A REPORT ON

RASPBERRY PI

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CERTIFICATE OF APPROVAL

I hereby certify that the summer internship project report has been prepared under my supervision.

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INTRODUCTION

Raspberry Pi is a credit-card sized computer manufactured and designed in the United Kingdom by the Raspberry Pi foundation with the intention of teaching basic computer science to school students and every other person interested in computer hardware, programming and DIY-Do-it Yourself projects.

The Raspberry Pi is manufactured in three board configurations through licensed manufacturing deals with Newark element14 (Premier Farnell), RS Components and Egoman. These companies sell the Raspberry Pi online. Egoman produces a version for distribution solely in China and Taiwan, which can be distinguished from other Pis by their red coloring and lack of FCC/CE marks. The hardware is the same across all manufacturers.

The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, VideoCore IV GPU and was originally shipped with 256 megabytes of RAM, later upgraded (Model B & Model B+) to 512 MB. It does not include a built-in hard disk or solid-state drive, but it uses an SD card for booting and persistent storage, with the Model B+ using a MicroSD.

The Foundation provides Debian and Arch Linux ARM distributions for download. Tools are available for Python as the main programming language, with support for BBC BASIC (via the RISC OS image or the Brandy Basic clone for Linux), C, Java and Perl.

THE IDEA TO CREATE: RASPBERRY Pi

The idea behind a tiny and affordable computer for kids came in 2006, when Eben Upton, Rob Mullins, Jack Lang and Alan Mycroft, based at the University of Cambridge's Computer Laboratory, became concerned about the year-on-year decline in the numbers and skills levels of the A Level students applying to read Computer Science. From a situation in the 1990s where most of the kids applying were coming to interview as experienced hobbyist programmers, the landscape in the 2000s was very different; a typical applicant might only have done a little web design.

Something had changed the way kids were interacting with computers. A number of problems were identified: majority of curriculums with lessons on using Word and Excel or writing web pages; the end of the dot-com boom; and the rise of the home PC and games console to replace the Amigas, BBC Micros, Spectrum ZX and Commodore 64 machines that people of an earlier generation learned to program on.

There isn't much, any small group of people can do to address problems like an inadequate school curriculum or the end of a financial bubble. But those students felt that they could try to do something about the situation where computers had become so expensive and arcane that programming experimentation on them had to be forbidden by parents; and to find a platform that, like those old home computers, could boot into a programming environment.

Thus came the idea of creating the device which kids could buy and learn programming or hardware on– The Raspberry Pi.

By 2008, processors designed for mobile devices were becoming more affordable, and powerful enough to provide excellent multimedia, a feature which would make the board desirable to kids who wouldn't initially be interested in a purely programming-oriented device. The project started to look very realisable and feasible. Eben (now a chip architect at Broadcom), Rob, Jack and Alan, teamed up with Pete Lomas, MD of hardware design and manufacture company Norcott Technologies, and David Braben, co-author of the BBC Micro game Elite, to form the Raspberry Pi Foundation to make it a reality. Three years later, the Raspberry Pi Model B entered mass production.

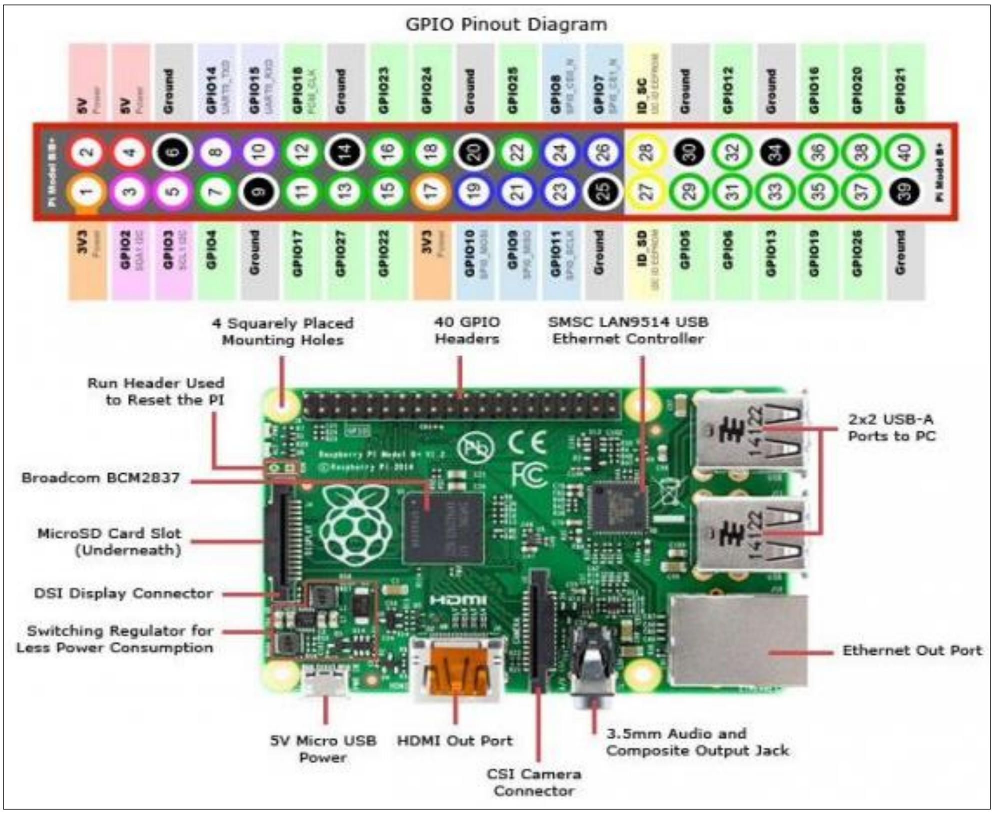

Fig. 1: Raspberry Pi 3B+

HARDWARE

1) System on Chip (SoC):

Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC

2) Central Processing Unit (CPU):

1.4GHz 64-bit quad-core ARM Cortex-A53 CPU

3) Random Access Memory (RAM):

1GB LPDDR2 SDRAM

4) Connectivity:

WiFi: Dual-band 802.11ac wireless LAN (2.4GHz and 5GHz).

