

HabPi: A Simple Framework for High Altitude Sensing

Robert Lowe

Division of Mathematics and Computer Science
Maryville College

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Outline

1 Introduction

2 HabPi

3 HabPi Flights

Motivation

- The Pellissippi State eclipse team needed practice.
- We needed an inexpensive, extensible payload.
- We wanted a payload simple enough to be assembled by grade-school students.

HabPi 1 - November 18, 2016

- The first untethered flight of the PSCC/MC Balloon Team
- HabPi payload was constructed by the students of Maryville College
- Released from PSCC Hardin Valley Campus in Knoxville, TN
- Reached an altitude of approximately 30,000 meters
- Came to rest in Pisgah National Forest near Blowing Rock, NC

HabPi 1 - November 18, 2016



Figure: HabPi 1 in Tree

Parts List

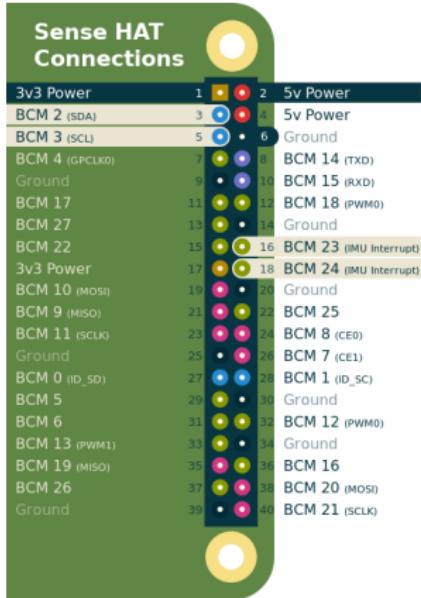
| Item | Approximate Cost |
|---|------------------|
| Raspberry PI 3 Model B. | \$35.00 |
| Sense HAT | \$30.00 |
| Raspberry Pi Camera V2 | \$30.00 |
| 32GB Micro SD Card | \$15.00 |
| 3 × DS18B20 Digital Thermometers | \$9.00 |
| 4.7kΩ 1/4 W Resistor | \$0.10 |
| 30 Row self-adhesive breadboard | \$5.00 |
| 4400 mAh USB Battery (Cell Phone Charger) | \$10.00 |
| 20 pack of Male/Female Jumper Wires | \$3.00 |
| 300mm Ribbon Cable for Pi Camera | \$2.00 |
| Total | \$139.10 |

Table: Parts List

Sense HAT Sensor Limits

- Two Digital Thermometers (-40°C to $+120^{\circ}\text{C}$) [3] and (-30°C to $+105^{\circ}\text{C}$) [4]
- Barometric Pressure Sensor (260 to 1260 hPa) [4]
- Relative Humidity Sensor (0% to 100%) [3]
- 3-Axis Magnetometer (± 16 gauss) [2]
- 3-Axis Gyroscope (± 2000 dps) [2]
- 3-Axis Accelerometer ($\pm 16\text{g}$) [2]
- Joystick for Input
- RGB LED Array for Output

Wiring the Sense HAT



(a) Minimal Raspberry Pi
Sense HAT Connections [1]



