked, only about two hours at noon to have light, the other time is dark, especially in the house is a dark.

"Wow!

After hearing the sound, Lumi quickly picked up the stick and flashlight to run inside. After going in, Lumi used the flashlight to shine at me. He found two bats attacking me.

"The light here is too dark, and there may be other dangerous

creatures sneaking in, so we need to light up the farm first," Lumi said.

"Why don't we just turn on the flashlights?" I asked.

"It doesn't work, the flashlight can only illuminate part of the light, and if all the flashlights are used at the same time, it consumes too much battery, so we have to use other hardware," Lumi said

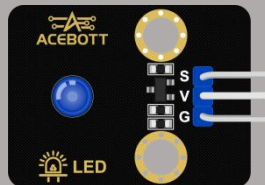
I asked, "What hardware does that require?"

"According to the current situation, we can first use the LED module and ESP32 controller board with the program to turn on the LED," Lumi replied.

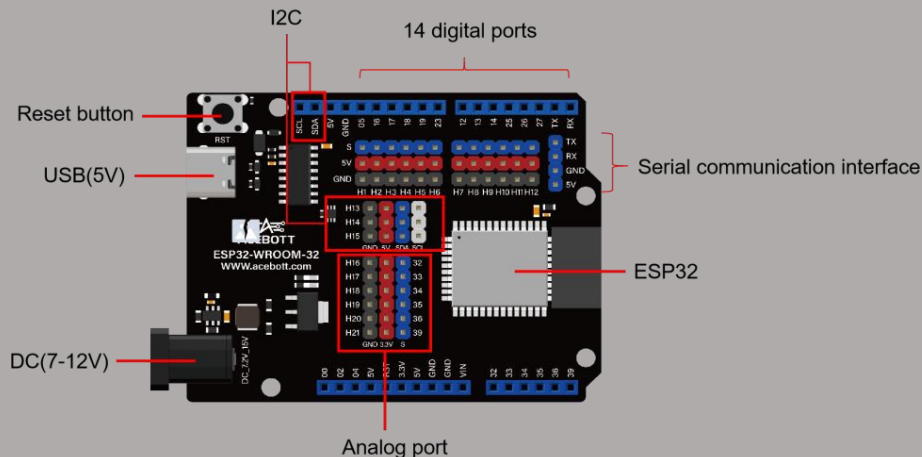
"What are LED module and ESP32 boards?" I asked.

"Let me introduce these two pieces of hardware," Lumi replied.

LED module is a component that integrates LED lamp beads, drive circuits, and housing to provide lighting, indicating, or display functions. According to the specific application requirements, the LED module can be a wide variety of shapes, sizes and colors, and its color depends on the material and the light emitting principle. A high level output to the LED module means to turn on the LED, and a low level output to the LED module means to turn off the LED. The LED module can also be controlled by analog signals, the larger the input signal value, the brighter the LED.



ESP32 controller board is a low-power, high-performance microcontroller that is well suited for iot development. It has a 240MHz dual-core processor, 520KB of RAM and 4MB of flash memory. Built-in WiFi and Bluetooth 4.2 module for wireless communication. It has 34 GPIO ports, which can connect and control various peripherals.



I asked, "How do we control the LED to turn on?"

"We need to program the LED," Lumi continued.

[【Click to get the program】](#)

```
void setup() {
    pinMode(27, OUTPUT); //Initialize the LED as pin 27 and output mode
}

void loop() {
    digitalWrite(27, HIGH); //The LED output is high level
}
```

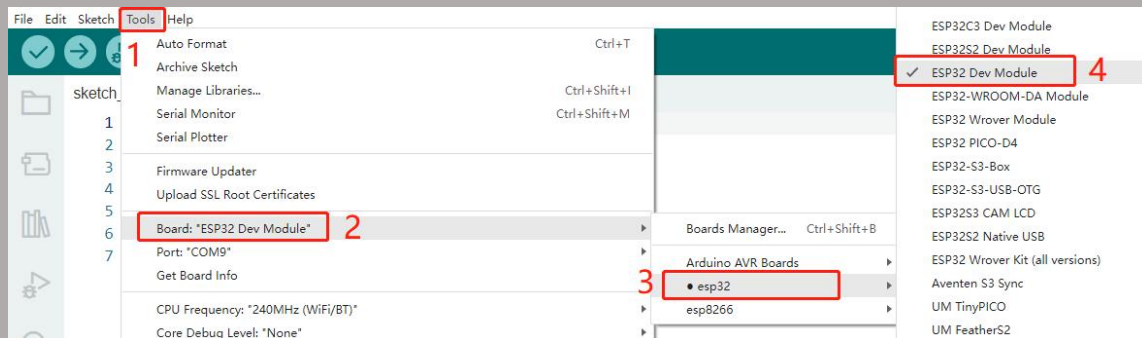
"Can we turn on the LED once we've written the program?"

"You also need to upload the program to the ESP32 controller board for it to work."

"How do you upload the program?"

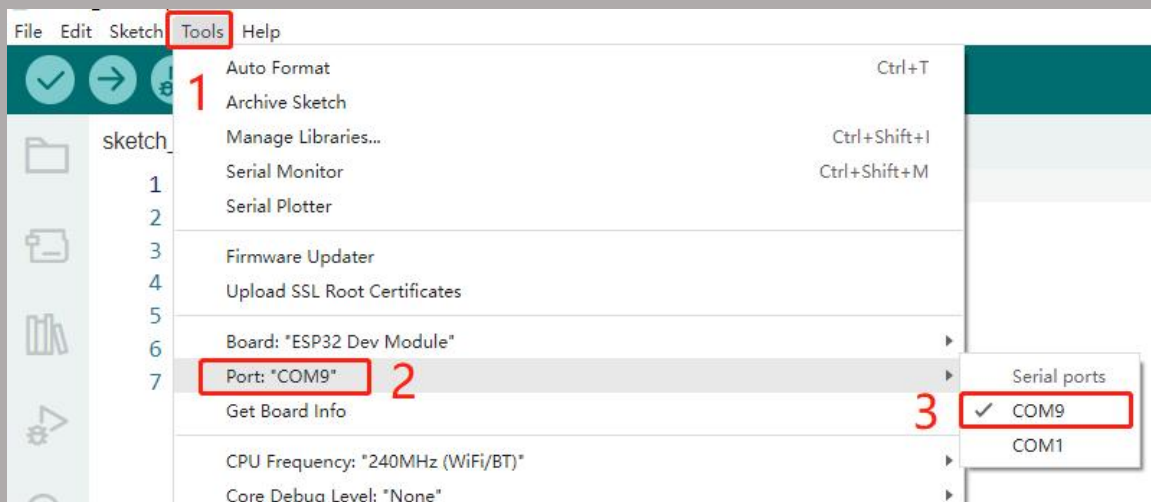
"Here is divided into four steps: select the controller board on the software, select the port, click upload, upload completed."

Step 1, follow these steps to choose the right board type: Tools>Board>ESP32>ESP32 Dev Module.



Step 2, select the correct port by following these steps: Tools>Port>COM9 (select the appropriate COM port on your computer).

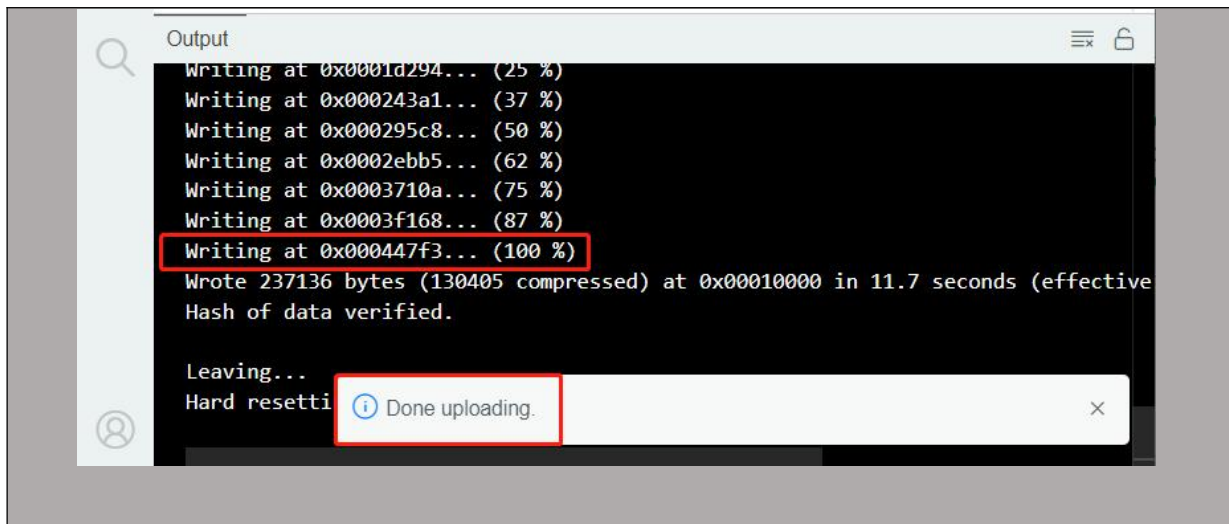
Note: The COM port to connect to is usually not COM1, click another COM port.



Step 3, click Upload, burn the program to the controller board.



Step 4, when the progress display number reaches 100%, the upload procedure ends.



I followed Lumi's instructions, and when the program was uploaded, the LED lit up, and the room lit up.



"Finally, I can see clearly, and there is no need to be afraid of unknown creatures sneaky in," I said.

"Before you get too excited, you won't be able to keep the LED on for long on the backup battery, so find a power source," Lumi said.

Lesson 3: Control of LED

"Oh, no! We only have three days' worth of spare batteries."

"Huh? Why is it so fast?"

"Because we've been running the LED on nonstop these days, they're running out too fast, and there's no place to recharge our batteries."

"How do we slow down the battery drain until we find the ship's warehouse?"

"You can add a device to control the LED, so that you can use the LED as needed."

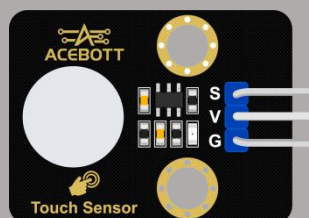
"What controls should be used?"

After searching in her backpack, Lumi picked up a piece of hardware and said, "Use this touch sensor."

"What is a touch sensor?"

"Let me introduce touch sensors."

Touch sensor is a kind of capacitive touch switch module, which can detect and respond to human touch. It has a built-in touch detection IC that is able to convert the user's touch action into electrical signals for interactive interaction with the device. The touch sensor outputs a low level when we touch a specific location with our finger, and switches to output a high level when there is no touch.



I asked, "How do we control LED with touch sensor?"

"We also need to program the touch sensor to control the LED," Lumi continued.