Bluetooth: Bluetooth 4.2

Ethernet: Gigabit Ethernet over USB 2.0 (max 300 Mbps). Power-over-Ethernet support (with separate Power-over-Ethernet (PoE) HAT).

Improved PXE network & USB mass-storage booting.

5) Power:

5V/2.5A DC power input.

6) SD Card:

The Raspberry Pi does not have any onboard storage available. The operating system is loaded on a SD card which is inserted into the SD card slot of the Raspberry Pi.

7) General Purpose Input Output (GPIO):

The Raspberry Pi 3B+ has 40 such GPIO pins. General-purpose input/output (GPIO) is a generic pin on an integrated circuit whose behaviour, including whether it is an input or output pin, can be controlled by the user at run time. GPIO pins have no special purpose defined, and go unused by default. The idea is that sometimes the system designer building a full system that uses the chip might find it useful to have a handful of additional digital control lines, and having these available from the chip can save the hassle of having to arrange additional circuitry to provide them. GPIO capabilities may include:

- GPIO pins can be configured to be input or output
- GPIO pins can be enabled/disabled
- Input values are readable (typically high=1, low=0)
- Output values are writable/readable
- Input values can often be used as IRQs (typically for wakeup events)

8) Display Serial Interface (DSI):

The Display Serial Interface (DSI) is a specification by the Mobile Industry Processor Interface (MIPI) Alliance aimed at reducing the cost of display controllers in a mobile device. It is commonly targeted at LCD and similar display technologies. It defines a serial bus and a communication protocol between the host (source of the image data) and the device (destination of the image data). A DSI compatible LCD screen can be connected through the DSI connector, although it may require additional drivers to drive the display.

9) RCA Video:

RCA Video outputs (PAL and NTSC) are available on all models of Raspberry Pi. Any television or screen with a RCA jack can be connected with the Raspberry Pi.

10) Audio Jack:

A standard 3.5 mm TRS connector is available on the RPi for stereo audio output. Any headphone or 3.5mm audio cable can be connected directly. Although this jack cannot be used for taking audio input, USB mics or USB sound cards can be used.

11) USB 2.0 Port:

USB 2.0 ports are the means to connect accessories such as mouse or keyboard to the Raspberry Pi. There is 1 port on Model A, 2 on Model B and 4 on Model B+. The number of ports can be increased by using an external powered USB hub which is available as a standard Pi accessory.

12) Camera Serial Interface Connector:

CSI is designed by MIPI (Mobile Industry Processor Interface) alliance aimed at interfacing digital cameras with a mobile processor. The RPi foundation provides a camera specially made for the Pi which can be connected with the Pi using the CSI connector.

13) High Definition Multimedia Interface (HDMI):

Full-sized HDMI type A port is provided on the Raspberry Pi to connect with HDMI screens.

OPERATING SYSTEM

The Raspberry Pi primarily uses Linux kernel-based operating systems. The ARM11 is based on version 6 of the ARM which is no longer supported by several popular versions of Linux, including Ubuntu. The install manager for Raspberry Pi is NOOBS. The OSs included with NOOBS are:

- Raspbian (recommended): Maintained independently by the foundation; based on ARM hard-float (armhf)-Debian 7 'Wheezy' architecture port, that was designed for a newer ARMv7 processor whose binaries would not work on the Rapberry Pi but Raspbian is compiled for the ARMv6 instruction set of the Raspberry Pi making it work but with slower performance. It provides some available debian software packages, pre-compiled software bundles. A minimum size of 2 GB SD card is required, but a 4 GB SD card or above is recommended. There is a Pi Store for exchanging programs. The 'Raspbian Server Edition (RSEv2.4)', is a stripped version with other software packages bundled as compared to the usual desktop computer oriented Raspbian.

- Archlinux ARM.
- OpenELEC.
- Pidora (Fedora Remix).
- Raspbmc and the XBMC open source digital media center.
- RISC OS was the operating system of the first ARM-based computer.

APPLICATIONS

The major aim behind the Raspberry Pi was to educate people, especially children and teenagers, towards programming and basic hardware interfacing. The open body structure of the Raspberry Pi makes it a machine on which one can learn computer concepts.

Applications of the Raspberry Pi can be given as follows:

- Teaching programming concepts.
- Teaching hardware interfacing.
- Raspberry Pi being very cost effective can be deployed in large numbers in underdeveloped and developing countries like Africa, India, China, Brazil etc. to schools and colleges and to everyone who is interested in computers and electronics.
- It can be used in robotics for controlling motors, sensors, etc.
- It can be used as a downloading machine replacing desktop computers. It consumes very low power and also can be accessed remotely.
- It can be used as a media centre at home. Any television can be converted to a smart TV with internet capabilities with the Pi.
- It can be used for designing prototypes of DIY projects and certain embedded devices. It becomes very cheap option for testing and evaluation purpose.
- It can be used to create and handle small servers.
- It can be used for making digital photo frames, tablets etc at home.

RASPBERRY PI SENSE HAT

The Raspberry Pi Sense HAT is the perfect product to learn about programming and how we interact with the world around us. I’m sure that with its full array of sensors we are yet to discover all the weird and wonderful applications that the global Raspberry Pi community will invent on this planet and beyond with the Sense HAT.

