

Be a Maker of Internet of Things

Asset Summer Program

Instructor



Rupin Chheda

With a background in Electronics Engineering, Rupin has worked with Fortune 500 companies in the past, has a Six Sigma Certification, and enjoys building crazy stuff. He has mentored and trained students for electronics, robotics and engineering projects as well. His interests lie in sharing and learning together with students on various topics like electronics and technology.

Teaching Assistant - Kishan

He has background of biology and he is a biochemist. He completed his masters in biochemistry and he wants to become a scientist so he will do his PhD. He loves to learn new stuff and also watch movies and TV series.



Teaching Assistant - Mridul



After graduating recently from IIT Gandhinagar in Chemical Engineering, Mridul is finding his way to contribute to the sustainable development. He has explored different path in life - from travelling across India for fifty days to working with a scientist in the USA. In his free time, he likes to play Table Tennis or binge on YouTube videos.

Mridul plans to join Central European University, Budapest for his Masters in August.

What is Curiosity Gym?

www.curiositygym.com

A place to :

Tinker

Learn

Make

Mentor

Do

Be mentored

Think

Invent

Design

Talk

Listen

CuriosityGym is appropriate for?

Students - to have applied learning, work on fun projects, get different credentials than pure academic/sport activity

Youth - to help find what they are passionate about in a flexible non competitive sharing environment

Homemakers - a place to learn new stuff after /during work break

Entrepreneurs - To get mentorship on design, process, organisation, network connects, investment connects

All - A place to share/showcase your talent in a non competitive, friendly env

What can you do at CuriosityGym

Learn new skills (workshops and mentorships)

Get mentoring on product / process design from experienced mentors

Get help on some cool projects you are stuck on (mentorships)

Get help on how to get started on something you want to do/make (mentorship)

Work on Projects/Topics related to Science, Technology, Engineering, Art, Math
(internships)

Knowing You!

Please talk about

- 1) Your name.
- 2) A Hobby.
- 3) You last project and what it did.
- 4) The project you are most proud of.
- 5) What do you aspire to be?
- 6) What do you wish to experience in this programme.
- 7) How do you see yourself at the end of the programme.

Layout for the Program

Week 1

- Learn Internet of Things Using Arduino and the Idiotware Shield.
- Choose an interesting project
- Form a team to work on the project
- Write an Abstract of the Project

Layout for the Program

Week 2

- Learn Python
- Learn image recognition with Amazon Rekognition and the Raspberry Pi Computer.
- Build and create the major sections of your project.
- Demonstrate the working of the project.

Layout for the Program

Week 3

- Document Project
- Make it more robust and user friendly
- Field Testing and Tuning
- Presentation and Opening Day

What to expect in the course?

- You may be stuck solving a problem
- Progress matters more than perfection
- It may take you a longer time than you anticipate to complete the project.
- There may be days of pure thrill and pure frustration.
- You will face roadblocks, and no progress on your idea may happen for days.
- You may feel angry.

What are we excited to see?

- Persistence. Good work takes time.
- Creative ideas.
- New questions.
- A Justification for answers.
- Clarity of thought.
- Relating and connecting concepts.
- Using terminology.
- Process is more important than result.
- Articulating thoughts to words.

What we will help you with?

- You can approach us with a problem, but do not expect straight answers.
- You can collaborate with other participants to bounce ideas.
- We can help you manage the frustrations that arise with your ideas.
- We can provide you with guiding questions (sometimes, but rarely, with hints).
- Conversations and Insights.
- Skills required to code challenges and problems.
- Pushing you to improve your solution.

General pointers

- Boredom is a choice. Look around you, an interesting discussion is happening.
- Your answer is as important as anyone else's. Give others a chance to answer.
- Ideas can come from anywhere.
- Having a sense of wonder will keep you learning for life.
- Have a growth mindset.

Wifi Usage and Restrictions

- Wifi in this course is specifically crafted for us. Let us not abuse it.
- Do not share usernames and passwords with other participants
- Keep an eye out for mischief and report to us.
- Do not download or stream videos on this network.

Wifi Credentials

- MUNET-1 and MUNET-2 are two networks provided in this class.
- Their passwords are and respectively.
- These are specific to IoT devices and computer use.

Accessing course material

<http://bit.ly/aspiot2018>

Session 1

Introduction to Digital Electronics and Logic

Learning Outcomes

- Basics of Computer Science and Software
- Central Processing Unit
- Memory in Computers
- Inputs and Outputs
- Bits and Bytes
- Digital Electronics and Binary Number System
- Binary and Decimal Conversions
- Introduction to Arduino and Software Setup

Why are we learning this?

- Get acquainted with Software and Hardware.
- Understand and appreciate how computers work internally.
- How memory in a computer is organised.
- How does a computer represent numbers.
- How does it perform mathematical operations on them.
- How do we express logic in a computer.

Basics of Computer Science and Software

- Computer science is the study of the theory, experimentation, and engineering that form the basis for the design and use of computers.
- In computer science, software is all information processed by a computer system, programs and data.



Central Processing Unit

The Central Processing Unit is the Brains behind your computer.

It has a couple of parts inside it

The ALU, L0 and L1 caches, and some additional circuitry called registers.

Most CPU's today have multiple cores, that allow them to execute multiple tasks in parallel.



Memory in computers

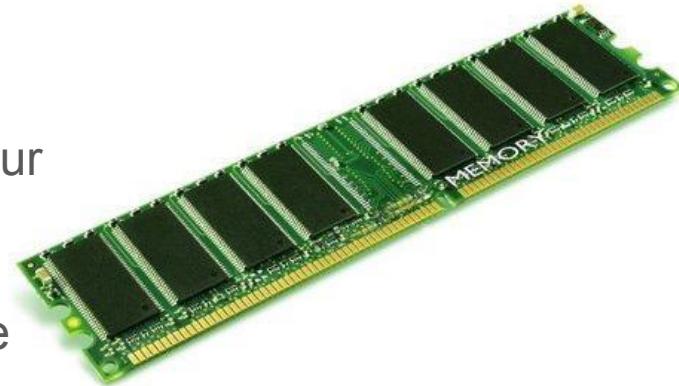
The CPU can process one instruction per core

Meaning it can only focus on executing one part of your program.

Each instruction is stored in sequence on a part of the computer called as memory.

The CPU can access the memory to fetch its next instruction, after executing the current instruction.

The address of the current instruction is stored on the Program Counter



Inputs and Outputs

Inputs and Outputs form the basis of work that a CPU does.

Inputs are keyboard, sensor, disk data etc

Outputs are motor speed, processed images, text on screen.