[【Click to get the program】](#)

```
#define LED 27//The interface of the LED is declared as 27
#define button 32//The interface of the touch sensor is 32

bool light_state = false; //Initialize the state of the light, where false means the LED is off
and true means the LED is on

void setup() {
  pinMode(LED,OUTPUT);//Set pin27 as the output mode
  pinMode(button,INPUT);//Set the pin32 input mode
}

void loop() {
  if(digitalRead(button) == 0){ //Determine whether the touch sensor is touched
    delay(200);//Delay 0.2s to increase the detection accuracy
    while(digitalRead(button)==0);//Wait for the button to release
    light_state = !light_state;//Switch the state of the LED
  }

  if(light_state){
    digitalWrite(LED,HIGH);//LED on
  }
  else{
    digitalWrite(LED,LOW);//LED off
  }
}
```

After a while, I had debug the program and said, "The program uploaded successfully. If my finger touches the touch sensor, the LED lights up, and another touch, the LED lights up."

"It will work for now. When the power station is repaired, you won't have to be so cash-strapped. And be sure to turn off the LED!" Lumi said.

Lesson 4: Light Control LED

"Wow, Lumi, take a look!"

Lumi thought there was some danger, got up and stood nervously outside the house.

Looking at Lumi, I couldn't help laughing. Lumi frowned and said, "What happened?"

I paused and said, "Don't you see anything different today?"

"Yi, it seems that the haze has dispersed, and finally see the sun!"

Under the sunlight, the surroundings were particularly bright, and even the usually dark room was exceptionally bright.

"It's a nice day, let's go and look for the shed," Lumi said.

"Since the weather is nice today, let's hurry and set out to find the spaceship warehouse that we lost earlier," Lumi said.

I asked: "Are we going to turn on the LED on the farm?"

"We're not sure how many days this trip will take. If we don't turn on the lights at night, many unknown creatures might come in, which could be dangerous," Lumi said.

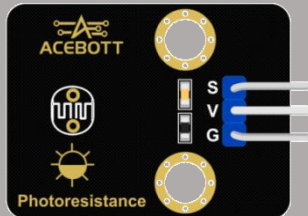
"Do you want to keep it open?"

"It's a waste of electricity. We can use light sensors to control the LED."

"What is light sensor?"

"Don't worry, let me introduce the light sensor first."

Light sensor is a type of sensor used to detect the intensity of ambient light. It is employed in various scenarios to measure light characteristics. Light sensor utilize the property of a light, whose resistance changes with the intensity of light. When light shines on the light, its resistance decreases, while in low light or dark environments, its resistance increases. By measuring the change in resistance, the intensity of light can be determined.



"Does that mean the controller board can control the LED lights based on the brightness values of the light?"

"Exactly, this way, it can illuminate at night and turn off when it's bright during the day, saving power."

"But how do we know the brightness values of the light?"

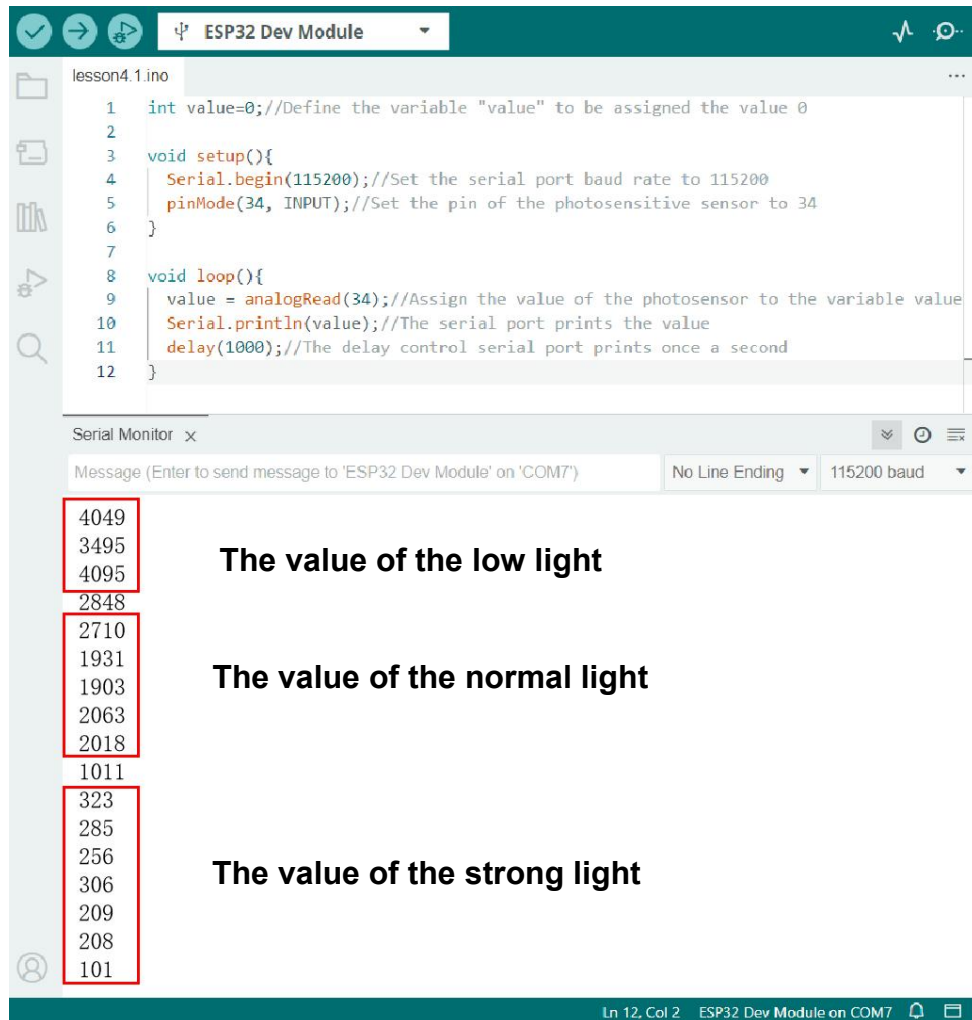
"We need to print real-time light data through the program on the programming software's serial port. This way, we can visually observe the changes in ambient light intensity."

[【Click to get program】](#)

```
int value=0;//Define the variable "value" to be assigned the value 0
void setup(){
  Serial.begin(115200);//Set the serial port baud rate to 115200
  pinMode(34, INPUT);//Set the pin of the light sensor to 34
}

void loop(){
  value = analogRead(34);//Assign the value of the light sensor to the variable value
  Serial.println(value);//The serial port prints the value
  delay(1000);//The delay control serial port prints once a second
}
```

Now that the program has been uploaded successfully, I open the serial port monitor of the programming software and observe the change of the light value.



```
lesson4.1.ino
1  int value=0;//Define the variable "value" to be assigned the value 0
2
3  void setup(){
4      Serial.begin(115200);//Set the serial port baud rate to 115200
5      pinMode(34, INPUT);//Set the pin of the photosensitive sensor to 34
6  }
7
8  void loop(){
9      value = analogRead(34);//Assign the value of the photosensor to the variable value
10     Serial.println(value);//The serial port prints the value
11     delay(1000);//The delay control serial port prints once a second
12 }
```

Serial Monitor x

Message (Enter to send message to 'ESP32 Dev Module' on 'COM7') No Line Ending 115200 baud

4049
3495
4095
2848
2710
1931
1903
2063
2018
1011
323
285
256
306
209
208
101

The value of the low light

The value of the normal light

The value of the strong light

Ln 12, Col 2 ESP32 Dev Module on COM7

"When we block the light with our hands, we see that the number increases," Lumi said.

"So we know the brightness of the light," I said.

"Exactly, now we can set a threshold to control the LED lights," Lumi said.

"How do you set the threshold?"

"For example, from the light data we just observed, when the value is

greater than 3500, it means the environment is dark and we need to turn on the LED. Otherwise, we turn off the LED," Lumi replied.

"With this logic in mind, I can now write the program to control the LED with the light sensor."

[【Click to get the program】](#)

```
int value=0;//Define the variable "value" to be assigned the value 0
void setup(){
    pinMode(34, INPUT);//Set the pin of the light sensor to 34
    pinMode(27, OUTPUT);//Set the LED pin to 27
}

void loop(){
    value = analogRead(34);//Assign the value of the light sensor to the variable value
    if (value > 3500) {//When the light value is greater than 3500, the LED light is on,
    otherwise the light is not on
        digitalWrite(27,HIGH);
    }
    else {
        digitalWrite(27,LOW);
    }
}
```

"The program has been successfully uploaded. Now the LED can automatically turn on and off based on the intensity of light. We can now pack up our equipment and confidently set out to find the spaceship warehouse," I exclaimed.

Following the map directions, we have to pass through a dark forest to reach the landing point of the spaceship warehouse. The trees in this forest are much larger than ordinary trees, almost as tall as a 50-story building.



"Be careful, things seem a bit eerie here," Lumi reminded us.

We cautiously advanced, weapons in hand. Before long, we found ourselves deep within the forest. Suddenly, Lumi stopped and asked, "Do you feel the ground shaking?"

I paused to sense the vibrations carefully. Soon, the tremors grew stronger. "This is not good. It seems like a giant creature is approaching. We need to hide quickly!" I exclaimed.

Without hesitation, Lumi and I darted into a massive tree hollow.

Through a crevice, I caught sight of the colossal creature before us. My pupils dilated in shock—it was a "dinosaur"! We held our breath, afraid to make a sound.



After observing its surroundings for a while, the "dinosaur" departed. It wasn't until we no longer felt the tremors that we breathed a sigh of relief.

I asked in horror, "What's going on? How can there be dinosaurs here? According to the earth's historical records, dinosaurs have been extinct for ages, haven't they?"

"Perhaps these aren't the dinosaurs recorded in history. I speculate that radiation and the lack of natural predators might have caused some creatures to mutate again, evolving into dinosaur-like giants," Lumi

analyzed.

"It seems that the earth is far more complex than we imagined," I remarked.

"We need to stay alert and quickly find the spaceship warehouse," Lumi said.

We proceeded with even greater caution. After over an hour, we finally found the spaceship warehouse.

"We have three hours until nightfall. Let's hurry and move the supplies. We must return to the farm before dark," Lumi urged.

Each of us packed our bags to the brim. Just as we were about to leave, the sky suddenly darkened with ominous clouds, indicating an impending rainstorm. We hastened our pace in response.

Lesson 5: Animal Alarm

We hadn't walked for long when a fierce storm suddenly broke out, and the dense rain blocked our vision ahead. For safety, we consulted the map and found a small cave marked on it. We took shelter in the cave to wait out the storm.

The downpour lasted nearly 5 hours before finally subsiding. By then, the sky had turned completely dark. In the dim forest, aside from the sound of water dripping from the trees, we could faintly hear the cries of wild beasts in the distance.

Nervously, I asked, "Should we continue our journey?"

Lumi replied, "Let's stay here for the night and resume our journey at dawn. It's too dangerous to travel now."

"Now, there's a tricky issue with no door at the entrance. What if wild animals suddenly rush in at night?"

"Well, that's a possibility, and we need to prepare in advance. We can make an animal alarm."