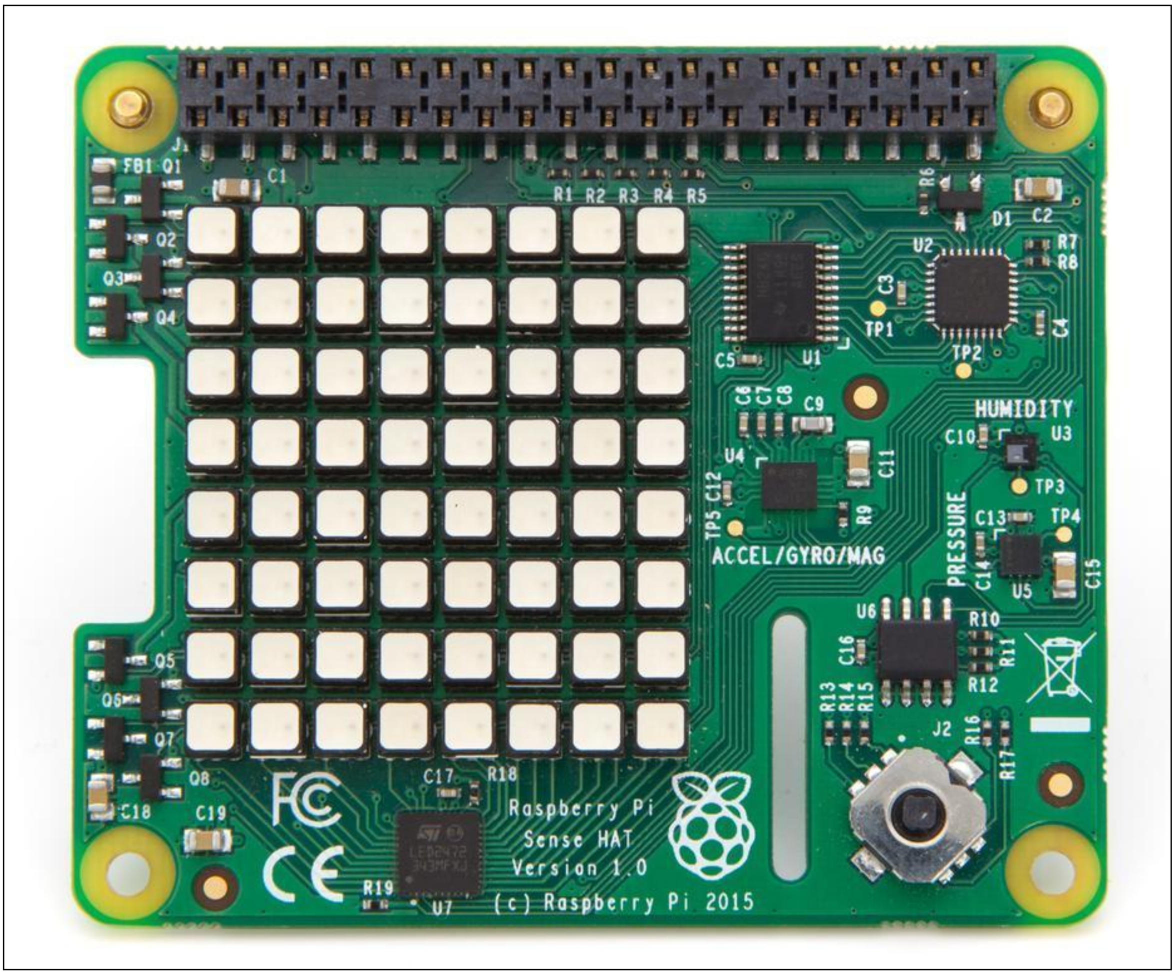

Fig. 2: Raspberry Pi Sense HAT

Features:

The Raspberry Pi Sense HAT is attached on top of the Raspberry Pi via the 40 GPIO pins (which provide the data and power interface). The Sense HAT has several integrated circuit based sensors that can be used for many different types of experiments, applications, and even games.

The sensors enable us to read:

- Orientation (Yaw, Pitch & Roll) using the accelerometer, 3D gyroscope and magnetometer
- Pressure
- Humidity
- Temperature

Furthermore, the Sense HAT includes a full-colour 8*8 LED Matrix that can be used to display messages. It also includes a joystick (Up, Down, Left, Right) which can also act as a push button.

Technical Specifications:

- Gyroscope – angular rate sensor: +/-245/500/2000dps
- Accelerometer - Linear acceleration sensor: +/-2/4/8/16 g
- Magnetometer - Magnetic Sensor: +/- 4/8/12/16 gauss
- Barometer: 260 – 1260 hPa absolute range (+/- 0.1 hPa under normal conditions)
- Temperature sensor (Temperature accurate to +/- 2 °C in the 0-65 °C range)
- Relative Humidity sensor (accurate to +/- 4.5% in the
- 20-80%rH range, accurate to +/- 0.5 °C in 15-40 °C range)

CONTROLLING SENSE HAT USING RASPBIAN OS

Raspbian is the official supported Raspberry Pi Operating System- based on Debian Buster and the first ZIP file was downloaded (from: https://www.raspberrypi.org/downloads/raspbian/).