Bits and Bytes

- A bit is the fundamental building block of data in computers.
- A bit can only have two states, True/False, On/Off, High/Low
- A group of bits form together to form bytes.
- 8 bits together correspond to a byte.
- Since each bit can represent two states, 0 and 1.
- 1 byte of 8 bits together can have 256 different states.
- With 1 byte, you can represent numbers from 0-255.
- Let us look at how decimal and binary conversions happen.

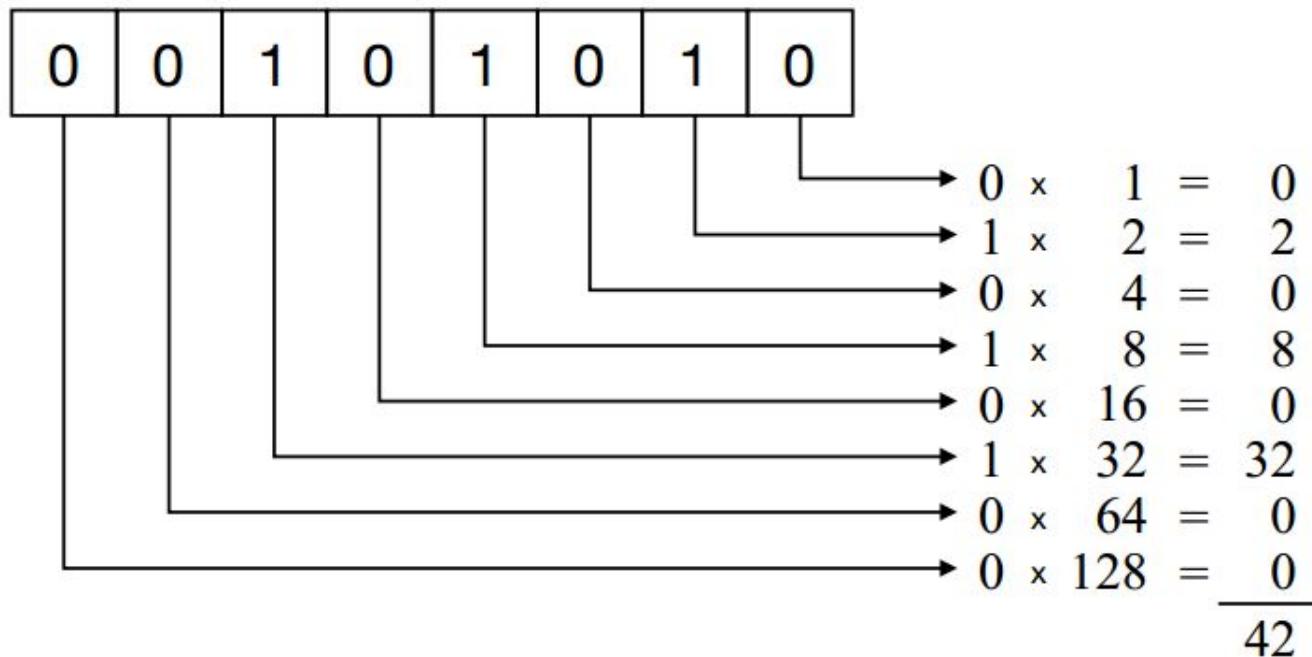
Digital Electronics and Binary Number System

- The binary number system is the basis of all digital computing.
- Music, Images, Files, everything digital is stored as bits and bytes.
- Numbers can be converted from Decimal to Binary Systems interchangeably.
- Numbers in the binary system, are represented as a group of 0's and 1s
- For example Binary Number 10101010 is Decimal 170.

Decimal and Binary Conversion

- Each bit in a byte represents a power of 2. The right most bit is 2^0 , the left most represents 2^7
- The binary representation of a decimal number is the sum of powers of two that add up to the decimal number.
- If a power of two does not contribute in the sum, its bit value is 0. Else its bit value is 1

Decimal and Binary Conversion



Binary Arithmetic

- Binary Addition has straightforward rules

RULES

- $0 + 0 = 0$
- $0 + 1 = 1$
- $1 + 0 = 1$
- $1 + 1 = 0$ (With 1 to carry)
- $1 + 1 + 1 = 1$ (With 1 to carry)

What is the 2s Complement of a Number?

- Instead of doing $A-B$, we do $A+(-B)$.
- We take the Binary Equivalent of B , invert all bits (change 0's to 1s and 1s to 0s). This is called the 1s Complement
- We add 1 to this 1s complement to get our 2s complement.

$$\begin{array}{r} 5 = 0\ 0\ 0\ 0\ 0\ 1\ 0\ 1 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ 1\ 1\ 1\ 1\ 1\ 0\ 1\ 0 \\ \text{Complement Digits} \\ + 1 \\ \hline -5 = 1\ 1\ 1\ 1\ 1\ 0\ 1\ 1 \end{array}$$

$$\begin{array}{r} -13 = 1\ 1\ 1\ 1\ 0\ 0\ 1\ 1 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0 \\ \text{Complement Digits} \\ + 1 \\ \hline 13 = 0\ 0\ 0\ 0\ 1\ 1\ 0\ 1 \end{array}$$

Binary Arithmetic

- Binary Subtraction is a little complex, but it has multiple ways of doing it.
- The complexity arises because there are ways to represent a negative result.
- The easiest way to do it is using 2s Complement Number.

Convert the number to binary.

Perform two's complement on the second number.

Add both numbers together.

Binary Arithmetic

- The result obtained from the addition of A and the 2's complement of B could be negative or positive.
- The carry generated from the addition of the last bit is discarded.
- The left most bit of the number is 1, the number is negative, and is in 2's complement form. Invert all bits, add 1 to it, and that is your negative answer.
- If the left most bit is 0, the number is positive, and no further process is required.

Arduino Setup and Installation

You can install Arduino for your Operating System.

Go to Arduino.cc on the web, and under software, look for the installer for your Operating system.

Once Installed, we can verify if everything is working by trying our first program.

Breakout and Discussion

- Work on Exercises
- Ask Questions

Session 2

Introduction to Arduino Programming constructs

Learning Outcomes

- Introduction to the Idiotware Shield
- What is a Program
- Syntax of the Arduino Programming Language
- Basic Programming Constructs
- Writing our First Program- Blink a light
- Flow Statements
- Pattern Generation on LEDs
- User Inputs
- Overview of Product Design Process

Why are we learning this?