"What kind of animal alarm?"

"I happen to have a PIR sensor and a buzzer in my backpack. We can use these two hardware components to create an animal alarm."

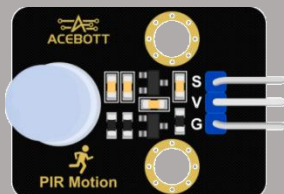
"What are a PIR sensor and a buzzer?"

"Let me first introduce the PIR sensor."

The PIR sensor is a device that detects human movement based on infrared radiation. When a person or another heat-emitting object enters the sensor's detection range, it triggers changes in infrared radiation, which are then detected by the sensor.

One characteristic feature of this sensor is that it only outputs corresponding electrical signals when external radiation causes changes in the sensor's own temperature. When the temperature stabilizes, no signal output occurs, making it sensitive only to living organisms in motion.

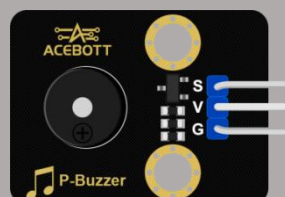
Additionally, when a human body is detected, the sensor outputs a high-voltage signal and has a certain delay time. If the human body remains within the sensor's range, it will continue to maintain the high-voltage signal. Only when the person leaves and the delay ends does the sensor signal switch to low voltage.



"I just realized that the PIR sensor can detect the infrared radiation emitted by moving living beings," I said, "but how does it sound an alarm?"

"Don't worry, we still need to use the buzzer for the alarm function," Lumi replied.

The buzzer is an integrated electronic sounder that is powered by a direct current power supply. It is widely used in electronic products such as toys and alarms. Buzzer can be divided into passive buzzers and active buzzers. Passive buzzers do not have an internal oscillation source and require a square wave of 2K~5K to drive them; active buzzers can continuously emit sound when connected to a power source.



"I understand now. When the PIR sensor detects an animal

approaching, the buzzer will sound the alarm, so we can be prepared in advance," I said.

"That's right. Now let's write the program for the animal alarm together!"

[【Click to get the program】](#)

```
int value=0;//Define the variable "value" to be assigned the value 0

void setup(){
  pinMode(34, INPUT);//Set the pin of the PIR sensor to 34
  pinMode(25, OUTPUT);//Set the pin of the buzzer module to 25
}
void loop(){
  value = digitalRead(33);//Assign the value of the PIR sensor to the variable value
  if (value == 1) { //When an animal approaches, the value of the PIR sensor becomes 1,
and the buzzer sounds the alarm
    tone(25,262);
    delay(100);
    noTone(25);
    delay(100);
  }
  else {
    noTone(25);
  }
}
```

After uploading the program, we placed the animal alarm about 5 meters away from the cave entrance. Then, we collected some wooden blocks, sharpened their heads, and nailed them around the entrance. After completing these tasks, we felt relieved and returned to the cave.

Inside the cave, we leaned against the wall. Due to the constant journey, we felt very tired, and soon drowsiness overcame us, and we fell asleep.

Suddenly, an alarm sounded, startling us awake. By now, it was already daylight. Lumi quickly went to the cave entrance to observe and urgently said, "There's an adult brown bear foraging nearby. Let's hurry!"

We swiftly packed our bags and left cautiously. Following the map's directions, two hours later, we finally emerged from the forest.

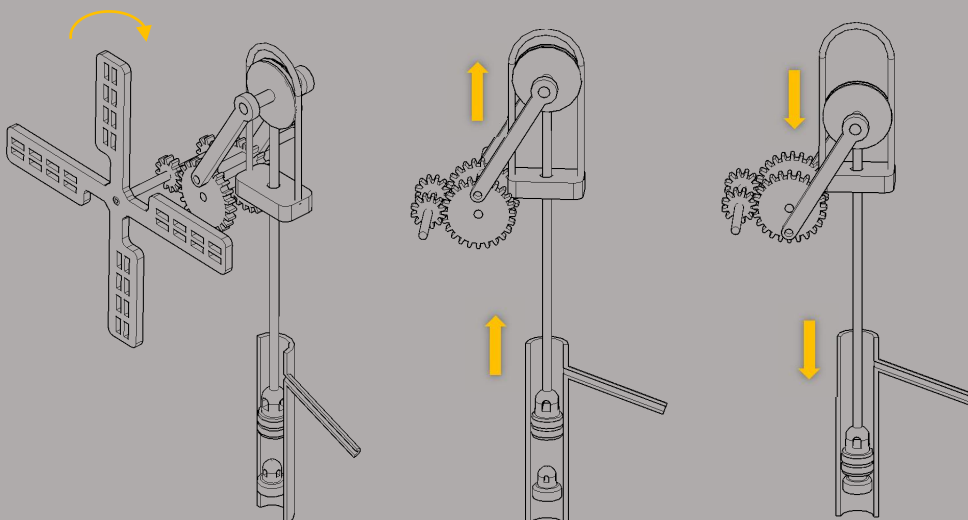
Lesson 6: Solar Windmill

When we returned to the farm, we found it flooded. Lumi remembered that this area was low-lying and highly susceptible to flooding during continuous heavy rain.

As I pondered the situation, Lumi pointed to the windmill and said, "The farm's windmill can be used to drain the water." I was enlightened by the idea and eagerly asked how the windmill could drain the water.

Windmill drainage is a device that utilizes the rotation of a windmill to drive a water pump for drainage purposes. When the windmill rotates, it drives its connecting shaft to rotate as well, which in turn drives the gear structure connected to the shaft to rotate. The rotation of the gear structure causes the connecting rod structure attached to it to move up and down in a reciprocating motion. The water pump shaft connected below the connecting rod structure moves up and down in sync, causing changes in hydraulic pressure in the water, resulting in water being drawn out and transported to other locations through pipes.

In summary, the water pump is connected to the windmill via the connecting shaft and is powered by the rotational energy of the windmill. The core principle of windmill drainage lies in converting wind energy into mechanical energy, which is further converted into hydraulic pressure energy to achieve drainage objectives.



"But now there is no wind, how does the windmill turn? Is it powered by batteries?" I asked.

"No, because our batteries are currently being charged at the temporary hydroelectric power station, and they can barely sustain our daily usage," Lumi replied.

After the storm, the sunlight was unusually bright. Suddenly, Lumi looked at the sunlight and said, "We can use sunlight as the driving source."

"How does sunlight drive it?"

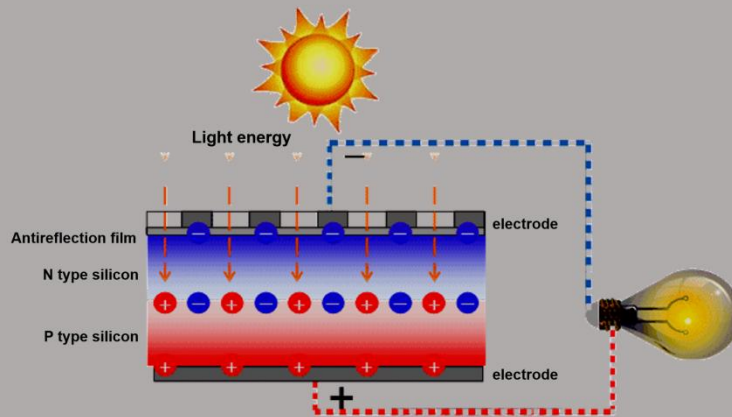
"By shining sunlight onto solar panels. The solar panels generate electricity to control the rotation of the windmill. We happen to have brought a solar panel this time because the weather has been gloomy previously, and we didn't have the chance to use it. Now, with the sunlight being so strong, we can use it perfectly."

"How do solar panels generate electricity?"

"Let me explain the working principle of solar panels."

The working principle of solar panels is primarily based on the photovoltaic effect, which is a physical phenomenon that directly converts light energy into electrical energy. Solar panels use semiconductor materials, where electrons on the surface of the semiconductor material can absorb photon energy. When a sufficient number of photons are absorbed, it stimulates the generation of charges, which are then collected by conductors to form an electric current.

Specifically, when sunlight shines on the semiconductor, photons enter the semiconductor material and interact with the electrons. When electrons gain sufficient energy, they undergo a transition, producing free electrons and free holes, thus generating a certain potential difference. When the solar cell is connected to a circuit, these free electrons move in an orderly manner under the influence of voltage, thereby forming a current and powering external electrical devices.



After understanding the working principle of solar energy, I and Lumi worked together to build the solar windmill. Under the intense sunlight, the solar panel quickly began to generate power, causing the windmill to spin. Soon after, the accumulated water on the farm started to slowly drain away.

"We can use toggle switches to control the circuit of the solar windmill," Lumi said. "When we don't need the windmill to turn, we can just turn the switch off."



Four hours later, most of the water accumulated on the farm had been drained, and we finally could take a break.

At that moment, Lumi held a glass jar and said, "I found a jar of plant seeds in the farm warehouse. Try cultivating them. It's likely to be the experimental plant mentioned in the documents, which can purify the air."

"No problem. I also brought some fruit and vegetable seeds from Planet F. Let's plant them together. I haven't had fresh vegetables in a long time," I exclaimed excitedly.

After saying that, we scattered the experimental plant seeds and the fruit and vegetable seeds into the soil of the farm...

Lesson 7: Soil Moisture Detection

"Wow, it's so hot these days, unusually hot," I complained.

"Yeah, it's been scorching for the past few days," Lumi remarked.

At that moment, Lumi looked stunned as she received a message on her smartwatch from a probe satellite left in outer space by F Planet. The message warned of an impending severe solar storm, predicting drastic climate changes on the earth.

Seeing my worried expression, Lumi said, "Don't worry just yet. Our mission here is to document the earth's changes firsthand. If we retreat now, the Earth Restoration Project will be halted. We've already invested too many resources, so we can't afford to back down. The solar storm hasn't erupted yet, so we still have time to complete our tasks. Right now, the priority is to plant the crops on the farm and record the environmental data here."

I glanced at the thermometer, noting that the temperature had already reached 50 ° C, and the soil in the plantation was beginning to crack. Seeing this, I worriedly looked at the plants we had recently planted. Today, I had already watered them five times, but every hour or so, the soil surface dried up again. It seemed like someone needed to keep an eye on it constantly.

Observing my furrowed brow in the garden, Lumi asked, "What's the tricky problem you're facing?"

I explained my problem, and Lumi said, "I know there's a sensor that can detect moisture in the soil."

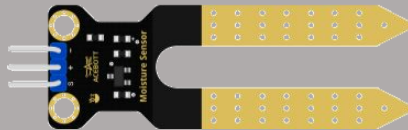
I eagerly asked, "Really? What sensor is it?"

Lumi pulled out a piece of hardware from her backpack and said, "It's this soil moisture sensor."

"What exactly is a soil moisture sensor?" I inquired.

"Don't worry, let me introduce you to the soil moisture sensor," Lumi replied.