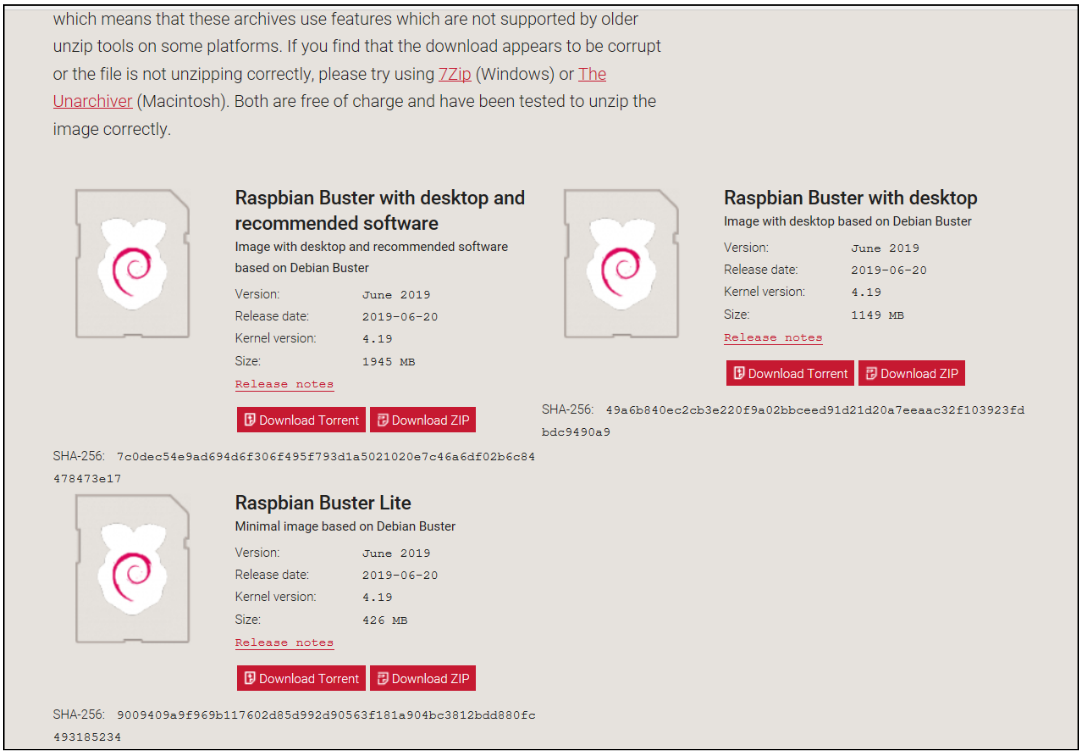

Fig. 10: Block Code using Sense HAT

Now, in a Windows machine, this .zip file can be easily extracted using 7Zip and the extracted .img file needs to be flashed onto an SD Card (using: Etcher, as suggested by the Website).

Now, in a Fedora machine, after extracting the .zip file, the .img file can be flashed onto an SD Card using the following command in the Terminal:

```
sudo dd bs=4M if=2018-11-13-raspbian-stretch.img of=/dev/sdb conv=fsync
```

Here, our SD Card was sdb (use command: 'lsblk' to find out) and put the name of your .img file after "*if=*".

The SD Card was then inserted into the Raspberry Pi and was powered On.

The Desktop on Raspbian looks as follows:

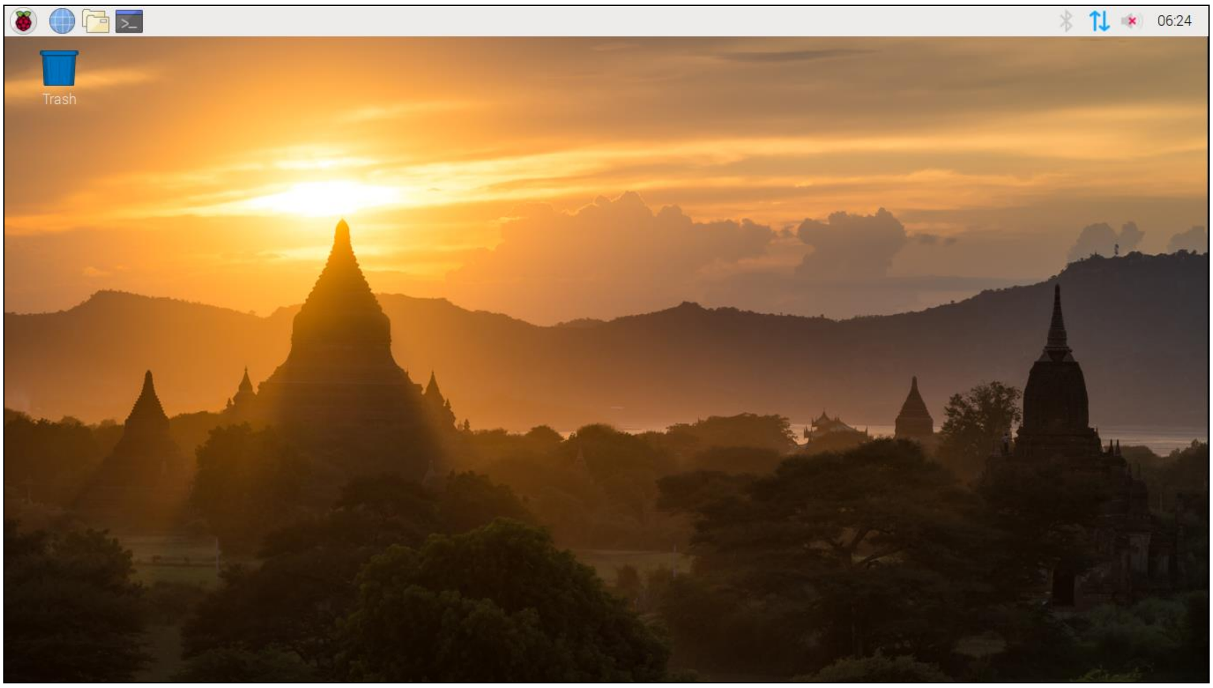

Fig. 11: Raspbian Desktop

The Raspbian OS comes pre-installed with an IDLE named Mu. It can be found under the Programming Menu in the Main Menu.