- Understand what an Arduino is
- Understand how do you expand the capabilities of the Arduino with a Shield
- What a program is
- Process of writing a program and testing it
- The C programming Language
- Overview of designing a product

Introduction to the Arduino

- The Arduino is a Electronics Prototyping Platform.
- The heart of the Arduino is a MicroController called the ATMega328.
- The Microcontroller (uC) has a
 - 8 bit CPU running at 16 Mhz
 - 32kb of Non Volatile Flash Memory for Programs
 - 2kb of Volatile RAM for Program Data
 - Additional Pins for connecting to Sensors and Outputs.
- Additionally, it has got hardware that allow it to interface with other devices.

What is a Shield

- The Arduino, though powerful, has limited features in terms of additional hardware
- People all around the world manufacture products called shields that fit on top of the Arduino.
- This eliminates messy wiring and errors caused due to incorrect connections.
- It provides compactness to projects.

Introduction to the Idiotware Shield

- Idiotware Shield: IoT for Arduino, Simplified
- The Idiotware Shield is a learning platform for quickly bringing to life hundreds of Arduino projects, whether you're a novice or expert.
- The Idiotware Shield is the Swiss Army Knife of Arduino shields, with plenty of integrated inputs and outputs and options for connectivity and expansion.

What is a Program?

A program, in simple terms is a sequence of sentences(called program statements), written in a language (called the programming language) which a computer can understand, and execute, thereby achieving a specified goal.

Arduino Language Syntax

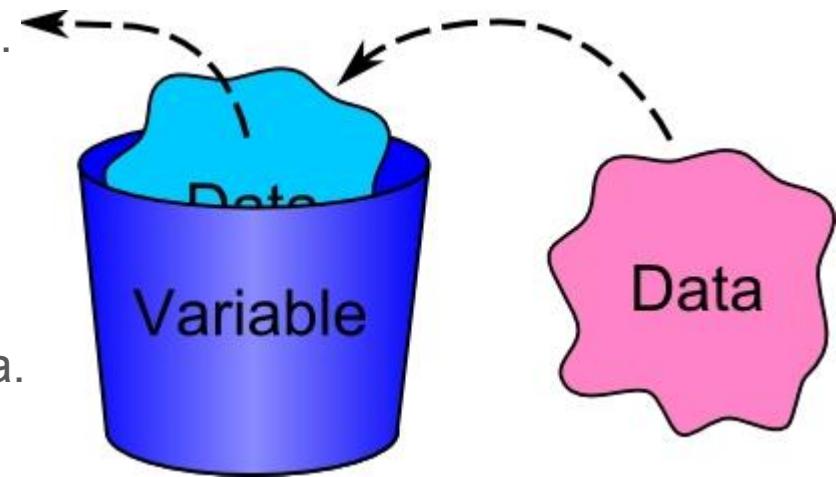
- Every language has its rules, called as grammar.
- Programming languages have very strict rules on what users write as a program.
- The grammar of a programming language is called its Syntax.
- The Arduino Programming Language is based on C/C++ syntax.

Basic Programming Constructs

- The Arduino Cheat Sheet is a good document to get accustomed to the programming language.
- Let us look at some of the constructs of the C Language.

Variables

- Data is like blood flowing through a person.
- Variables are buckets of data
- Using programming constructs you can change this data.
- Data is stored in the RAM memory
- A variable is also a way to access that data.



Variables

- You can create your own variables and give them meaningful names
- While defining a variable there are a couple of mandatory parts and some are optional.
- A variable is defined as follows

```
datatype variable-name=data;
```

DataType

- The datatype of a variable signifies what kind of data is going to put the variable.
- Data can be in form of
 - byte(0-255): 0, 1, 5, 255
 - int(-32,768 to 32,767): -32, 43, 0, 1, 2 etc
 - float(3.4028235E+38 to -3.4028235E+38): 12.34, 3.14 , 0.0008
 - char: A, X, Y <, #
 - String: "My Name is Rupin"
- The data type also signifies how much memory to reserve for that data i.e the size of the bucket.

Input and Output

- In most computers, inputs and outputs play an important role.
- For an arduino, Inputs can come from sensors.
- Outputs are through LED's or motors.
- The arduino can control simple digital outputs and respond to digital inputs.
- Let's look at outputs first!

First Program- Blink a Light

- In your Arduino IDE, navigate to File > Examples > Basic > Blink
- This program is written in Arduino Language and will blink a light on the Arduino every 1 second.
- To program the Arduino, connect the Uno thorough a USB cable to your laptop.
- Navigate to Tools > Port and select the entry that says Arduino Uno.
- Navigate to Tools > Board and select Arduino/Genuino Uno
- Click the Upload Button
- What happened?



Critical Thinking

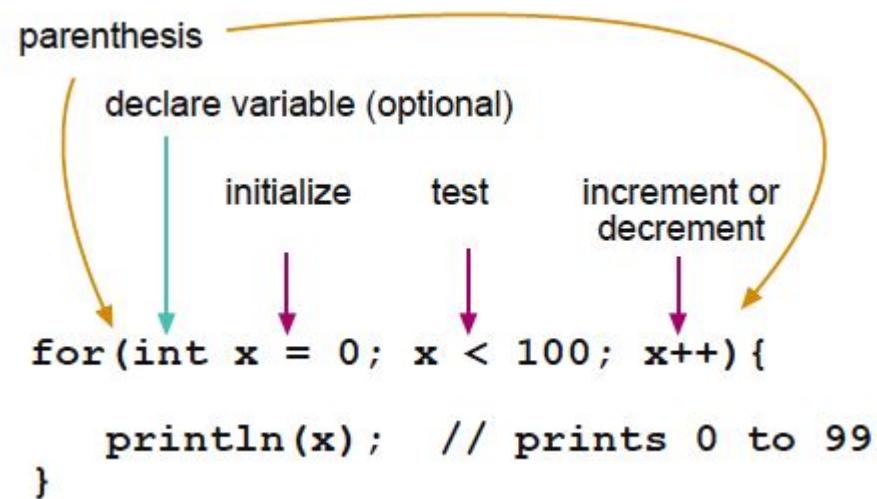
- What are the parts of this Arduino Program?
- What is happening on the Arduino Board?
- What is happening inside the Arduino board?
- Why is the light doing what it is doing right now?
- How is the physical change on the board related to the program?

Loops

- Loops Allow you club together multiple statements together and execute them a finite number of times.
- For example, blink a light only 10 times or make the buzzer beep 3 times.
- There are two main kinds of loop in the C language
 - for loop
 - while loop

For Loop

- The for loop in C has three parts.
 - Initialisation
 - Test Condition
 - Change
- All the above three work on a variable called the loop variable.
- The loop variable holds the most recent occurrence of the loop.