The soil moisture sensor involves inserting two probes into the soil and passing a current through it. The sensor reads the resistance between the two probes as the current passes through the soil and converts this resistance value into a moisture content reading. Since higher moisture content corresponds to lower resistance, the soil's conductivity improves with more water. Therefore, if the soil lacks water, the sensor's analog output decreases; otherwise, it increases.



"How can we obtain the soil moisture data?"

"We still need to obtain the soil moisture data by printing it out through the serial port. We need to write a program to read the soil moisture data through the serial port."

[**【Click to get the program】**](#)

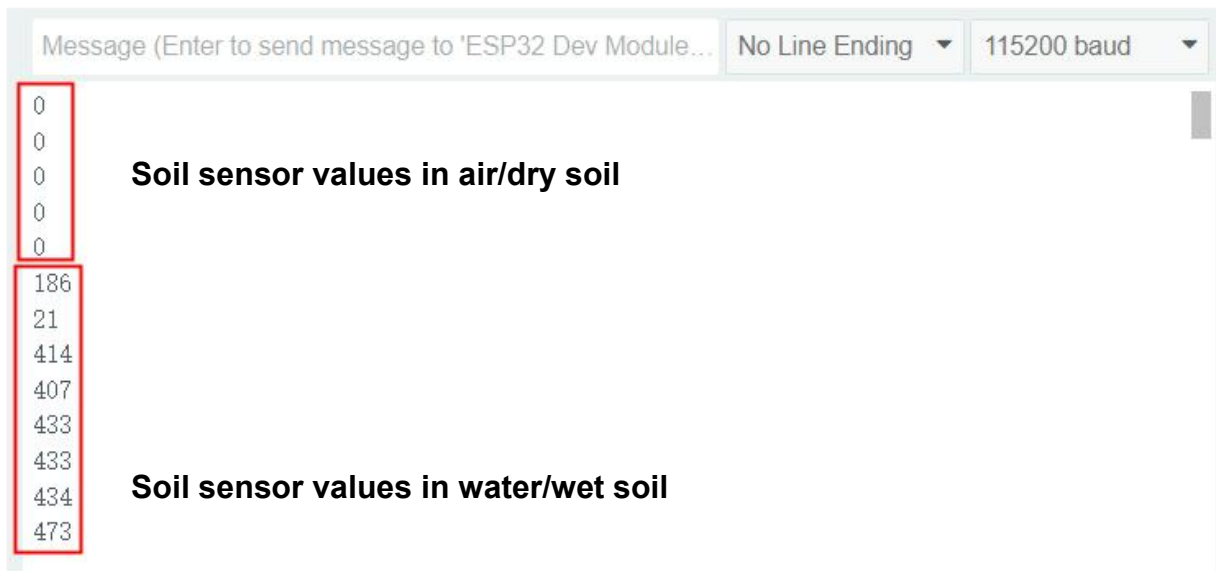
```
int value=0;

void setup(){
  Serial.begin(115200);
  pinMode(35, INPUT);//Set the pin of the soil moisture sensor to 35
}

void loop(){
  value = analogRead(35);//Assign the value of the soil moisture sensor to the variable value
  Serial.println(value);
  delay(1000);
}
```

Now that the program has been uploaded, let's look at the soil moisture data on the serial port monitor.

Then I inserted the soil moisture sensor into the soil to see how the soil moisture changed.



"After finally knowing the soil moisture level, I'll record it first," I said, rushing to document the soil data. Then, based on the data, I'll analyze the correlation between plant growth and soil moisture.

For a whole week, I've been back and forth to the river to fetch water

for the plants. Finally, I've compiled the soil moisture data that's most conducive to plant growth."

Lesson 8: Automatic watering

The scorching heat persisted, making the repetitive trips to fetch water extremely strenuous. After discussing with Lumi, we decided to dig a well directly next to the plantation.

Initially, we estimated that digging around 20 meters deep should yield a well. However, even after reaching a depth of 30 meters, we found no water. As we hesitated about whether to continue digging deeper, a sudden cracking sound emanated from underground. A gigantic earthworm emerged from the well pit, startling me so much that my face turned pale. I had never seen an earthworm so thick, resembling a tree trunk, and stretching tens of meters in length.

The colossal earthworm writhed frantically, then swiftly burrowed into the soil far away.

Relieved, we approached the well pit, only to find water gushing out from it.

Lumi chuckled, "Seems like luck was on our side. The giant earthworm breaking through the well pit's bedrock spared us from further digging."

"Now that we have water, there's still another issue," I remarked.

"What's the problem?"

"I've calculated the optimal soil moisture required for the plants and estimated the duration of soil dryness. Currently, we need to water the soil every 6 hours to prevent it from drying out."

“Ah? So does that mean we have to get up in the middle of the night to water the plants?”

"That's been a problem bothering me all along. It would be great if we could automate the watering."

"Automate the watering? I have an idea," Lumi said.

"What idea?"

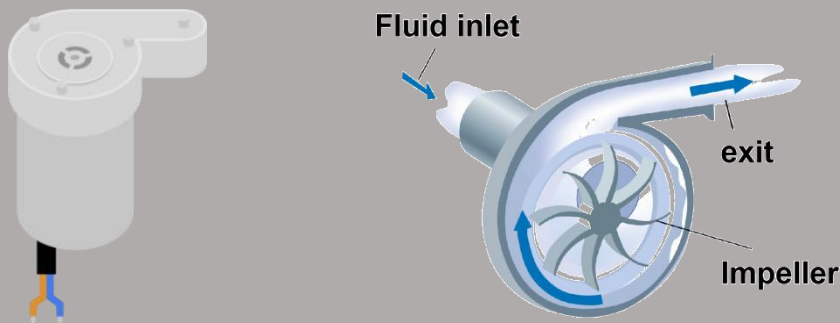
"We can add a water pump and use the soil moisture sensor's readings as the trigger for watering. If the soil moisture falls below a certain threshold, it will activate the water pump to automatically water the plants. And when the soil moisture exceeds another threshold, it will stop the watering," Lumi explained.

"That's a fantastic idea!" I exclaimed. "That way, I won't have to keep an eye on it all the time."

"Let me introduce you to the water pump," Lumi replied.

A water pump is a machine commonly used in daily life to transport liquids such as water, oil, and liquid metals. It works by drawing liquid from a lower level and moving it to a higher level through pipes, making it a key mechanism in agricultural irrigation systems. Water pumps typically work in conjunction with relays for convenient control.

Comprising components like an electric motor, impeller, pump shaft, pump casing, and inlet/outlet pipes, a water pump operates as follows: When the pump is activated, the pump shaft drives the impeller to rotate. The rotation of the impeller creates centrifugal force, which propels the water outward towards the edges of the impeller and into the flow channels of the pump casing. Eventually, the water flows out through the outlet pipe of the pump. At the center of the impeller, the water being propelled outward creates a vacuum, causing water from the suction pool to be drawn into the pump casing under atmospheric pressure. As the impeller continues to rotate, water is continuously drawn in or discharged, achieving the purpose of water transportation.



"Moreover, because the water pump requires a large current, the controller board's I/O port cannot directly drive it, so a relay module is also needed for control," Lumi replied.

I asked, "What is a relay module?"

Lumi answered, "Let me continue explaining about relay module ."

Relay module is a device used to control circuit switches through electrical currents. The main function of relay module is to protect and control circuits. In conventional terms, relay module functions somewhat like an electromagnet. It operates by opening or closing one or multiple contact points through this "electromagnet." The armature of this electromagnet can either close or open one or more contact points. When an electric current passes through, it is attracted by the electromagnet, which alters the state of the contact points. The relay's output terminals consist of three interfaces: COM, NC, and NO. Among them, COM is the common terminal connected to the positive pole; NC is the normally closed terminal, usually left unconnected; NO is the normally open terminal, connected to the positive pole of the water pump.



"Then how do we go about automating the watering process?" I asked eagerly.

"We need to write a program that uses the soil moisture sensor to control the water pump for irrigation," Lumi replied.

[【Click to get the program】](#)

```
int value=0;

void setup(){
  pinMode(35, INPUT);///Set the pin of the soil moisture sensor to 35
  pinMode(26, OUTPUT);///Set the pin of relay module to 26
}

void loop(){
  value = analogRead(35);///Set the value of the soil moisture sensor to the variable
value
  if (value < 100) {
    digitalWrite(26,HIGH);///When the soil moisture value is less than 100, the relay
closes the COM and NO ports and the water pump works    }
  else {
    digitalWrite(26,LOW);///Otherwise, the relay module closes the COM and NC
ports and the water pump does not work

  }
}
```

"The program has been successfully uploaded. Now let's place the water pump inside the well together," Lumi said.

After debugging, the automatic watering device finally started working. Whenever the soil moisture was low, the water pump would automatically draw water. Once the soil moisture reached the desired level, the water pump would stop.

"We finally solved the watering problem. Now we can relax a bit," I exclaimed.

Lesson 9: Water Level Detection

"The solar storm is getting closer, and we may not have much time left. Our farm still needs further improvement," Lumi said to me.

"Yeah, I'll take care of the plants and gather more data as soon as possible," I replied.

I led Lumi to the plantation and couldn't help but be amazed. The experimental plant seed had grown too fast and had already sprouted into a small sapling, while the fruits and vegetables we planted together had just begun to sprout.

"But why is the soil cracked again?" I frowned as I squatted down to examine the soil.

When I went to check the well, I noticed that the water level was significantly lower than it was initially. It seemed that the low water level prevented the water pump from drawing enough water, causing the soil to crack.

I speculated that the underground water might have dried up due to the solar storm, but it was strange that the water level in the well only decreased at night. During the noon, the well was filled with water again, which was puzzling. I asked Lumi, "Is there any way we can detect when the water level in the well drops to a certain level and be alerted?"

"We can install a water level sensor in the well, combined with a buzzer. If the water level drops to a certain point, it will sound an alarm,

reminding you to manually water the plants," Lumi suggested.

"Let's learn more about the water level sensor then."

The water level sensor is an instrument that can convert the water level parameter of the measured point into a corresponding electrical signal in real-time. Its working principle is to measure the size of the water level using the traces of its parallel conductors, thus determining the water level. The analog value output by the water level sensor can be directly read by the controller board and can be used for water level alarm purposes in practical applications.



According to the principle of the water level sensor and the principle of the buzzer previously understood, I began to write a program.

[【Click to get the program】](#)

```
int value=0;
int i=0;

void setup(){
  pinMode(36, INPUT);//Set the pin of the water level sensor to 36
  pinMode(25, OUTPUT);//Set the pin of the buzzer module to 25
}
void loop(){
  value = analogRead(36);//Set the value of the water level sensor to the variable value
  if (value < 1500) { //When the water level value is less than 1500, the buzzer sounds
    for(i=0;i<100;i++)//Output a frequency of sound
    {
      digitalWrite(25,HIGH);//Turn on the buzzer at a high level to sound
      delay(1);//The delay is 1ms. The frequency of the sound can be changed by
this delay
      digitalWrite(25,LOW);//Turn off the buzzer at low level and make no sound
      delay(1);
    }
    delay(100);
  }
  else {
    digitalWrite(25,LOW);//Otherwise, the buzzer does not sound
  }
}
```

The program was uploaded successfully, and after installing the water level alarm in the well, the buzzer would automatically sound an alarm when the water level was too low.