(b) Sense Hat Connections

1-Wire Bus

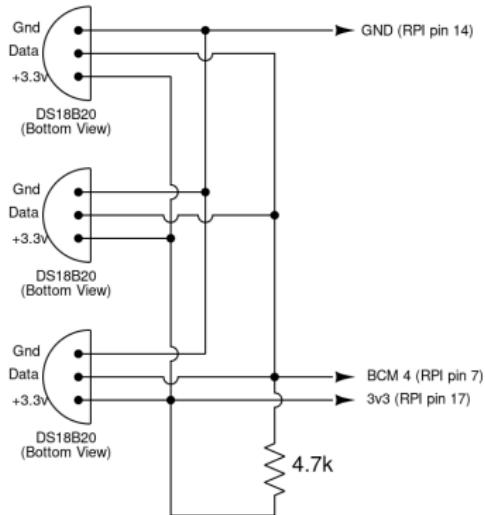


Figure: DS18B20 1-Wire Circuit

Complete Interior

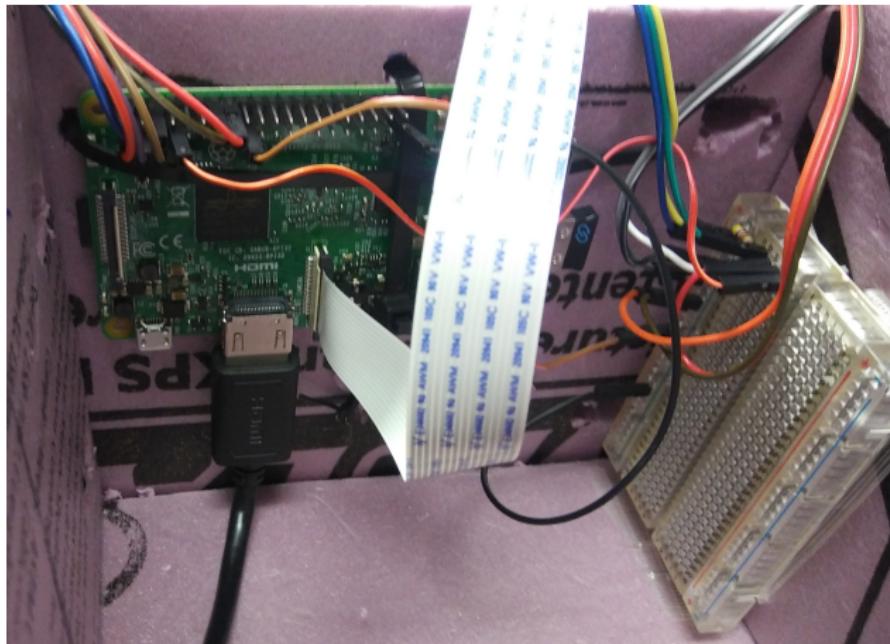


Figure: HabPi Interior

HabPi Software

- Creates an access point with a configurable network for wireless data access
- Provides a simple user interface using the SenseHat
- Creates a time-labeled data directory under /home/pi/habpi/data
- Executes experiments contained in /home/pi/habpi/experiments