The Mu IDLE with (Python 3) code running is shown below:

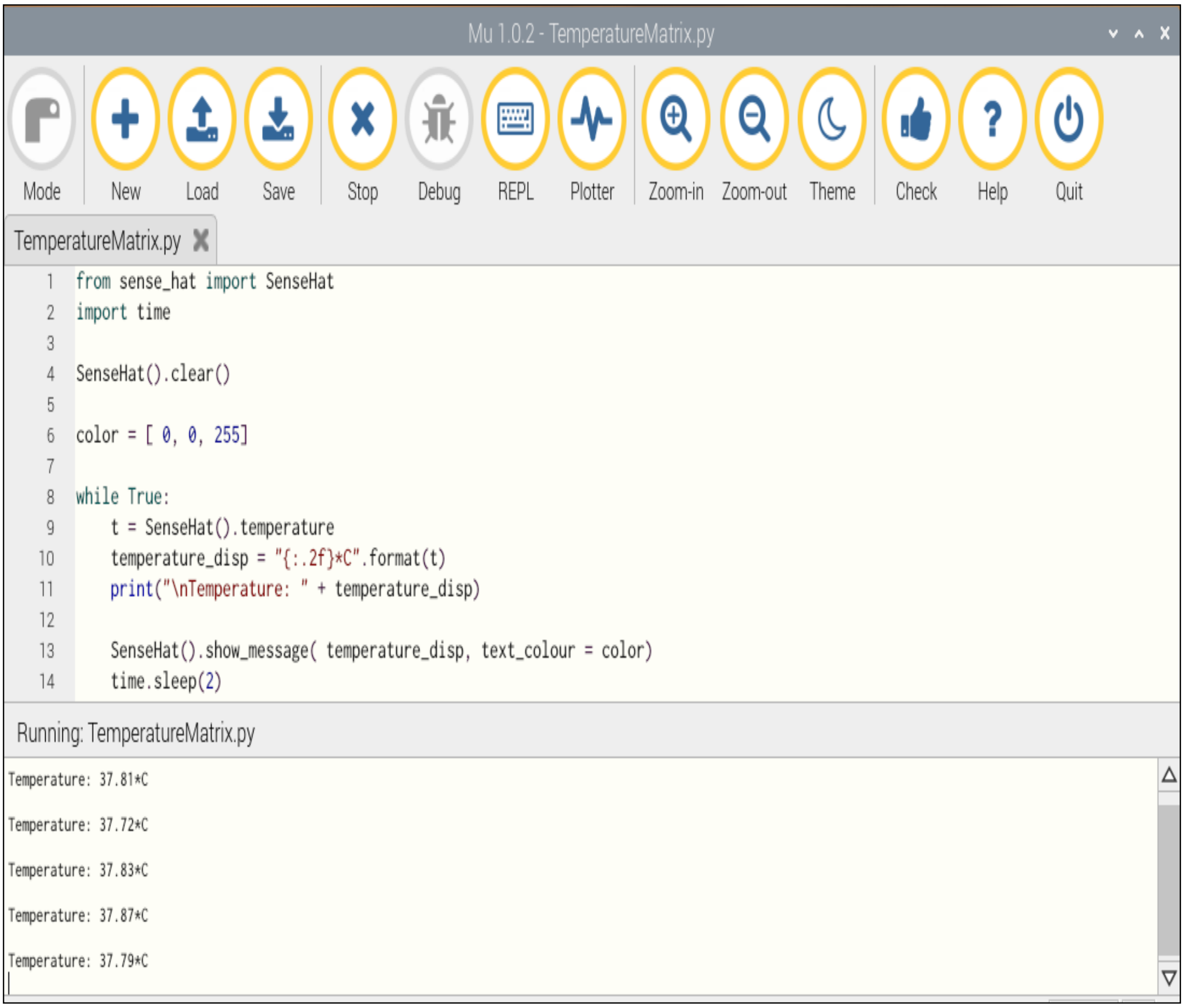

Fig. 12: Mu IDLE

CONTROLLING SENSE HAT USING WINDOWS IOT CORE

The Windows IoT Core Operating System was used to control and access the Raspberry Pi Sense HAT to display Temperature, Pressure, Relative Humidity and Magnetic North Bearing. This was done through the Windows IoT Core Dashboard.

Setup:

First, we downloaded the Windows IoT Core Dashboard (from: https://docs.microsoft.com/en-us/windows/iot-core/downloads).

Then, using Windows Installer and the Setup Wizard, we installed it on our Windows Machine and opened it.

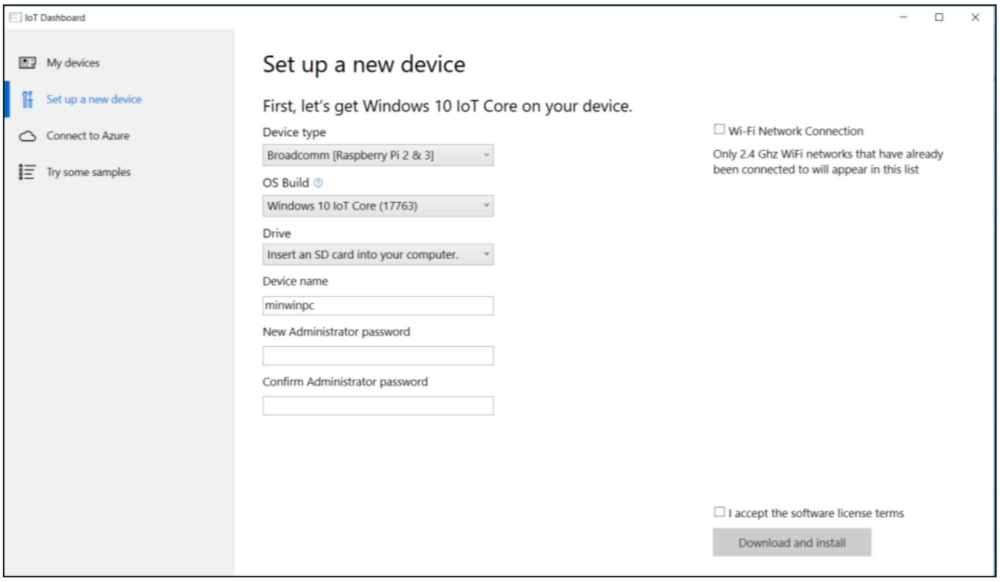

Fig. 3: Windows IoT Core Dashboard

Now, after inserting a 16GB SD Card, all the required fields were entered under the “Set up a new device” menu, Software Licenses were accepted and the “Download and Install” button was pressed.