In the evening, the buzzing sound of the buzzer woke up Lumi, who was sleeping, and he quickly woke me up to go outside and observe the situation. When we ran to the well, we were shocked to see a large group of deer, glowing in the dark, drinking water.



At this moment, the group of deer also looked at us, seemingly surprised to find humans here. After a while, a doe noticed that we meant no harm. She then turned around, as if wanting to lead us somewhere. I also sensed that the deer herd seemed to have some difficulty, so I followed the doe.

After walking for about five minutes, the doe called out to a pit. I quickly looked ahead and saw a kitten had fallen into the pit, and its right leg seemed to be bleeding.

Lumi and I hurriedly rescued the kitten from the pit. The kitten was already very weak, obviously starving for days. Without proper treatment, it could lose its life.

At this point, regardless of whether the doe understood or not, I immediately took the kitten back to the farmhouse for treatment.

The doe glanced back at the kitten, then silently followed the herd as they left.

Lesson 10: Plant Growth Lamp

These past few days, I've been taking care of the kitten at the farm. The kitten recovered quickly, and three days later, it could already stand up. I play with it every day, so the kitten has temporarily become my pet.

Under the influence of the solar storm, the weather on the earth has become more complex and unpredictable. Now, with the haze blocking the sunlight, the sky around us has become dark and gloomy.

I record the growth of the farm's plants every day. However, due to the weather, it seems that the growth of the plants has stagnated. I investigated many reasons, and finally, based on experience, I confirmed that it was due to insufficient light, which led to a decrease in photosynthesis and thus the plants' growth stagnation.

"The plants have stopped growing recently due to insufficient light," I sighed.

"Insufficient light? I have a flashlight. You can borrow it," Lumi said.

"Ordinary light won't work. Plants require specific wavelengths of light, mainly red and blue. The flashlight's light is just for illumination and does not concentrate the appropriate spectrum. So shining a flashlight on the plants won't have any effect."

"Red and blue light? I have an idea."

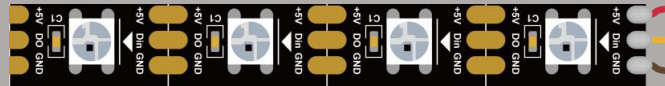
"Really? What's the solution?"

"You can achieve what you need with an RGB LED strip."

"What's an RGB LED strip?"

"Let me introduce you to the RGB LED strip."

RGB LED strip typically consists of multiple RGB LEDs arranged at regular intervals and connected on a circuit board. Each RGB LED contains three individual light-emitting diodes (LEDs) – one each for red, green, and blue colors. When the three LEDs inside each RGB LED are illuminated at different intensities, they combine in various proportions to produce a wide range of colors.



"Wow, so this is an RGB LED strip. RGB can mix any color, so it can definitely assist plant growth. I can use it as a plant growth lamp."

Lumi asked, "Does the plant growth lamp need to be on all the time?"

"I only need it when there's insufficient natural light. If there's enough sunlight, I won't need to turn it on."

"Then we also need to add a light sensor. It will activate the RGB LED strip only when it's dark, otherwise, it stays off."

"Yes, let's write the program for it!"

[【Click to get the program】](#)

```
#include <Adafruit_NeoPixel.h> //Import the strip library

int value=0;
//The initialized RGB strip is pin 13 and the number of lights is 4
Adafruit_NeoPixel rgb_display_13 = Adafruit_NeoPixel(4,13,NEO_GRB + NEO_KHZ800);
void setup(){
  rgb_display_13.begin();
}
void loop(){
  value = analogRead(34);
  if (value > 3500) { //If the light value is greater than 3500, set lights 1 and 3 red; 2, 4 light
  blue
    rgb_display_13.setPixelColor((1)-1,(((255 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 0));
    rgb_display_13.setPixelColor((2)-1,(((0 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 255));
    rgb_display_13.setPixelColor((3)-1,(((255 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 0));
    rgb_display_13.setPixelColor((4)-1,(((0 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 255));
    rgb_display_13.show();
  }
  else {
    rgb_display_13.setPixelColor((1)-1,(((0 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 0));
    rgb_display_13.setPixelColor((2)-1,(((0 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 0));
    rgb_display_13.setPixelColor((3)-1,(((0 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 0));
    rgb_display_13.setPixelColor((4)-1,(((0 & 0xfffff) << 16) | ((0 & 0xfffff) << 8) | 0));
    rgb_display_13.show();
  }
}
```

"The program upload was successful. The plant growth lamp is now on," Lumi said.

The four bulbs of the RGB LED strip lit up in the dim environment. Bulbs 1 and 3 glowed red, while bulbs 2 and 4 emitted blue light. From a distance, these two light sources merged together, resulting in a magenta hue.

Watching the activated plant growth lamp, I hurriedly approached to record the growth data of the experimental plants under the supplemental light.

Lesson 11: Automatic feeding

Under the assistance of the plant growth lamp, the plants on the farm are growing rapidly. In the vegetable area, the greens have already sprouted leaves, and tomatoes have started bearing fruit. What's even more amazing is that the experimental plants, which purify the air, have grown into 2-meter-tall trees. The current earth environment allows plants to grow quickly, and they are growing large in size as well.

Under my careful care, the kitten has completely recovered and is now very lively. Sometimes it likes to stay under the plant lamp and rest everywhere when tired. Once, when Lumi called for feeding, the kitten didn't respond despite calling for a long time. Anxiously, he searched everywhere and finally found the kitten sleeping in the ventilation duct.

Upon seeing this, Lumi said, "Why not build a small nest for the kitten?"

"I've actually had that idea, but I've been too busy and kept postponing it. Since that's the case, let's build the cat's nest now," I said helplessly.

Lumi said, "Hold on, have you thought about what kind of cat nest you want to build?"

"Well... because I'm too busy, and sometimes I forget to feed the kitten. It would be perfect if we could build a nest with an automatic feeding function. Do you have any good ideas?"

"That's indeed a good idea. Since we want to add the automatic feeding function, we need to make some structural adjustments. We can design a funnel at the top of the cat's nest to hold the cat food, then at the bottom of the funnel, we can install a rotating flap. We can control the opening and closing of the flap using a servo motor. Additionally, we need to add a touch sensor to control the servo motor. We can place the touch sensor at the entrance of the cat's nest so that when the cat is hungry, it can trigger the release of food by touching the sensor. This way, we can achieve the automatic feeding function for the cat's nest."

"It sounds quite complicated. What exactly is a servo motor?"

"Let me explain what a servo motor is."

The main structure of a servo motor is as shown in the diagram below, consisting of several components: the outer shell, the gearbox, the motor, the adjustable potentiometer, the electronic control board, and the servo horn.

Its working principle involves the control board receiving control signals from the signal source and driving the motor to rotate. The gearbox reduces the speed of the motor many times over and amplifies the output torque of the motor accordingly, then outputs it. The potentiometer and the final stage of the gearbox rotate together to measure the rotation angle of the servo motor shaft. The circuit board detects and determines the rotation angle of the servo motor based on the potentiometer, then controls the servo motor to rotate to the target angle or maintain the target angle.

The working process is as follows: control signal → electronic control board → motor rotation → gearbox reduction → servo horn rotation → position feedback potentiometer → control circuit board feedback.



"Got it, so it's a motor that can determine its position."

"That's right."

"Then let's start building the cat's nest."

Then we started collecting wood to build the nest, and after a while, the nest was finally built.



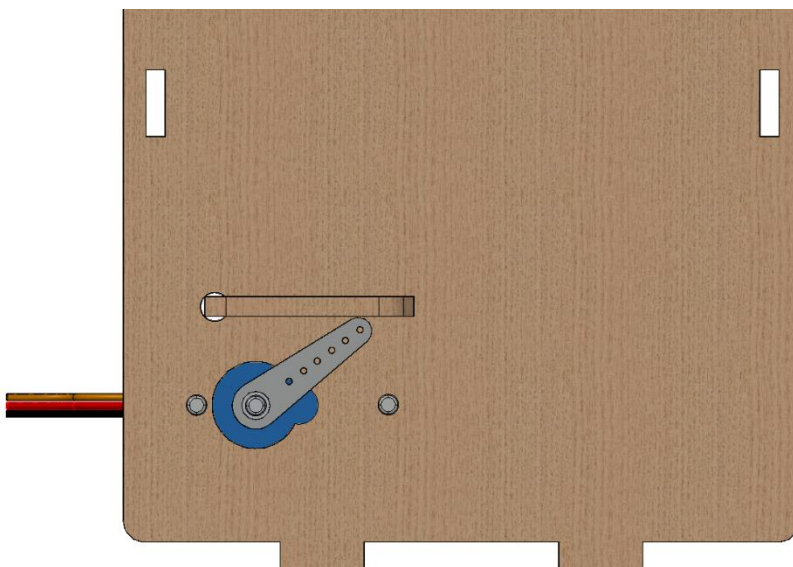
I immediately asked, "How do we implement the automatic feeding function?"

"Let's write the program together!"

[【Click to get the program】](#)

```
#include <ESP32Servo.h> // Import servo library
int value=0;
Servo myservo; // Create the servo object
int servoPin = 14; // Set the servo pin to 14
void setup(){
    pinMode(32, INPUT); // Set the touch sensor pin to 32
    myservo.attach(servoPin);
}
void loop(){
    value = digitalRead(32);
    if (value == 0) {
        myservo.write(0); // When the touch sensor is pressed, the servo is 0°
        delay(1000); // Delay 1 second
    }
    else {
        myservo.write(90); // Otherwise the servo is 90°
    }
}
```

Note: After uploading the servo program, the installation direction of the steering wheel needs to tilt to the upper right corner to finally support the D5 Linden board to maintain a horizontal posture.



"The program uploaded successfully, so I quickly called the kitten over. The kitten looked at the new cat's nest in front of it, seeming to

understand that it was meant for him, and happily rubbed against my legs."

"What's the purpose of the structure at the entrance, shaped like a cat paw?"

"That houses the touch sensor. If the cat is hungry, it can touch here, and then food will automatically drop from the cat's nest."

"I see. I'll teach the kitten how to use it." After explaining, I demonstrated the process to the kitten, and surprisingly, it quickly learned to operate it on its own."

Lesson 12: Christmas Eve

This morning, Lumi and I arrived at the farm's plantation, only to be amazed by what we found. It seemed that overnight, the fruits and vegetables had ripened. The tomatoes were as big as watermelons, and the cabbages had grown over a meter tall with leaves spreading over a meter wide. What was even more astonishing was that the experimental plant had grown into a full-sized tree, bearing red fruits.