While Loop

- The while loop in C has three parts.
 - Initialisation
 - Test Condition
 - Change
- All the above three work on a variable called the loop variable.
- The loop variable holds the most recent occurrence of the loop.

```
int i=0;           ← Initialisation
while(i<20)       ← Test Condition
{
    print(i);
    i=i+1;|        ← Change
}
```

What would happen?

1

```
int i=0;  
while(i<20)  
{  
    print(i);  
}  
}
```

2

```
int counter=0;  
while(counter>20)  
{  
    print(i);  
    counter=counter+1;  
}
```

3

```
for(int i=0;i<28;i--)  
{  
    print(i);  
}
```

Flow Statements

- Flow statements allow modifying the normal linear flow of a program.
- You can write code which reacts to conditions
- The most common Flow statement is the *If* condition

If condition syntax

```
int i; //Declare I as an integer variable
i=0;// Set i to 0
if(i==0) //Check if i is equal to zero, note the == sign
{
    i=i+2; //modify i
    print(i);
}
else if(i==3)
{
    print("i is 3");
}
else
{
    print("i is neither 2 nor 3");
}
```

Concept of condition

- A condition is a statement within your C code whose value can only be true or false.
- The conditional operators are the mathematical or logic signs between the two operands.
- The common ones do mathematical and logical operations.

>
<
>=
<=
!=
!
&&
||

Greater Than
Less Than
Greater Than or Equal To
Less Than or Equal To
Not Equal To
Not
And
Or

Pattern Generation

- With this new found knowledge, can we build a program that allows you to make a pattern on the Idiotware Shield LED's
- The three patterns are
 - Blink every LED from 1-12 sequentially every 1 second
 - Turn on every LED from 1-12 one after the other, every one second, then turn it off.
 - Blink every third (3,6,9,12) LED then turn it off.

User Inputs

- Like digital outputs, user inputs are also digital in nature.
- For example, pressing and releasing a switch will have two states, pressed and released.
- The Idiotware Shield has a switch wired to Pin 4 and Pin 5. The switch on the Pin 4 is a touchpad.
- Looking at the cheatsheet for Arduino, which statement would you use to read digital inputs?
- Once you have the information about the input, how can you use it?

Using Inputs

- With this new found knowledge, can we build a program that allows you to make a pattern on the Idiotware Shield LED's
- Can you try the following exercises?
 - When touchpad is touched, can you make the LED spin in the opposite direction?
 - The buzzer is also an Output, connected to A1 Pin of the Arduino. Can you build a musical instrument which responds to both the Touchpad and the Switch?

Breakout and Discussion

- Work on Exercises
- Ask Questions

Session 3

Arduino Libraries and a Gadget

Layout for the Session

- Introduction to a Library, Installing a Library
- Use a Library to Access Sensor Data
- Fundamentals of Hardware Connections
- Precautions while wiring external hardware
- Using Two or more libraries in Tandem
- A primer on Empathy
- Designing for a User

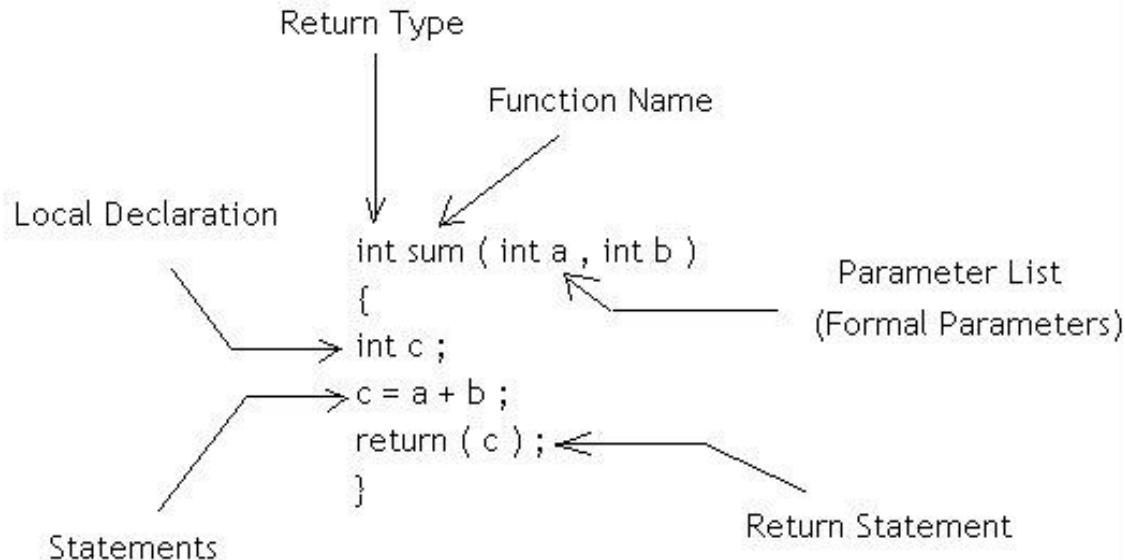
Why are we learning this?

- Understand what a function is
- To understand how to install a library
- To understand and implement the features of a library
- Prevent costly mistakes while wiring electronics
- How to use two or more libraries together
- Thinking, Designing and Building a Gadget for a unique problem.

Functions

- Functions are sections of your program that do **one thing and one thing only.**
- They are superior way to organize your code.
- Functions make code modular, easier to read.