Raw Temperature Data

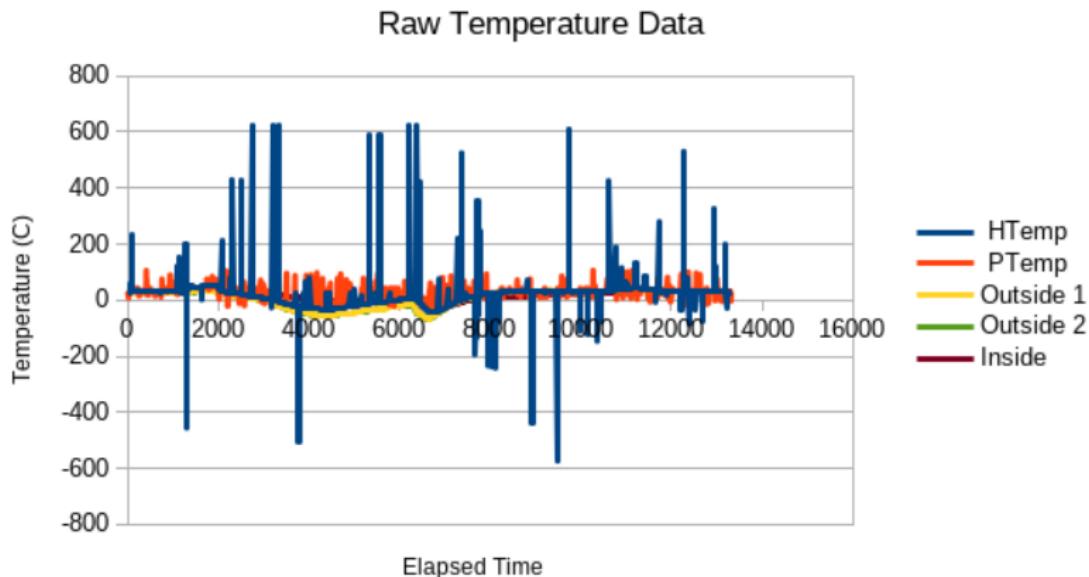


Figure: Raw Temperature Data

1-Wire Data

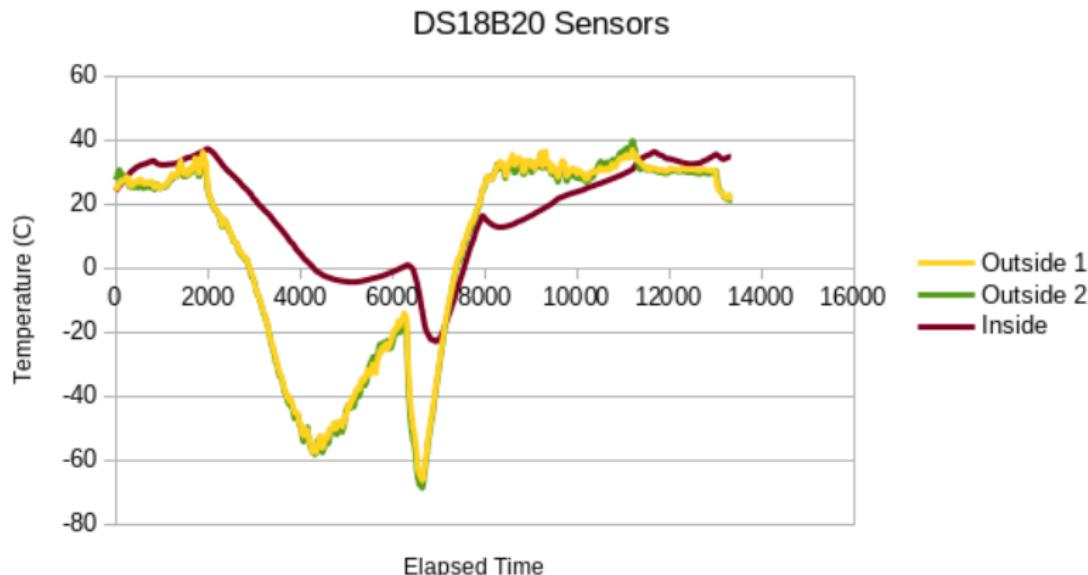


Figure: DS18B20 Temperature Data

Smoothed Temperature Data

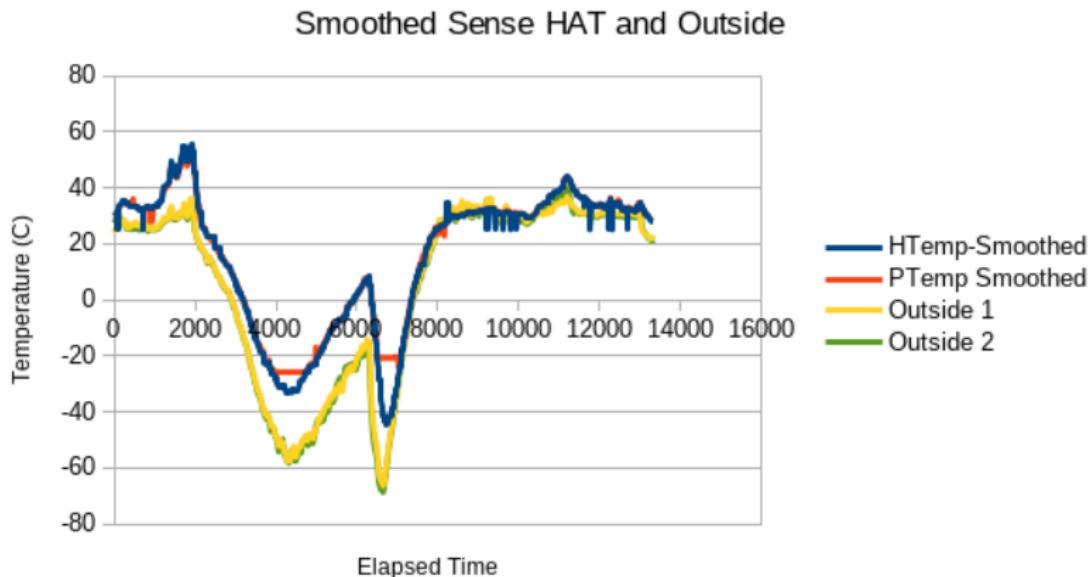


Figure: Smoothed Temperature Data

HabPi 2 - March 19, 2017

- Reference HabPi device built by Robert Lowe
- Released from Russell Springs Kentucky
- Reached an Altitude of 42,000 Meters
- Recovered near New River, TN