With Christmas just a few days away, after enduring so many challenges since arriving on the earth, Lumi felt it was time for a celebration.

Three days later, Christmas arrived, and we gathered under the farm's large tree to celebrate joyfully. We enjoyed fresh vegetables and huge tomatoes, all of which tasted exceptionally delicious. After dinner, we all eagerly took turns cuddling the adorable kitten, and the atmosphere of reunion made everyone feel immensely content.

"I think it would be perfect to hear some Christmas songs on this special day," I remarked.

"On this special holiday, it would be perfect to hear some Christmas songs," I remarked.

"We can play songs using a buzzer," Lumi suggested.

"A buzzer can be used to play music?"

"Yes, because a buzzer can emit different musical notes. By arranging

them in a structured sequence, we can create various melodies."

"How do we make the buzzer emit different musical notes?"

"Each musical note corresponds to a specific frequency of sound. We just need to make the buzzer vibrate at a fixed frequency to produce the corresponding musical note. Here's a chart showing the frequency of each musical note," Lumi explained as he presented a chart showing the frequencies of musical notes.

Note	C3(1)	D3(2)	E3(3)	F3(4)	G3(5)	A3(6)	B3(7)
Freq	131	147	165	175	196	221	248
Note	C4(1)	D4(2)	E4(3)	F4(4)	G4(5)	A4(6)	B4(7)
Freq	262	294	330	350	393	441	495
Note	C5(1)	D5(2)	E5(3)	F5(4)	G5(5)	A5(6)	B5(7)
Freq	525	589	661	700	786	882	990

"Can we start playing music now?" I asked.

"Don't rush, music isn't just about notes, it also involves rhythm. Next, we'll delve into understanding the components of a song in detail," replied Lumi.

Following that, Lumi presented the sheet music of a Christmas carol and explained the meanings of the notes and beats.

Jingle bells

1=C $\frac{4}{4}$ ♩=88

<u>3</u> <u>3</u> 3	<u>3</u> <u>3</u> 3	<u>3</u> 5 <u>1</u> · <u>2</u> 3	–	
<u>4</u> <u>4</u> <u>4</u> <u>4</u>	<u>4</u> 3 <u>3</u> <u>3</u>	<u>3</u> 2 <u>2</u> <u>1</u> 2	5	
<u>3</u> <u>3</u> 3	<u>3</u> <u>3</u> 3	<u>3</u> 5 <u>1</u> · <u>2</u> 3	–	
<u>4</u> <u>4</u> <u>4</u> <u>4</u>	<u>4</u> 3 <u>3</u> <u>3</u>	<u>5</u> <u>5</u> <u>4</u> <u>2</u> 1	–	:

1.Common notes, like the first note 1, occupy one beat.

2.Notes with an underline represent 0.5 beats.

3.Some notes have a dot after them, indicating an additional 0.5 beat, making one note worth $1 + 0.5 = 1.5$ beats.

4.Some notes have a "-" after them, indicating an additional 1 beat, making one note worth $1 + 1 = 2$ beats.

Note	Beat	Symbol
Common note	1	1
Notes with an underline	0.5	<u>1</u>
Notes have a dot	1.5	1.
Notes have a "-"	2	1-

"What is the beat?"

Lumi continued, "Beat is the timing between notes. The duration of each beat varies from one song to another. We can see in the sheet music ♩=88, which indicates playing 88 beats per minute. Therefore, we can calculate that one beat lasts approximately $60000/88 \approx 682\text{ms}$."

"I didn't realize there was so much to music."

"Of course! Now, let's program the buzzer to play a Christmas song for everyone."

[Click to get the program](#)

```
int buzzerPin = 25; // Define the buzzer pin
// Defining notes
#define C4 262
#define D4 294
#define E4 330
#define F4 350
#define G4 393
#define A4 441
#define B4 495
int length0=24; // Length of tune
// Define a song tune
int tune0[] = { E4, E4, E4, E4, E4, E4, E4, G4, C4, D4, E4, F4, F4, F4, F4, F4, E4, E4, E4, G4,
G4, F4, D4, C4 };
// Define the tune beat
float dur0[] = { 1, 1, 2, 1, 1, 2, 1, 1, 1.5, 0.5, 3, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 3 };

void setup()
{
    for (int x = 0; x < length0; x++) {
        tone(buzzerPin, tune0[x]);
        delay(341 * dur0[x]); // Beat time of the song
        noTone(buzzerPin);
    }
}

void loop()
{
}
```

"The program uploaded successfully. Let's listen together."

Then, a familiar and timeless Christmas melody filled the air. Soon, we couldn't help but hum along, and in that moment, it felt like we could almost see Santa Claus racing through the snow on his reindeer.



Lesson 13: OLED Display

Now the transformation of the farm has begun to take shape, I led Lumi to visit every corner of the farm, while I introduced and tested each data individually, and finally kept recording the environmental data of the farm and the growth of plants in the book.

Lumi said, "Aren't you taking too much time?"

"It's a little time consuming, but in order to accurately and completely record the various data in the environment, there is no way to do it."

"Why not just show the data all at once?"

"If you can display it all at once, it really reduces a lot of work, and more importantly, it allows you to manage the data from every location on the farm."

"I think it's time to upgrade the farm," Lumi said.

"How can I upgrade it?"

"In the plan, we need to upgrade the original farm into a smart farm, and finally realize the transmission of farm related data to F Planet. Now that we have achieved the basic functions of the farm, I suggest that we first visualize the environmental data of the farm, and finally repair the communication and power, and then realize the remote data transmission," Lumi said.

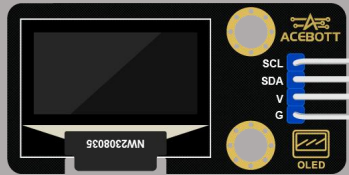
"What will we use to display the data?"

"I think we can use OLED screens to visualize the farm data."

"What is an OLED screen?"

"Let me introduce the OLED screen first."

OLED belongs to a current type of organic light emitting device, also known as organic laser display, organic light emitting semiconductor. Under the action of electric field, the internal electrons of OLED will move and meet, and the energy excitons generated will excite luminescence, thereby producing visible light.



Lumi asked, "What data do you need to display?"

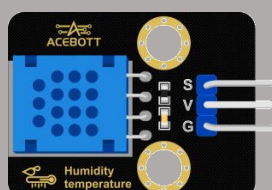
"I need to display light data, temperature data, and humidity data for the farm environment."

"The light data can be obtained using the photosensitive sensors we learned earlier, but the temperature and humidity require new sensors called temperature and humidity sensors."

"What is a temperature and humidity sensor?"

"Let me introduce the temperature and humidity sensor."

Temperature and humidity sensor is based on the digital temperature and humidity sensor DHT11 a sensor, it is a set of temperature, humidity one of the composite sensor, it is the temperature and humidity physical quantities through temperature, humidity sensitive elements and the corresponding circuit into convenient data acquisition equipment directly read digital quantities can be measured temperature range of 0°C~50°C, accuracy of $\pm 2.0^{\circ}\text{C}$, The humidity ranges from 20% to 80% and the accuracy is 5%.



"Now how can we display data on light and temperature and humidity?"

"We also need to write programs to display light values and temperature and humidity values on the OLED screen."

[【Click to get the program】](#)

```
#include <U8g2lib.h> //Import OLED library
#include <Wire.h> //Import Arduino's IIC library
#include <DHT.h> //Import the temperature and humidity library
U8G2_SSD1306_128X64_NONAME_F_HW_I2C u8g2(U8G2_R0, U8X8_PIN_NONE);

String light; //Define light variable
String hum; //Define humidity variable
String tem; //Define temperature variable
DHT dht23(23, 11); //Define temperature and humidity of the pin

void Page1() { //Define the content of the OLED display
    u8g2.setFont(u8g2_font_timR12_tf); //Set display font
    u8g2.setFontPosTop(); //Set font position to align against top
    u8g2.setCursor(0,0); //Set font display coordinates
    u8g2.print(String("light: ") + String(light)); //Display light value
    u8g2.setCursor(0,20); //Set font display coordinates
    u8g2.print(String("hum: ") + String(hum)); //Display humidity value
    u8g2.setCursor(0,40); //Set font display coordinates
    u8g2.print(String("tem: ") + String(tem)); //Displays the temperature value
}

void setup() { //Initialize the OLED display
    u8g2.setI2CAddress(0x3C*2);
    u8g2.begin();
    light = "";
    hum = "";
    tem = "";
    dht23.begin();
    u8g2.enableUTF8Print();
}

void loop() {
    pinMode(23, INPUT);
    u8g2.firstPage();
    do
    {
        Page1(); //Call display function
    } while(u8g2.nextPage());
    light = analogRead(34); //Get the light value
    tem = dht23.readTemperature(); //Get the temperature value
    hum = dht23.readHumidity(); //Get the humidity value
    delay(1000);
}
```

"The program has been uploaded successfully, and the OLED screen has displayed the light value, temperature value and humidity value. Next time, there is no need to test and record the data separately," I said happily.

"Now is just the first step of farm intelligence, the next step is how to get the current weather information and remote access to farm data is the key."

Lesson 14: Weather Detection

The frequency of solar storms is getting higher and higher. The weather changes in these days are very strange. One second is still scorching sun, and the next second is stormy.

Five days later, when the weather finally settled down, Lumi decided to fix the weather station.

"I'm going to the weather station today to fix the weather equipment and the servers inside, and you'll stay on the farm to help with the weather capture function," Lumi said.

I quickly asked, "but how can I get the weather information?" "Don't worry, I'll contact you by satellite phone when I've fixed the weather station and we'll talk about the details then."

"No problem. Be safe."

Lumi examined the map carefully, identified his location, and then set off for the weather station with his backpack. On his way up the mountain, he passed a hilltop and looked into the distance. He saw a city with tall buildings in the distance, but it was now deserted.

After an hour or so, Lumi finally found the weather station.

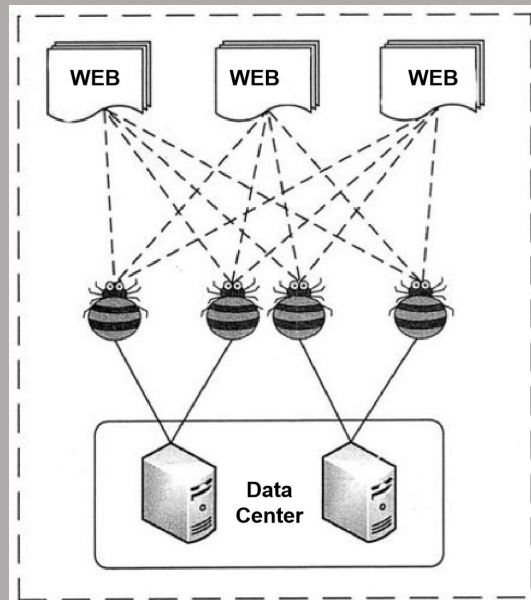


At this time, the weather station was overgrown with grass, and most of the wall skin of the building had fallen off. Lumi first repaired the weather equipment, and then went to the computer room to repair the weather station server.

