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HIGH ALTITUDE BALLOON FOR PHOTOGRAMMETRY AND TELEMETRY USING RASPBERRY PI & ARDUINO UNO

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ABSTRACT

The purpose of our project was to conduct a series of high altitude balloon experiments on student-designed launch platforms. Many design goals were considered, including, but not limited to: horizontal control for helium weather balloons, tethered camera platforms (controlled and passive), high-definition video platforms, and miscellaneous data collection. Over the course of the project, the High Altitude Ballooning payload design and microcontroller programming was designed and tested. We have also conducted tests on tethered camera payloads. We have also tested the system for atmospheric data collection and collected the data from the respective sensors and successfully mapped the data for scientific purposes. No such system exists to date that maps data first hand independently. Also the imagery obtained is full High Definition and can be used for geoinformatic and cartographic purposes.

KEYWORDS: Raspberry Pi, Arduino Uno, Raspberry Pi Camera, Bmp180, Dht11, Hmc5883l.

INTRODUCTION

High Altitude Ballooning (HAB) is the application of analog and digital amateur radio to weather balloons. Often referred to as "The Poorman's Space Program", HAB allows amateurs to design functioning models of spacecraft and launch them into a space-like environment. Bill Brown (amateur radio call sign WB8ELK) is considered to have begun the modern ARHAB movement with his first launch of a balloon carrying an amateur radio transmitter on 15 August 1987. The first recorded HAB launch, however, is recorded to have taken place in Finland by the Ilmari program on May 28, 1967.

An HAB flight consists of a balloon, a recovery parachute, and a payload of one or more packages. The payload normally contains a camera system, data collection and amateur radio transmitter that permits tracking of the flight to its landing for recovery. Most flights use an Automatic Packet Reporting System (APRS) tracker which gets its position from a Global Positioning System (GPS) receiver and converts it to a digital radio transmission. Other flights may use an analog beacon and are tracked using radio direction finding techniques. Long duration flights frequently must use high frequency custom built transmitters and slow data protocols such as RTTY, Hellschreiber, Morse code and PSK31, to transmit data over great distances using little battery power. Use of amateur radio transmitters on an ARHAB flight requires an amateur radio license, but non-amateur radio transmitters are possible to use without a license.

There is also a data collection platform that involves an Arduino and a multi sensor system that writes the data collected from the sensor(s) on to a simple XML (Extensible Markup Language) database. This raw unformatted data is carried on the SD Card and the later processed and plotted to obtain changes and variation in atmospheric parameters.

The availability of such real time data is very useful for meteorological purposes and accurate analysis can be obtained from the data to take appropriate steps for logistics, agricultural purposes, and maritime and aviation navigation.

The camera platform which uses a multi camera platform to obtain high quality images for cartographic and geoinformatic purposes. This is stored locally on the payload and cannot be transmitted effectively due to high quality and hence increase in bandwidth that cannot be implemented on a short wave transmission system on the payload. The images are stitched either as a manual or an automated task.

The images can be geotagged or visually identified by any reference map taken of the same location previously like a satellite image of the same and can also superimposed on the older map to create a newer map. Data can be extracted from the base map to create vectors and that data can be stored on the cloud the provide data stream to any requested user.

MATERIALS AND METHODS

A payload (an insulated box containing some electronics such as a Camera system, data collection, GPS and a radio to allow you to follow progress) is attached to a balloon which is filled with helium (He). The balloon is released and, as He is lighter than air, the balloon rises and pulls the payload with it. As the balloon rises the outside pressure decreases which leads to the helium inside the balloon expanding (imagine like its expanding to fill the gap as the outside pressure decreases), this causes the balloon to stretch.

The balloon is made of a form of latex and is incredibly stretchy however it gets to a point where it can't stretch anymore and bursts. Now that there isn't any upward pull from the balloon the payload begins to fall to earth pulled by gravity, as it falls the parachute opens up slowing its descent and it gently glides down to earth. Therefore if you want to fly a HAB mission you need to construct a payload box with a tracking device (e.g. Telemetry module, microcontroller and then a radio). Additional components include for example cameras and atmospheric data sensor. You also will need a parachute, a balloon and some helium and permission to launch.