In C functions have a couple of parts to them, as shown next



Introduction to a Library

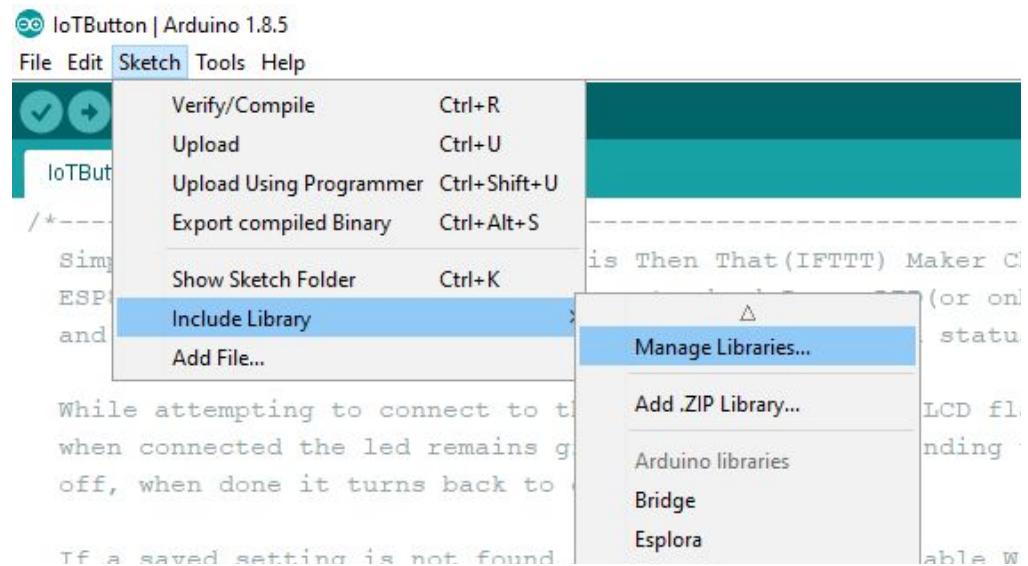
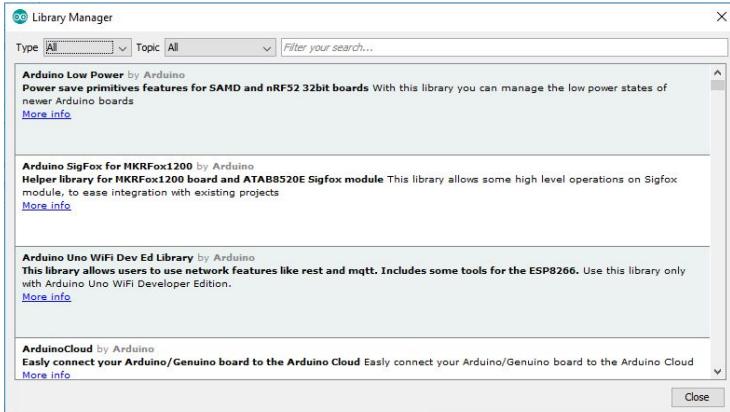
- A library is packaged collection of useful **functions** put together
- It allows you to use someone else's code to build a project
- Most of these are open source and very well tested
- Community support and access to the developer is also sometimes available.
- You can freely modify libraries that have specific community licenses.

Installing a library in Arduino

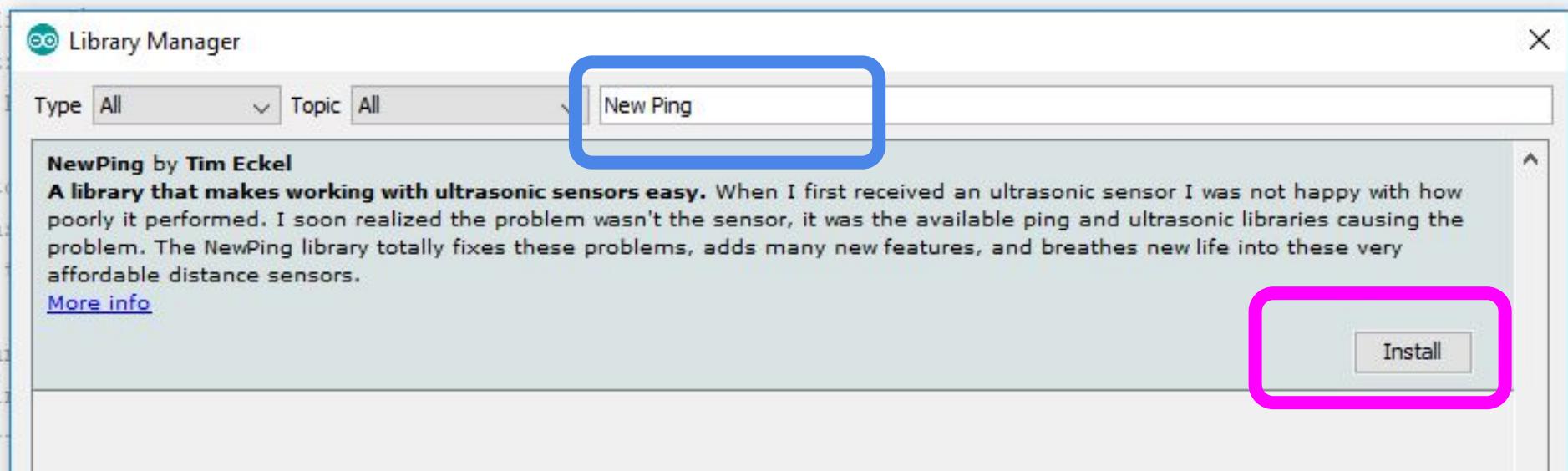
In the menu go to

Sketch>Include Library>Manage Libraries

This will open the Library Manager



Search for a Library, Then Install



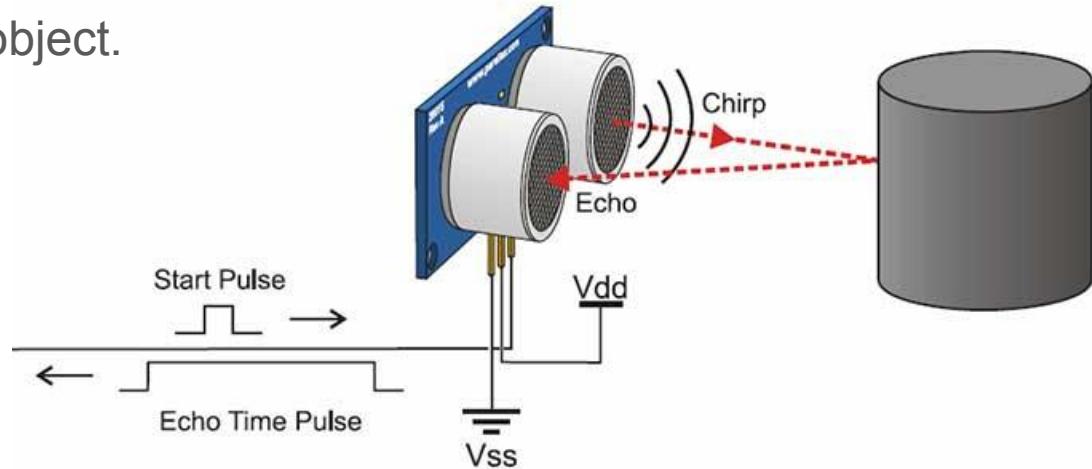
Introduction to the Ultrasonic Sensor

- The Ultrasonic Sensor has a Transmitter and a Receiver which allows measuring distance.
- The math involved in the process of measurement is pretty simple.



How Does it work?

- A High frequency sound wave gets emitted from the transmitter.
- This sound wave travels at speed of about 340m/s, and bounces back to the receiver with the same speed.
- The time of travel of the sound wave is recorded, and a simple calculation yields the distance to the object.