After the overhaul, most of the equipment and servers of the weather station can still be used, as long as the server of the weather station is repaired, and log on to the original meteorological website here, you can

obtain weather data through web crawler.

Web crawler (also known as web spider) is a program that automatically grabs web information according to certain rules. The workflow of crawler: send request to simulate browser (get web code)----> extract useful data -----> store in database or file;



After fixing the server, Lumi called me on a satellite phone. "I've fixed the weather station," he said. "I just sent you an application to get the weather, open it and upload it to the controller board."

[【Click to get the program】](#)

Note: The wifi account number and password need to be filled in by yourself.

"No problem, but where will the weather data be displayed?"

"Weather data will be displayed on the OLED screen."

"Ok, now the app uploads successfully, I see the weather data."



Note: This function will get local weather data based on the IP address of the connection network.

"Now that we've solved the problem of getting the weather, we're going to solve the problem of controlling the farm remotely," Lumi said.

"How to solve?" "I need to go to the communication station near here to repair the signal transmission function and restore the function of the Internet, and then the smart farm will finally realize the function of the Internet of things."

So Lumi takes care of this and goes on to the communication station.

Lesson 15: Internet of Things Remote Control

The station was 20 kilometers northwest of the weather station. Lumi walked through the center of the city, stopped and stopped all the way. Finally, after three hours, he reached the station.

After years of wind and rain, the communication station has become dilapidated and deserted, and the communication equipment inside is covered with thick dust. Lumi quickly detected the equipment, and after the detection, the server here reopened, he came to the base station on the roof, and replaced the transmitter, and now the signal can cover the radius of 50 kilometers.



Lumi pulled out a router to connect, and after a while, he was able to search for a WiFi signal on the Superwatch.

Lumi calls a satellite phone and says, "Hey, I have fixed the communication station, now I need you to use the router to try to connect to the WiFi."

"Ok, just a moment."

After a while, I replied, "Lumi, the signal is fine, you can get it."

"Ok, next I'm going to try the Internet of things."

"What is the function of the Internet of things?"

"Let me introduce you to the Internet of Things first."

The Internet of Things is an intelligent network established on the basis of wireless communication technology. In this network, various devices and objects can achieve interconnection. It is not limited to traditional computers and mobile phones, but also includes various smart devices such as home appliances, cars, and sensors. Through the Internet of things, people can monitor and control various devices and objects anytime and anywhere, making life more intelligent and convenient.

In short, the Internet of things is "things connected to the Internet", according to the network protocol, the goods and the Internet connected, information exchange and communication, to achieve intelligent identification, positioning, tracking, monitoring and management of a network.



"How do you test the capabilities of the IoT?"

"I want to remotely control the farm's LED lights on and off by means of the Internet of things."

"How do you do that?"

"First, the controller board and the terminal equipment are connected to the same WiFi to form a LAN, and then upload a web control LED

lamp program, in the LAN we can access the webpage through the IP address, and then click the LED control button of the webpage, the control information will be transmitted back to the controller board, and finally control the state of the LED."

"I'm going to send you a program to remotely control the farm's LED lights, and you can open it and upload it to the ESP32 controller board," Lumi said.

[【Click to get the program】](#)


```
#include<WiFi.h>//Import WiFi library
#include<WebServer.h>//Import the web server library
const char* ssid = "xxx";//Please enter your WiFi name
const char* password = "xxx";//Please enter your WiFi password
int ledPin = 27;
WebServer server(80);//Set the web server port

void handleRoot(){//Remote control LED web program
  String HTML = "<!DOCTYPE html>\n
  <html>\n
  <head><meta charset='utf-8'></head>\n
  <body>\n
  Control LED! \n
  <script>var xhttp = new XMLHttpRequest();\n
    function sw(arg){\n
      xhttp.open('GET', '/sw?Led=' + arg,true );\n
      xhttp.send();\n
    }\n
  </script>\n
  <button onmousedown=sw('on')>LED ON</button>\n
  <button onmousedown=sw('off')>LED OFF</button>\n
  </body>\n
  </html>";
  server.send(200,"text/html",HTML);
}

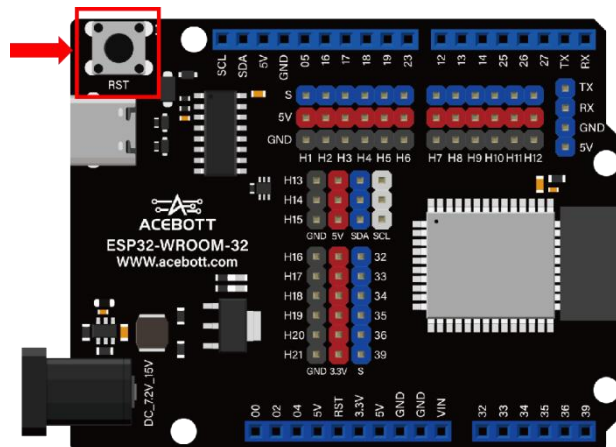
void setup() {
  Serial.begin(115200);
  pinMode(ledPin, OUTPUT);
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);
  while(WiFi.status() != WL_CONNECTED){//Waiting to connect to WiFi
    delay(500);
    Serial.print(".");
  }
  Serial.print("\nIP address: ");
  Serial.println(WiFi.localIP());//Serial port prints the IP address of WiFi
  server.on("/", handleRoot);
  server.on("/sw",ledSwitch);
  server.on("/c", [](){server.send(200,"text/html","hello");});
  server.onNotFound([](){server.send(200,"text/html;charset=utf-8","Page not found !
  ");});
  server.begin();
}
```

```
void ledSwitch(){
  String state = server.arg("Led");
  if(state == "off"){
    digitalWrite(ledPin, LOW); //Web page click turn off the lights, LED off
  }else if(state == "on"){
    digitalWrite(ledPin, HIGH); //Web page click turn on the light, LED on
  }
  server.send(200, "text/html", "LED IS <b>" + state + "</b>.");
}
void loop() {
  server.handleClient();
}
```

Note: The wifi account number and password need to be filled in by yourself.

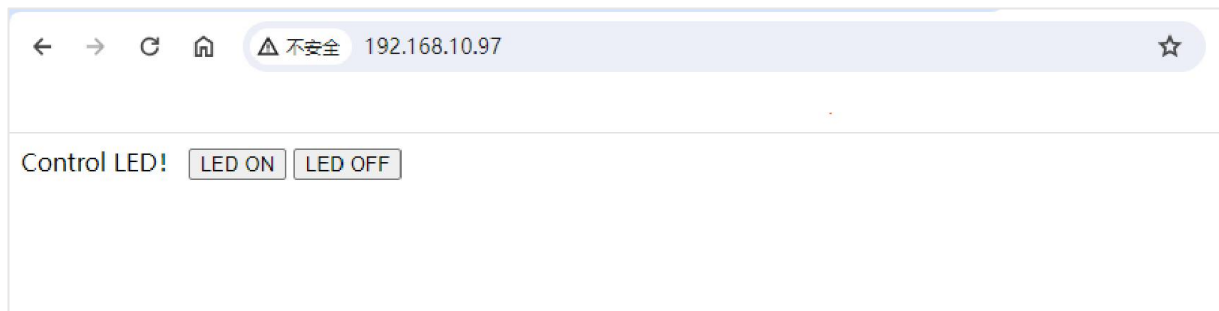
"Ok, uploading succeeded, now what?"

"Now you tell me the IP address shown in the serial port, if not, please press the reset button on the controller board."



"Ok, the IP address of the current connection is shown as: XXX.XXX.XX."

"Now enter this IP address in the browser, then a webpage control page will be displayed, I now click the LED ON and then click the LED OFF, you observe whether the LED light will turn on and off?"



"Amazing, the LED did turn on and off!"

"Ok, so now the remote control function test is successful."

"Haha, great! The farm upgrade is finally complete."

"Don't get excited, we still have one last step to take. We need to integrate everything into the APP so we can control it," Lumi said.

"Alert alert! Solar storm expected in three days!" Lumi's super watch suddenly received a message from the satellite, and the atmosphere became very solemn.

Lesson 16: APP Control

"I need to get back to the farm and find a way to secure it," Lumi said.

"If it's too destructive, normal protection might not work," I said.

"If the solar storm is too destructive, then only the farm's energy shield can be activated."

"What energy shield?"

"This is an energy shield that Instructor Luca gave me before we left. It's a very strong physical defense. He stressed that it should only be used in an emergency, but the energy shield can't withstand the radiation from the solar storm, so we have to go underground."

"Under the ground? I thought you said last time you found traces of an underground shelter on the farm."

"Yes! But the information needs to be reconfirmed," Lumi replied.

Lumi then plans the shortest path to the farm and quickly travels. On the way, he finds a large number of creatures migrating, as if avoiding some kind of disaster. There are crows flying south in the sky, fish jumping in the river, and some bison on the land in a mass migration.



For a time, there were many animals fighting each other all over the place, and the scene was very chaotic. Seeing this situation, Lumi felt bad and tried to avoid the creatures along the way, which also caused him adds a lot of distance.

He finally returned to the farm two days later, the last day of the solar storm, when a large cloud covered the whole sky, huge lightning continued to cast huge flames in the sky, and a giant tornado was faintly seen forming in the distance.

Suddenly "Ho!" With a loud noise, there was a meteorite. In the sky, several meteorites were falling rapidly in succession, forming a fireball under the friction of the air. Fortunately, the fireball fell more than 200 kilometers away from the farm.

When I saw Lumi, I said anxiously, "I've found the bomb shelter. Let's get in."

"Okay, I'll start with the energy shield," Lumi said quickly.

At this time the tornado slowly moved forward, the situation is becoming more and more critical, as the wind is getting stronger and stronger, the wooden house is squeaked by the wind.

Suddenly there was a meteorite in the sky falling in the direction of the farm. It was expected to fall in about five minutes.

Lumi was anxiously waiting for the energy shield to open. Two minutes later, a translucent curtain of light shot out of the shield and covered the farm.

With the hood activated, Lumi quickly ran to the underground bunker. As soon as Lumi stepped into the shelter, there was a loud noise, and then the ground continued to shake strongly.

The meteorite hit the location of dozens of meters from the farm, there was a huge deep pit, but also splashed countless gravel, many different sizes of gravel fell toward the farm, but fortunately the energy shield's defensive force is very strong, all the gravel was blocked outside.



Under the shelter, I said anxiously, "I wonder when the solar storm will end. How will we know about the farm?"

"Don't worry, I've built an APP to manage my farm remotely."

"Great! How do you use it?"

"Don't worry, let me explain how to install the APP first."

For an IOS device, search for ACEBOTT in the APP Store and download it.

For Android phones, search the Google Play Store for ACEBOTT and download it. The icon is shown below.



"Install it and you can control it directly?"