RASPBERRY PI

The methodology that we decided to use for the project is to use a Raspberry Pi Model B+ for obtaining the images via the proprietary Pi Camera and webcam and an Arduino Uno for collecting the data.

The webcam is used for horizon photography purely for aesthetic purpose and horizon lock platform. The proprietary Pi Camera is used for vertical surface facing imagery for photogrammetric purposes. The Arduino Uno is used to interface the sensors and collect and store the data.

Released in July 2014, the Model B+ is an updated revision of the Model B. It increases the number of USB ports to 4 and the number of pins on the GPIO header to 40. In addition, it has improved power circuitry which allows higher powered USB devices to be attached and now hot-plugged. The full size composite video connector has been removed and the functionality moved to the 3.5mm audio/video jack. The full size SD card slot has also been replaced with a much more robust microSD slot as shown in Fig 1.1

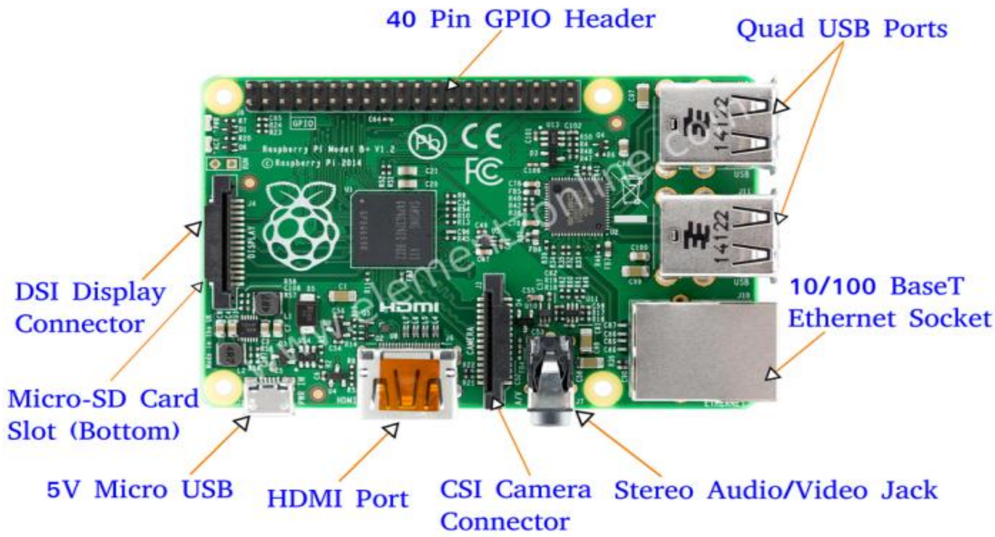

Fig 1.1 Raspberry Pi Labelled Physical Diagram

ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as Pulse Width Modulation outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started as shown in Fig 1.2.