This created the Image file (around 4.8GB) of the Operating System which was flashed onto the inserted SD Card.

This SD Card was then loaded into the Raspberry Pi and was powered On. The Raspberry Pi now booted with Windows IoT Core as it’s Operating System.

Once, booted the device should be visible in the Windows IoT Core Dashboard under the “My Devices” menu as follows:

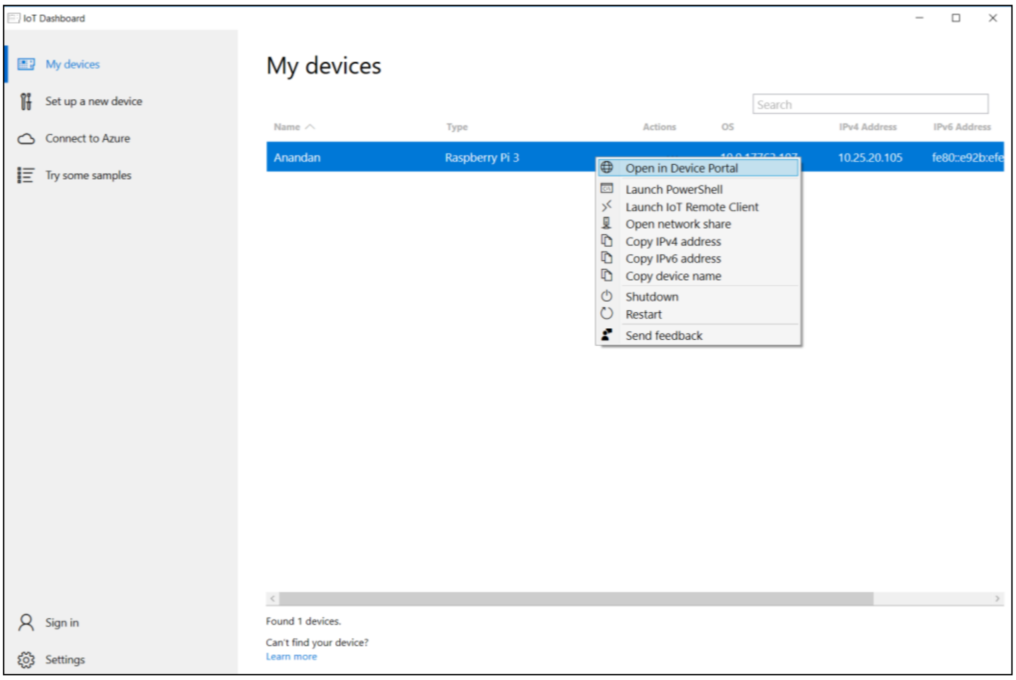

Fig. 4: Windows IoT Core Dashboard

Upon right-clicking on your device a list of options will occur asking the user how they want to control their Raspberry Pi. For this project the “Device Portal” was launched and the device from controlled from this portal.

The Device Portal looks as follows:

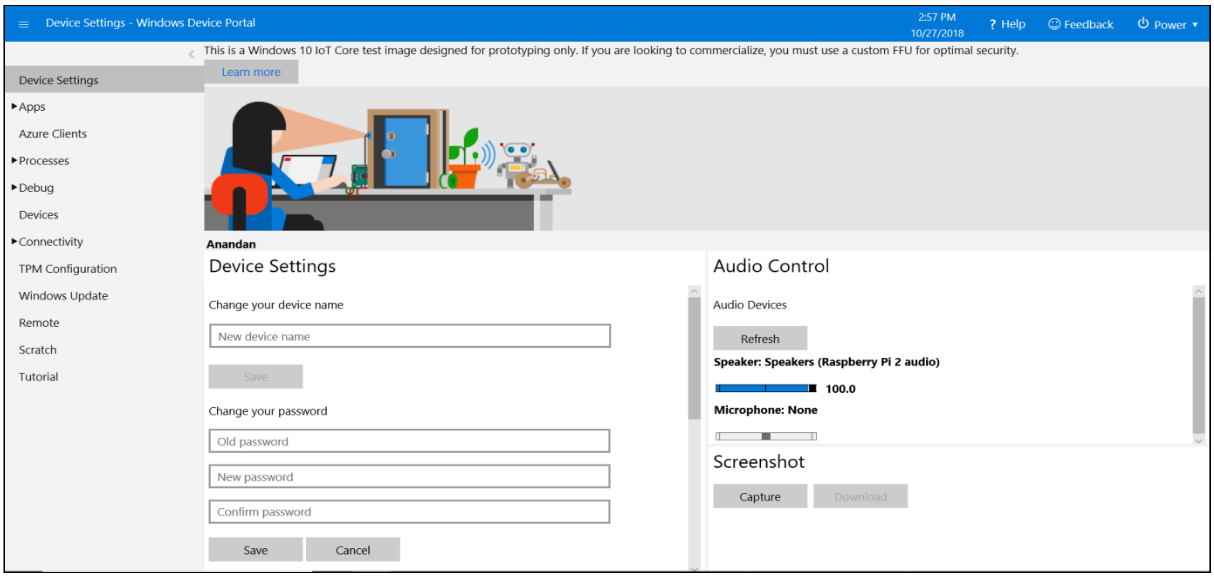

Fig. 5: Windows Device Portal

Here, under the Apps Menu, we have used the IoT Core Blockly Demo app to construct the required program for using the Sense HAT which has been installed and deployed through the browser itself.