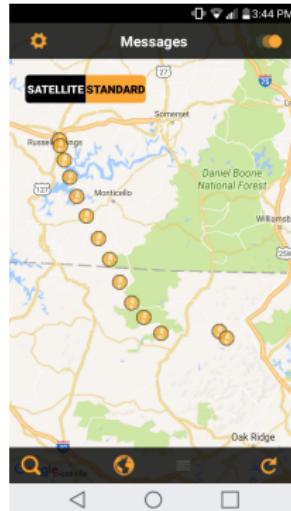
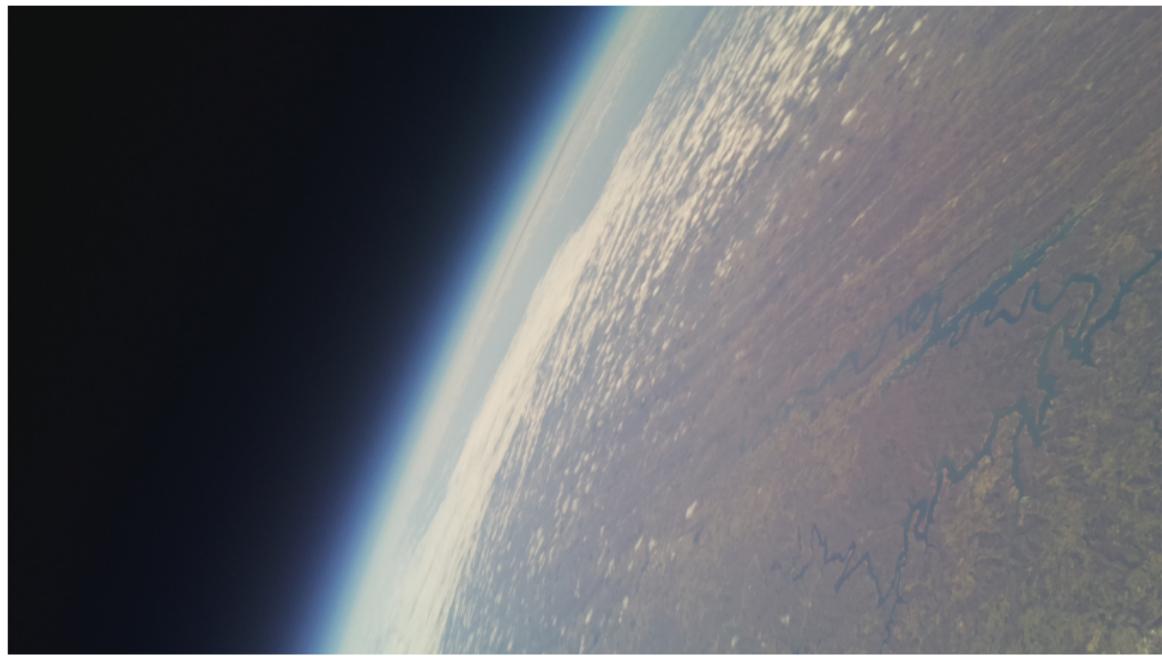


Figure: HabPi 2 Spot Tracker

HabPi 2 - March 19, 2017



HabPi 2 - March 19, 2017



HabPi 2 - March 19, 2017



HabPi 2 - March 19, 2017



HabPi 3 - May 13, 2017

- 3 HabPi Payloads constructed by students from Concord Christian School
- 1 HabPi Payload constructed by BSA Troop 255
- Released in Sunbright TN
- Reached an Altitude of 27,000 Meters
- Flew through restricted air space at low altitude

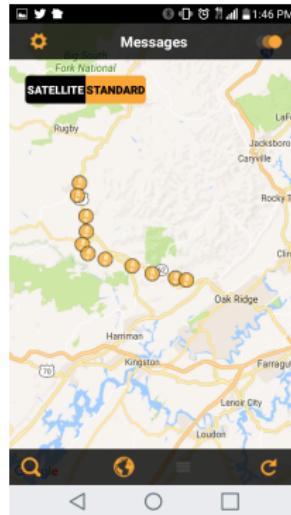


Figure: HabPi 3 Spot Tracker

HabPi 3 - May 13, 2017



HabPi 3 - May 13, 2017



HabPi 3 - May 13, 2017



HabPi 4 - July 18, 2017

- Constructed by students in the ARC ORNL Summer Institute
- First HabPi to carry adequate battery power for download
- Released from Pellissippi State Community College
- Reached an Altitude of 27,000 Meters
- Recovered lying neatly beside a farm road

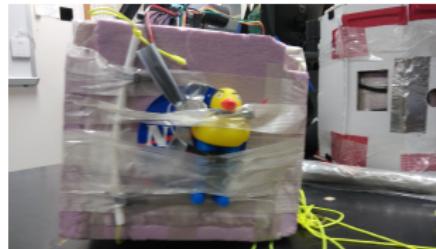


Figure: Linda

HabPi 5 - October 7, 2017

- First flight of a revised HabPi payload
- Released from Athens, TN
- Reached an Altitude of 25,000 Meters
- Recovered from a power line in Knoxville, TN
- Successful test of wireless data download



Figure: HabPi 5 - Peak Altitude

Future Directions

- Develop a School Curriculum for HabPi
- Improved User Interfaces
- A detailed write-up of HabPi construction and flight procedures



Figure:

<http://github.com/pngwen/habpi>

Bibliography I

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