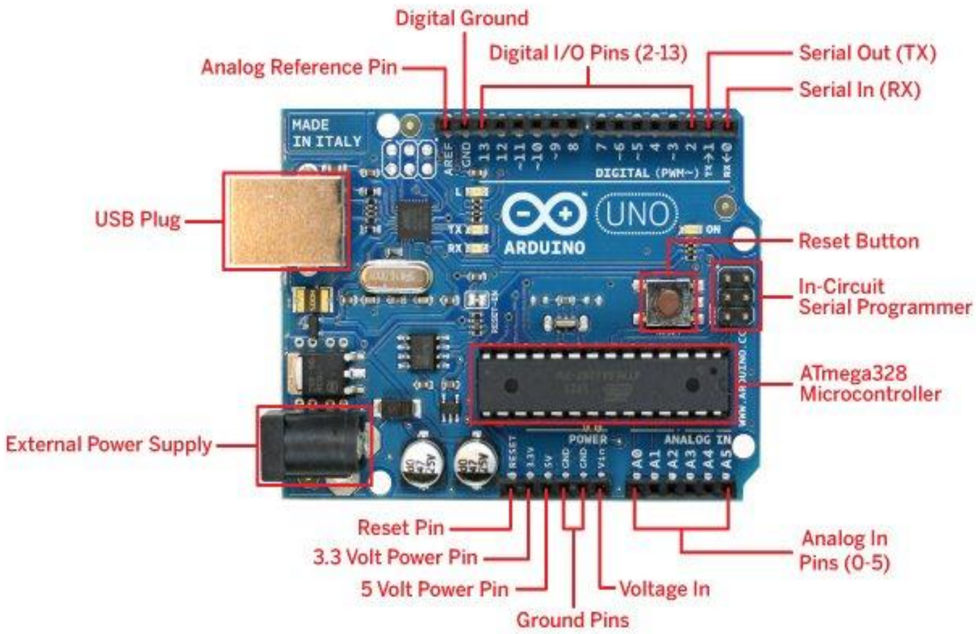

Fig 1.2 Arduino Uno Physical Diagram.

RASPBERRY PI CAMERA

The Raspberry Pi camera module is capable of taking full HD 1080p photo and video and can be controlled programmatically as shown in Fig 1.3.