Fig. 6: Device Info screen in Windows IoT Core

Controlling Sense HAT using Windows 10 IoT Core Blockly:

First, we go to the IoT Core Blockly App under the Quick-Run Samples menu under the Apps menu in the Device Portal.

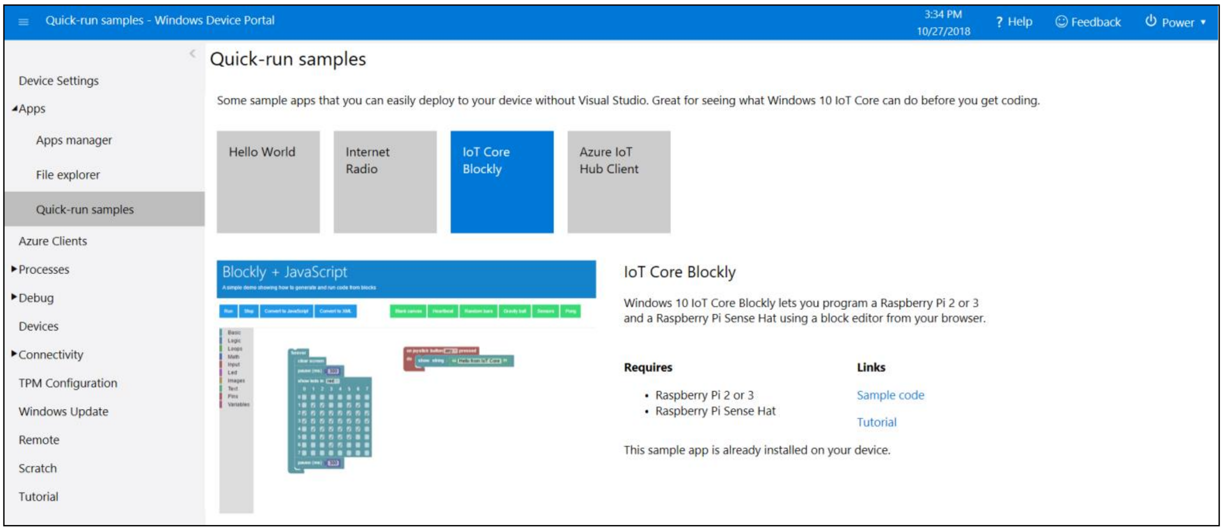

Fig. 7: IoT Core Blockly

The first time when we are in this menu, we click on the Install & Deploy Button. Upon subsequent boots of the IoT Core machine we must issue the following commands as shown:

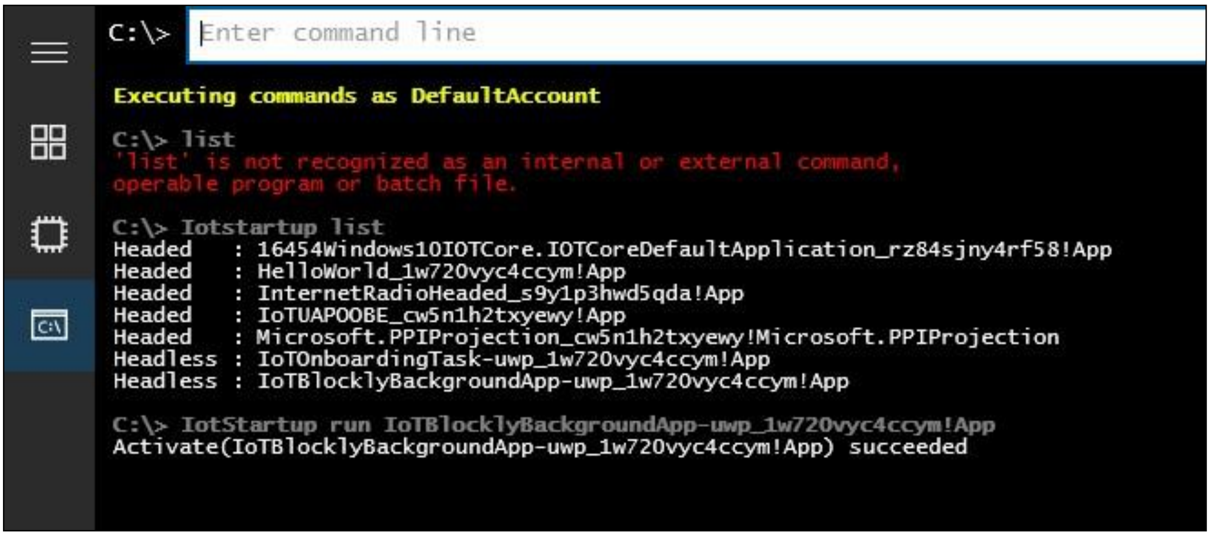

Fig. 8: Command Lines

Now, to deploy the Blockly Editor in the browser the following URL is entered http://rpi-IP Address:8024/ (eg: http://10.25.10.217:8024/).

