Lunar Lava Tube Exploration Rover

National Aeronautics and Space Administration

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Abstract

Through the Artemis program, NASA is going back to the moon to establish a permanent human presence on the lunar surface. If proven stable, lunar lava tubes could serve as a space to help shield human occupied structures from solar radiation. Also, to escape the extreme temperatures experienced during the day/night cycles on the moon. Scientifically, there has not been a human or robot yet to set foot inside any of these lava tubes making these features important for study. Water-ice or other important resources could be located inside and can also be used to support the Artemis program. The goal of this project is to explore lava tubes on the lunar surface with an Arduino-based rover. Data collected will come from a hall-magnetic sensor, a UV sensor, and a gravimeter. Sensor data will then be written onto a SD card located on the Arduino Uno microcontroller.

Arduino Code

Data_Logging | Arduino IDE 2.1.1

File Edit Sketch Tools Help

Arduino Uno

Data_Logging.ino

```ino
#include <SPI.h>
#include "SdFat.h"
#include "RTClib.h"

SdFat sd; // SD Card object
File myFile; // File object
RTC_DS1307 rtc; // RTC object
float uvSensorVoltage; // Variable for uv sensor voltage
float uvSensorValue; // Variable for uv sensor reading

void setup() {
  Serial.begin(9600);
  pinMode(A0, INPUT); // Mag sensor

  // RTC Init
  if (!rtc.begin()) {
    Serial.println("Couldn't find the RTC");
    Serial.flush();
    while (1) delay(10);
  }

  // RTC check if running
  if (!rtc.isrunning()) {
    Serial.println("RTC is NOT running, let's set the time!");
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
  }

  // SD Card Init
  if (!sd.begin()) {
    Serial.println("SD Card init failed!");
    return;
  }

  // Create/Open file
  myFile = sd.open("lavatubedata.csv", FILE_WRITE);
```

Sensors Code

Drive | Arduino IDE 2.1.1

File Edit Sketch Tools Help

Arduino Uno

Drive.ino

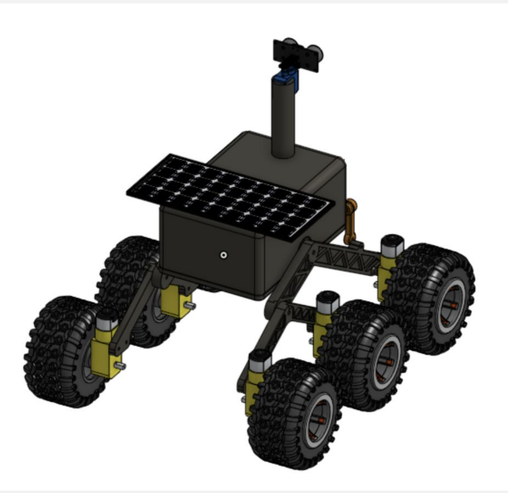
```ino
void loop()
{
  //DETECT THE DISTANCE READ BY THE DISTANCE SENSOR
  distance = getDistance();

  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" in");                    // print the units

  if (digitalRead(switchPin) == LOW) { //if the on switch is flipped

    if (distance < 10) {                    //if an object is detected
      //back up and turn
      Serial.print(" ");
      Serial.print("BACK!");

      //stop for a moment
      rightMotor(0);
      leftMotor(0);
      delay(200);

      //back up
      rightMotor(-255);
      leftMotor(-255);
      delay(backupTime);

      //turn away from obstacle
      rightMotor(255);
      leftMotor(-255);
      delay(turnTime);

    } else {                                //if no obstacle is detected drive forward
      Serial.print(" ");
      Serial.print("Moving...");


      rightMotor(255);
      leftMotor(255);
    }
  } else {                                  //if the switch is off then stop

    //stop the motors
    rightMotor(0);
    leftMotor(0);
  }
```

Motor Drive Code

The rover has two different types of code: sensors and motor drive. The sensors code measures gravity anomalies for rock density changes, as well as magnetic pole changes indicating presence of iron-rich rock. Sensors code also measures reflective light in the UV spectrum. This could help determine the presence of water-ice. Data collected will be written to a SD card for later down-linking. The drive code is primarily meant for rover object avoidance and mobility.

Rover Chassis

Aluminum was used because it's readily available and a more cost-effective option, considering PVC would have added to the Bill of Materials (BOM). The structure of the rover was based on the rocker-bogie design of the wheels, which allows flexibility and mobility on the loose regolith. An old radio controlled (RC) car was repurposed due to its sturdy chassis and useful parts. Wheels from the RC car were an important addition to the structure of the rover and they came with an attached suspension. To power the rover it uses solar panels to harness sunlight which is converted to energy. Collected energy is then stored in Lithium-polymer batteries. The rover possesses a protective layer shield to protect the internal components from micrometeoroid, loose regolith, extreme temperatures, and UV radiation.



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