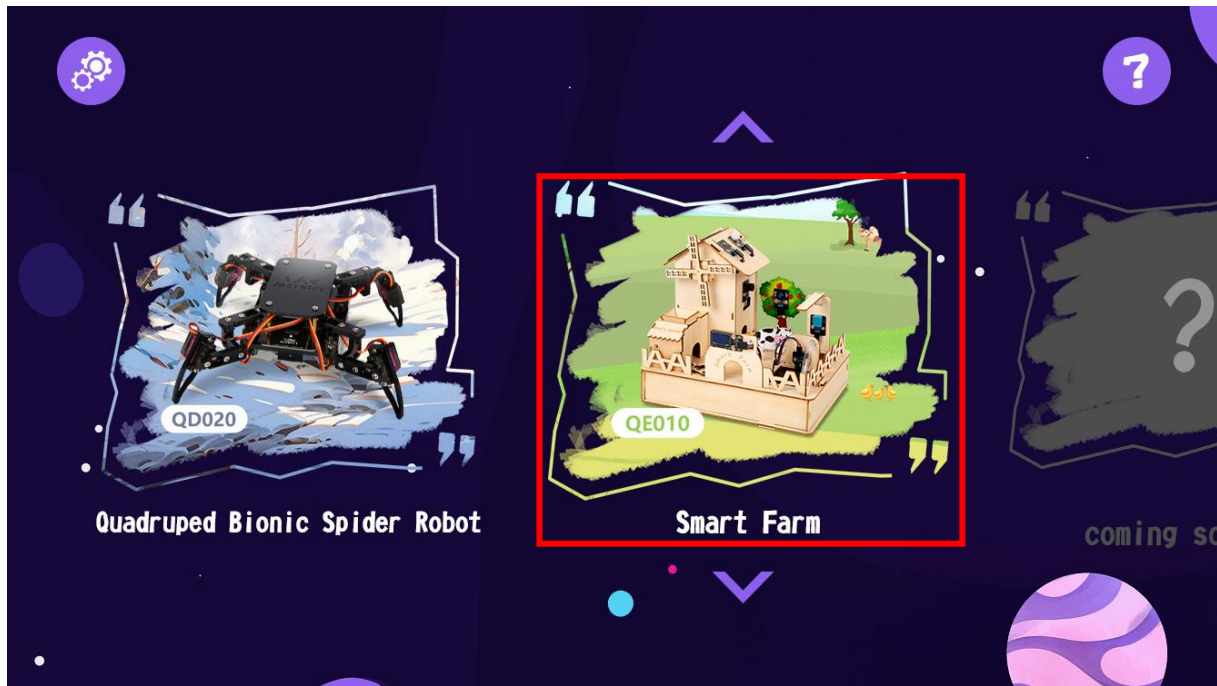
"Not yet, now we need to upload the control program to the ESP32 controller board in order for the APP to function," Lumi replied.

[【Click Get APP control】](#)

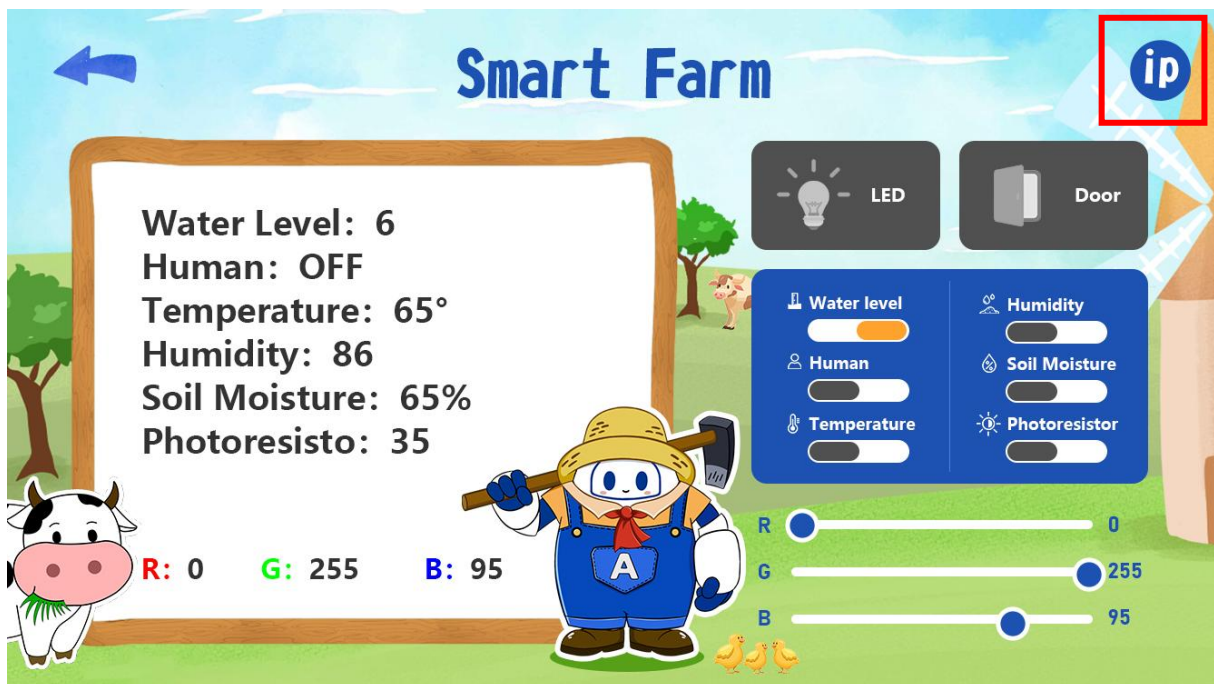
Lumi warns: "to upload your program before, remember to modify the program of the WiFi name and password, mobile phones and ESP32 also connect the same WiFi."

```
const char* ssid = "xxxx";//Please use your WiFi name  
const char* password = "xxxx";//Please use your WiFi password
```

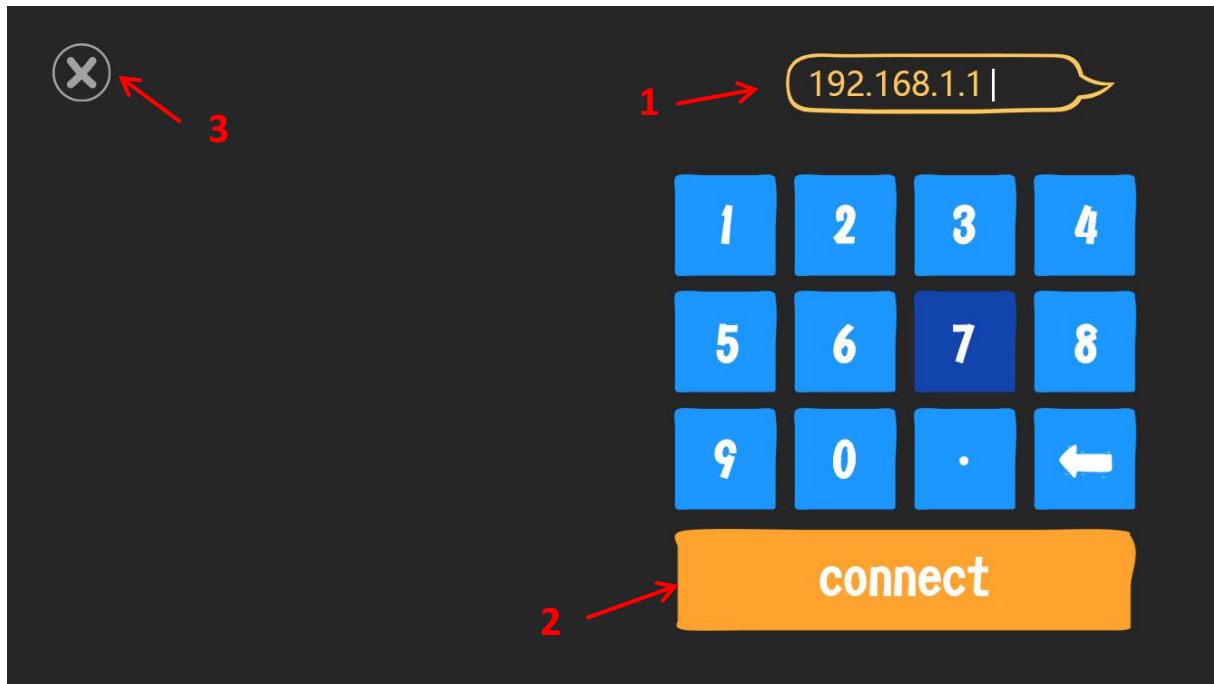
"Once connected to the WiFi, open the APP and select 'Smart Farm Starter Kit'."



"Once you are in the control screen of the smart farm, click on the 'ip' in the top right corner to connect to the ESP32," Lumi said.



"Then, according to the IP address displayed on the serial port display, manually enter the IP address in the App and click 'connect'."



"When we get the 'Connected Successfully' prompt, we're connected, and we're ready to take control, so we can get data from each group and take control of the farm."

"Great," I said excitedly. "I can't wait to try it!"

So I downloaded the APP according to the steps, uploaded the program and connected to the network, and then realized the function of managing the operation of the farm and checking the weather conditions outside on the APP.

End

The solar storm lasted for nearly a year, during which the environment outside the farm changed dramatically. During the day, the temperature on the earth was as hot as 60°C , and at night it was as cold as -40°C . At the same time, there were earthquakes, volcanic eruptions, hail, heavy snow, sand storms and other extreme weather.

I have been watching the weather outside on the APP, and it took another three months after the solar storm stopped, and the weather gradually became stable, before we came out of the bomb shelter. In order to better understand the environmental changes of the Earth after the solar storm, we plan to spend a year in the field to record the ecological situation in the radius of 1000 kilometers around the farm.

On the way, perhaps because of the dramatic changes in the atmosphere and the earth's crust, we found that the original bare ground emerged a lot of green plants, the earth's air became a lot of fresh, even the dark sky also appeared blue sky white clouds.

In addition, we also found that many large creatures died out because of the disaster, and some small creatures began to become active, and they were often seen jumping out of the grass.

We recorded as we walked through forests, grasslands, rivers, deserts, and coasts. Finally, a year later, we returned to the farm. After I had sorted out all my experiences and data on Earth, Lumi and I returned to F

Planet in the Voyager spacecraft.

Seven days later, when the Guardian Alliance leaders learned of our return, they held an urgent meeting to discuss the next step. Finally, they agreed to send 100 people to the key areas of the Earth to carry out the urban construction project.

After three months of preparation, a huge spaceship carrying 100 people and supplies flew from F Planet to Earth. They landed in a deserted town near the farm and began to build.

They restored the city's electrical and communications systems, built an ecological restoration center, and transplanted large areas of plants that used to clean the air.

Another 50 years later, the original city area was expanded by 50 times, and the ecology of the earth was finally restored to its original state with the help of purification plants.

At this point, the F Planet alliance high-level official implementation of the return to Earth program, in the vast universe, tens of thousands of spacecraft from the F Planet flew to the Earth.....