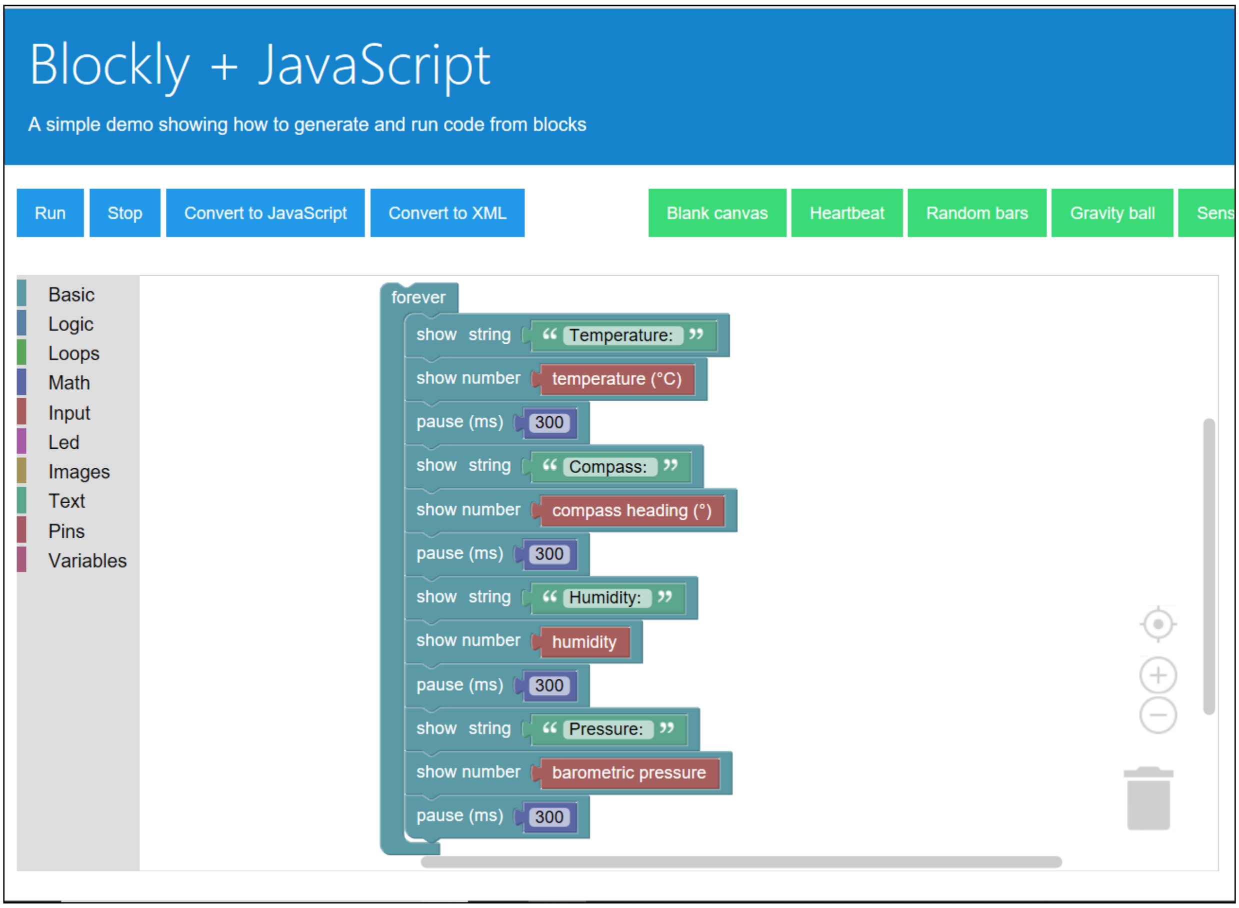

Fig. 9: Block Code using Sense HAT

The Block Code shown above displays the Temperature, Relative Humidity, Barometric Pressure and Magnetic North Heading using on the Sense HAT's 8*8 full-colour Matrix LED Display.

PYTHON CODES FOR SENSE HAT

1) Program to find the Magnetic North Heading of the Raspberry Pi:

```
from sense_hat          import SenseHat

import time

while True:
    b = SenseHat().get_compass()
    print("\nBearing: {:.2f}deg to North".format(b))
    time.sleep(2)
```

2) Program to find Temperature using the Sense HAT:

```
from sense_hat import SenseHat

import time


SenseHat().clear()


color = [ 0, 0, 255]


while True:

    t = SenseHat().temperature

    temperature_disp = "{:.2f}*C".format(t)

    print("\nTemperature: " + temperature_disp)


    SenseHat().show_message( temperature_disp, text_colour
    = color)


    time.sleep(2)
```

3) **Program to find Pressure using the Sense HAT:**

```
from sense_hat import SenseHat

import time


SenseHat().clear()


color = [ 0, 0, 255]


while True:

    p = SenseHat().pressure

    pressure_disp = "{:.3f}bar".format(p/1000)

    print(“\nPressure: ” + pressure_disp)


    SenseHat().show_message( pressure_disp, text_colour =
    color)


    time.sleep(2)
```

4) Program to find Relative Humidity using the Sense HAT:

```
from sense_hat import SenseHat
import time

SenseHat().clear()

color = [ 0, 0, 255]

while True:
    h = SenseHat().humidity
    humidity_disp = "{:.2f}%".format(h)
    print(“\nHumidity: ” + humidity_disp)

    SenseHat().show_message( humidity_disp, text_colour =
    color)

    time.sleep(2)
```

5) Program to find Raspberry Pi’s Orientation using the Sense HAT:

```
from sense_hat import SenseHat

import time


SenseHat().set_imu_config( True, True, True)


while True:

    o = SenseHat().get_orientation()

    p = o["pitch"]

    y = o["yaw"]

    r = o["roll"]


    print("\nPitch(deg): {:.2f}\tYaw(deg):
    {:.2f}\tRoll(deg): {:.2f}" .format( p, y, r))


    time.sleep(2)
```

CONCLUSION

The Raspberry Pi 3B+ may not be the most powerful computer according to hardware specifications but it's size, cost and overall product packaging makes it a very robust and versatile computer.

Furthermore, the online community of enthusiasts is ever-growing and manufacturers are constantly innovating making sure that the platform and new users are well-supported.

REFERENCES

- Raspberry Pi Cookbook (by Simon Monk)
- Microsoft Windows Dev Center

  (at: https://developer.microsoft.com/en-us/windows)
- GitHub IoT Blockly Samples

  (at: https://github.com/ms-iot/samples/tree/develop/IoTBlockly)