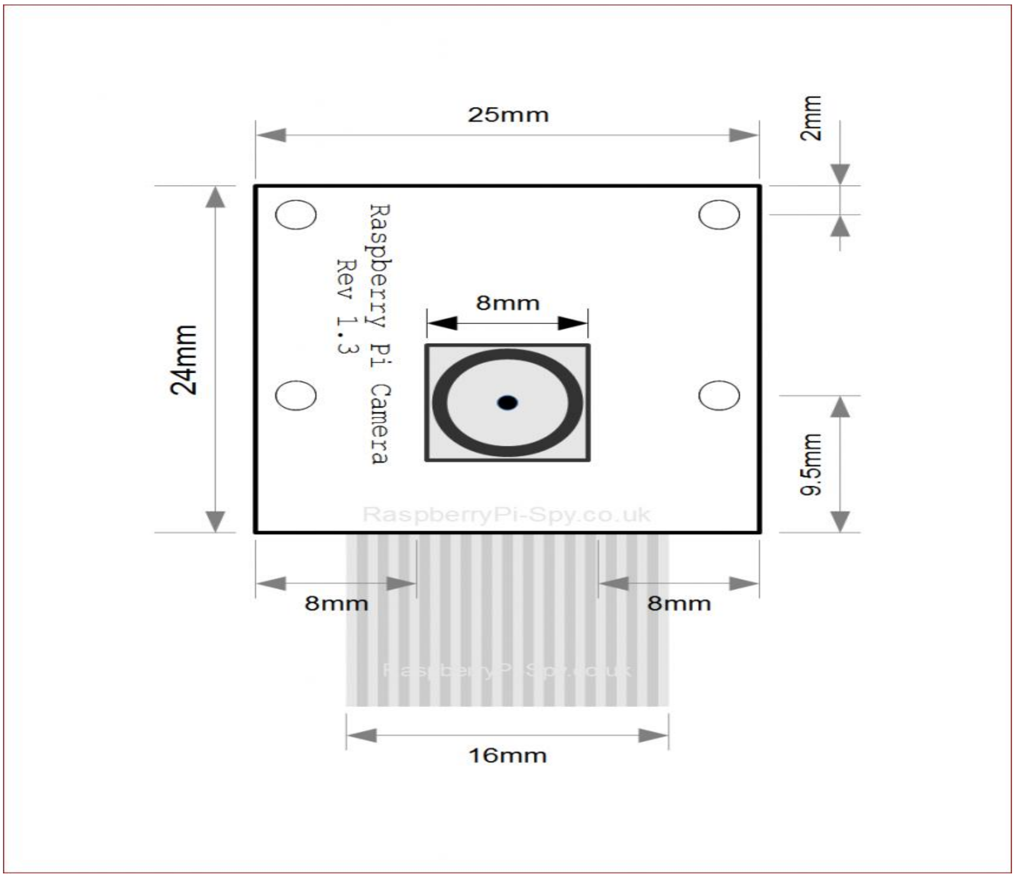

Fig 1.3 Raspberry Pi Camera Module

SENSOR PLATFORM

1. BMP180 (DIGITAL PRESSURE SENSOR)

The **BMP180** is the new digital barometric pressure sensor of Bosch Sensortec, with a very high performance, which enables applications in advanced mobile devices, such as smart phones, tablet PCs and sports devices. It follows the BMP085 and brings many improvements, like the smaller size and the expansion of digital interfaces.

The ultra-low power consumption down to 3 µA makes the **BMP180** the leader in power saving for your mobile devices. **BMP180** is also distinguished by its very stable behaviour (performance) with regard to the independency of the supply voltage as shown in Fig 1.4

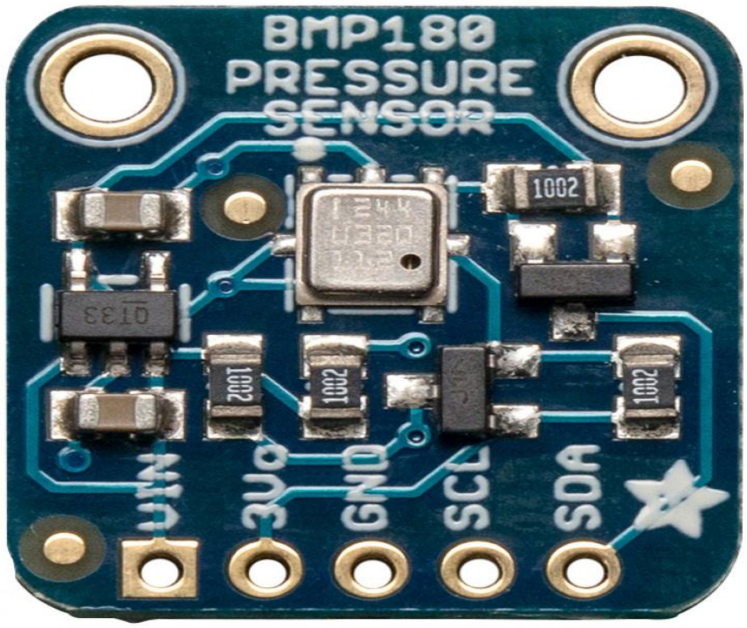

Fig 1.4 BMP180 Pressure Sensor

2. DHT11 (DIGITAL TEMPERATURE AND HUMIDITY SENSOR)

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

Each **DHT11** element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor’s internal signal detecting process. The single-wire serial interface makes system integration quick and easy.

Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users’ request as shown in Fig 1.5

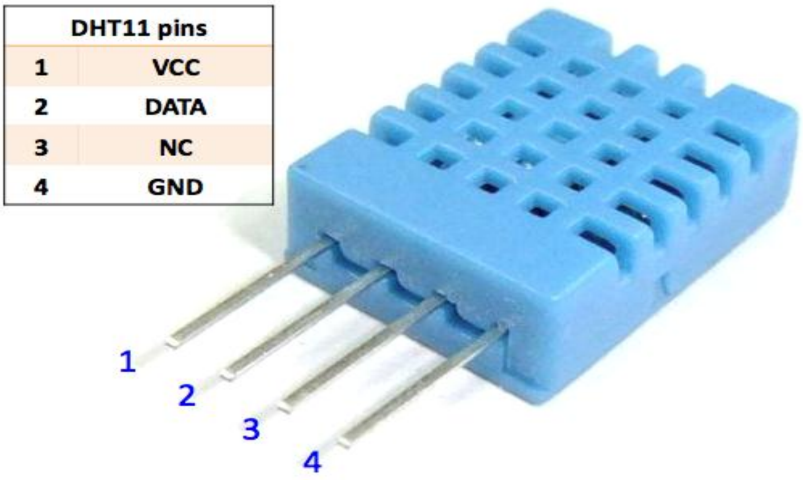

Fig 1.5 DHT11 (Temperature and Humidity Sensor)