Ultrasonic Sensor Math

- A High frequency sound wave gets emitted from the transmitter.
- This sound wave travels at speed of about 340m/s, and bounces back to the receiver with the same speed.
- The time of travel of the sound wave is recorded, and a simple calculation yields the distance to the object.



speed of sound:

$$v = 340 \text{ m/s}$$

$$v = 0,034 \text{ cm} / \mu\text{s}$$

Distance:

$$s = t \cdot 0,034 / 2$$

Internal Workings of the Sensor

- The Sensor has four pins Vcc, Echo, Trig and GND.
- The Arduino will make the Trig pin low, and start counting time.
- It stops counting time when the echo pin changes from Low to High.

Fundamentals of Hardware Connections

- VCC: Normally Connected to 5V source of power. The voltage can be lesser(part won't function below 4.2V), but it cannot be higher (part gets damaged) than 5V. For some devices, this is 3.3V
- GND: Ground, or the lowest voltage on your circuit. In a battery, this is the negative terminal of the battery. All ground connections across a circuit have to be connected to each other.
- TRIG and ECHO: These have to be connected to two spare pins of the Arduino. They can be any from 2-13, or A0-A5.

Wiring Precautions

- Never connect the Vcc and Gnd Connections in reverse.
- Never Connect Vcc and Gnd connections together.
- Always look out for wires getting connected to each other.
- Never keep electronics on metal objects, as these will conduct electricity and create a short circuit.
- Always review twice, before applying power.
- Review Connections with instructors.
- Distrust everything.
- Build in small parts, test and be certain that a part of the build works.

Libraries in Tandem

- In addition to the New Ping Library, there is a library called the Neopixel Library. The process to install it is the same.
- A RGB multicolor LED is connected to Pin 6 of the Arduino. This LED's name/model number is WS2812B.
- Can you write a program which glows the LED red, when the distance to an obstruction is less than 10cms, otherwise the LED is Green in Color.

Gadget Build

- Look at this photo for the next 3 minutes. (Photo is on the next slide)



Imagine

- Imagine yourself to be standing at this spot where the photo was taken
- You are either
 - A car driver
 - A mother with a baby in a pram or in her arms.
 - An elderly person with poor eyesight
 - A pesky kid running around
 - A person with a 3 huge grocery bags in each of their hands
- What do you see?
- How do you feel?

Let us see the photo again.



What are your feelings?

What is missing?

- For all those people, is there some element of the unknown?
- Can you help erase that uncertainty in their mind?
- Is there fear? Where does that fear come from? Your problem definition lies somewhere close to that.

If you can empathise with a different group of people, it will become so much easier to build an idea for that group.

Empathy as a key skill to design

You must be able to empathise with the person at the physical, the psychological and the emotional level.

- Does your idea require them to learn a new skill or a meaning?
- Does your idea require them to gain more physical energy than they currently have?
- Is your idea, its implementation and its use obvious to them? (subscribes to a mental model)
- Is the physical form of your idea natural to understanding, and successful use?
- Can the user feel a positive emotion when operating your idea or when the idea is in use?

Empathy in Design

<https://www.interaction-design.org/literature/article/design-thinking-getting-started-with-empathy>

Session 4

Introduction to Analog World and Sensors

Layout for the Session

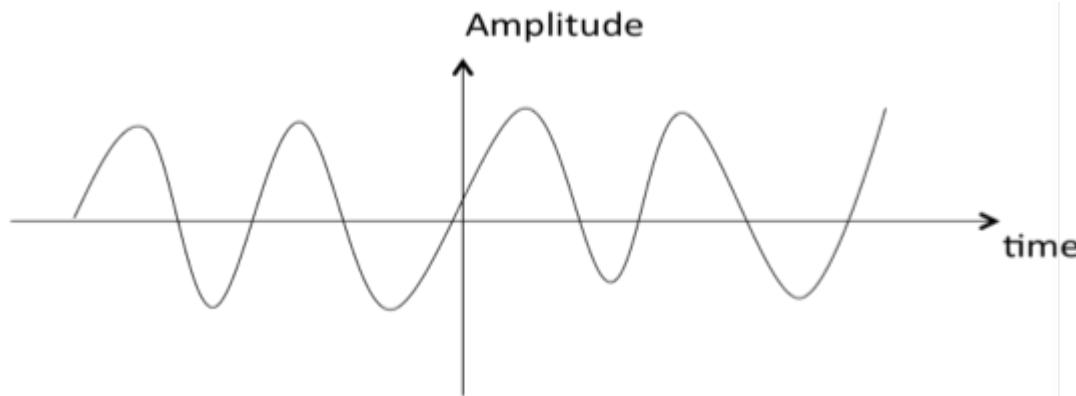
- Introduction to the ADC.
- Digital and Analog Reams
- Measuring Analog Sensors and Reporting
- Nyquist Frequency
- Quantization and Errors

Why are we learning this?

- Know what analog signals mean.
- Know what an ADC means
- How does it convert analog signals into digital ones
- Why does one need to convert an analog signal into digital?
- What is the Nyquist frequency?

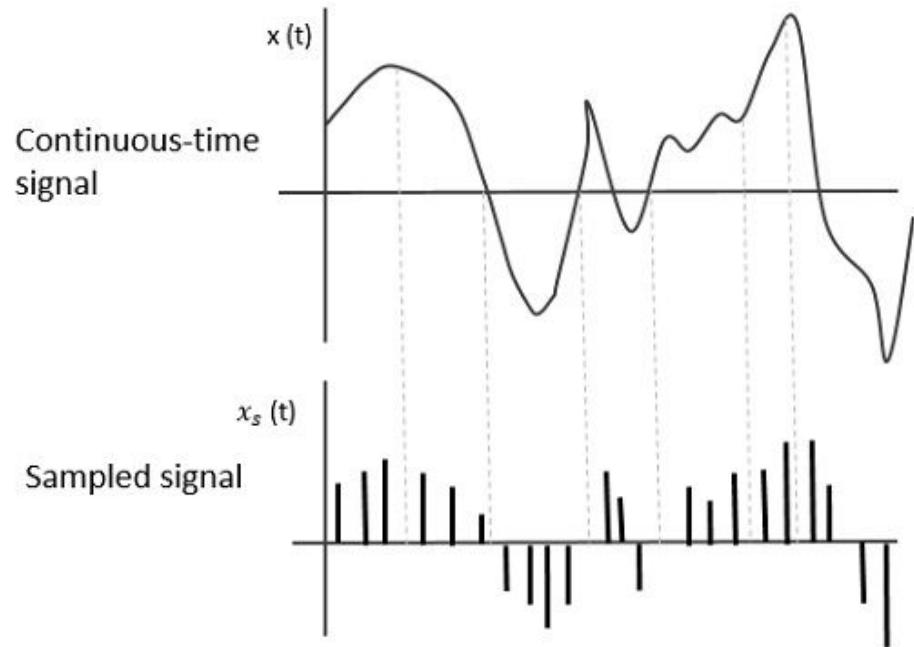
What are analog signals?