3. HMC5883L (3-AXIS DIGITAL MAGNETOMETER SENSOR)

The Honeywell **HMC5883L** is a surface-mount, multi-chip module designed for low-field magnetic sensing with a digital interface for applications such as lowcost compassing and magnetometry. The **HMC5883L** includes our state-of-theart, high-resolution HMC118X series magneto-resistive sensors plus an ASIC containing amplification, automatic degaussing strap drivers, offset cancellation, and a 12-bit ADC that enables 1° to 2° compass heading accuracy. The I 2C serial bus allows for easy interface as shown in Fig 1.6

The HMC5883L is a 3.0x3.0x0.9mm surface mount 16-pin leadless chip carrier (LCC). Applications for the **HMC5883L** include Mobile Phones, Netbooks, Consumer Electronics, Auto Navigation Systems, and Personal Navigation Devices. The HMC5883L utilizes Honeywell's Anisotropic Magnetoresistive (AMR) technology that provides advantages over other magnetic sensor technologies.

These anisotropic, directional sensors feature precision in-axis sensitivity and linearity. These sensors' solid-state construction with very low cross-axis sensitivity is designed to measure both the direction and the magnitude of Earth's magnetic fields, from milli-gauss to 8 gauss. Honeywell's Magnetic Sensors are among the most sensitive and reliable low-field sensors in the industry.

Fig 1.6 HMC5883L (3-Axis Digital Magnetometer Sensor)

RESULTS AND DISCUSSION

We the undersigned are interested in launching unmanned high altitude balloons into near space. High altitude ballooning is a multi-skilled hobby which lets you explore the edge of space relatively cheaply as shown in Fig 1.7

The camera system deployed are used for photogrammetric purposes and the radio portion is used to track the flight and retrieve the payload for scientific purposes.

Data collected and stored through the microcontroller are used to collect first hand independent atmospheric data.

This project is mainly a science platform through an engineering solution.

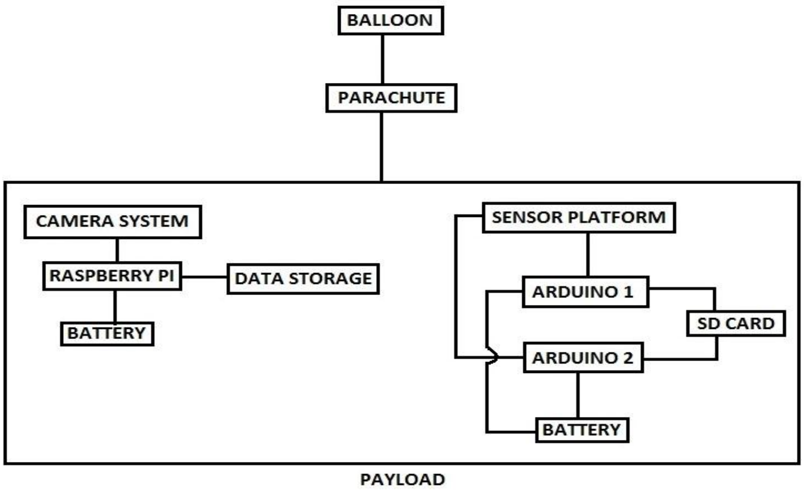

Fig 1.7 High Altitude Balloon Dependency Diagram

CONCLUSIONS

Our group has been able to make incredible strides in our understanding of payload design. We learned how to manage power resources to payload components and how to cope with stabilization and weight limitations.

We ran extensive tests on multiple types of microcontrollers before using the Arduino Uno. We learnt how to create a camera system from scratch and implement it in our project.

We also created the Arduino Data collection and sensor platform.

Overall, this project has expanded all of our horizons. We started with no experience new parts and with lots to learn, but now we have the resources for a fully operational near space program. What we have learned from this project will lay the foundation for more advanced works.

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