- A physical quantity that is continuous in nature.
- The value of the quantity varies continuously as time progresses.
- The temperature in the room, my voice, its amplitude is continuously varying.



How do you measure analog signals?

- An analog signal can be measured, at any instant of time.
- This process is called sampling.
- At different instants of time, the value of the signal is measured.
- The analog signal is now discrete i.e. it has specific values at specific points in time.



Sampling and Reconstruction

- Draw a graph of the function $f(x)=\sin(x)$ from 0 to 180 degrees.
- Sample the values of this graph at every 10 degrees.
- Can you reconstruct the shape of the graph from the sample values?

Introduction to the ADC

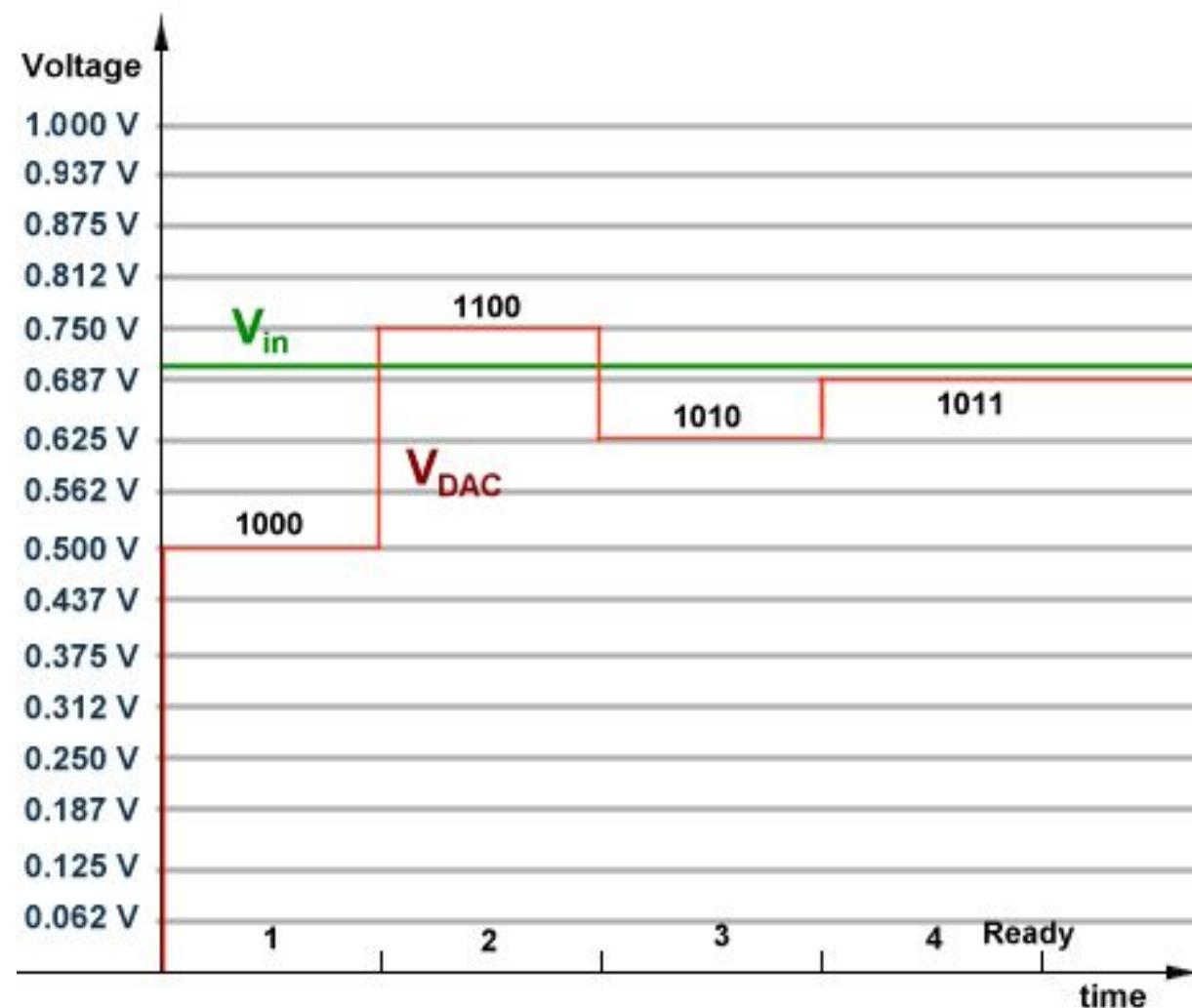
- The Arduino has 6 pins on which an analog signal can be applied.
- These Pins are A0 to A5.
- Through code, the value of the signal can be measured.
- The hardware that allows you to do this is called an ADC (Analog to Digital Converter)
- Let us look at how it works

Successive Approximation Register

- The ADC inside the Arduino is a pretty complicated device.
- It uses a SAR (Successive Approximation Register) type architecture and circuitry to measure the analog values.
- It basically generates an Analog voltage inside it.
- A comparison is made to check if the input analog voltage is greater or lesser than the internal voltage.
- The tries to reduce the difference between the internal generated voltage and the external input voltage.

Some assumptions to understand better!

- Let us say that the maximum voltage the ADC can measure is 1V.
- We only have 4 bits to represent the analog value to digital
- In 4 bits, you can have voltages between 0V and 1V divided equally in 16 parts.
- Each part has a value of $(1V-0V)/16=0.062V$
- The ADC jumps into action.
- Let us see what happens.



What are these values on the Arduino?

- The maximum voltage the Arduino can measure is 5V.
- We only have 10 bits to represent the analog value to digital.
- In 10 bits, you can have voltages between 0V and 5V divided equally in 1024 parts.
- Each part has a value of $(5V-0V)/1024=0.0048V$.

Measure Analog Quantities

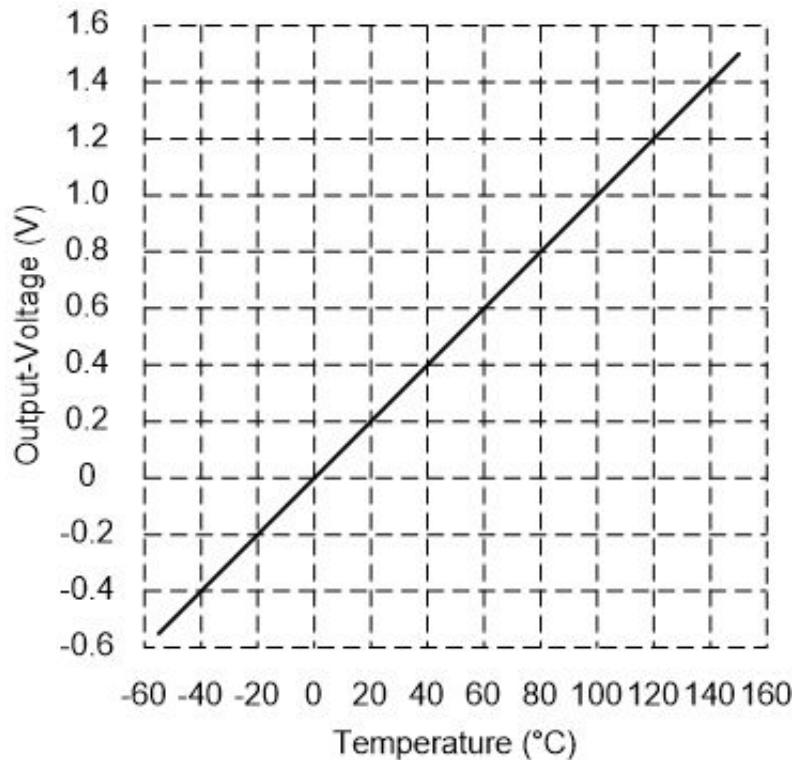
- In arduino the function to measure analog quantities is as follows

int analogValue= analogRead(pinNumber);

- Why are we using an int variable?

Measure Room Temperature

- The Idiotware Shield has a LM35 temperature sensor connected to A0 pin of the Arduino.
- Let us build a program that will give us the temperature in degrees.
- For every degree centigrade, the sensor generates an additional 10mV output.



Viewing the value of the sensor

- The Arduino does not have any display. How will you view the values of the temperature sensor?
- Arduino provides a convenient method of sending data to the computer. Its called Serial communication.
- The hardware required for the Serial communication is called a UART (Universal Asynchronous Receiver Transmitter)
- Let us understand the meaning of each of those terms.

Introduction to the UART

U-Universal, understood by a lot of devices and is a defacto standard on all computers

A- Asynchronous, meaning data is exchanged at any point in time, without synchronicity. When we talk about synchronous, we talk about time, clock etc. The data is sent and received at any point in time, and is successfully sent and received.

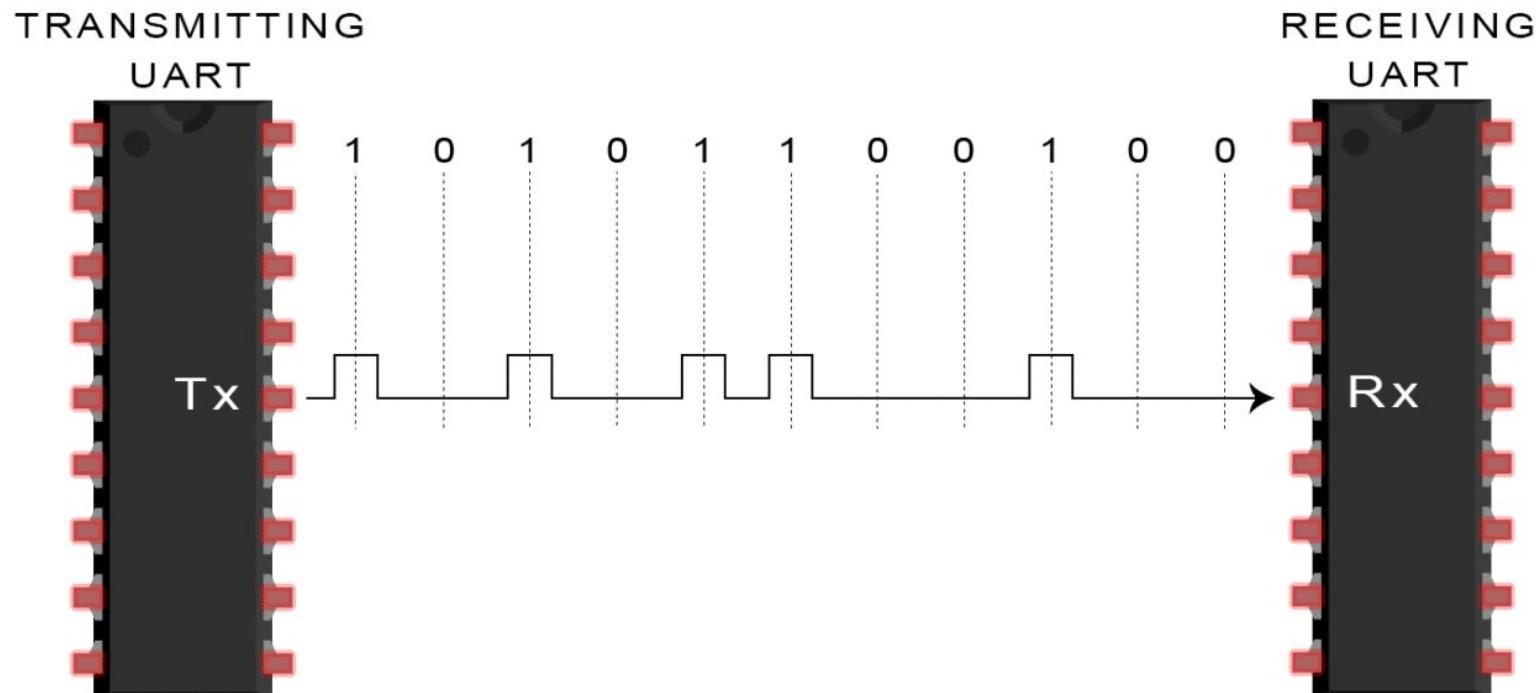
R- Receiver part of the hardware

T- Transmitter part of the hardware

Concept of Bitrate

- Since the UART communication is not synchronised, it means that both the receiver and transmitter must know the speed at which the information is sent.
- This speed is measured in bits per second, or called Baud.
- You cannot have any random bitrate, there are specific values like 9600bps, 115200bps.
- The receiver and transmitter must be “tuned” to a specific bitrate else the message is garbled or not received.

How does the UART work?



Serial Communication on Arduino

- The Arduino Serial Library allows UART communications
- Try out this program
- Program the Arduino.
- Open the Serial Monitor, there is a lens icon on the right top corner.

```
sketch_jan22a.cpp
1 void setup() {
2   Serial.begin(9600);
3 }
4
5 void loop() {
6   Serial.print("my first arduino program!");
7 }
```

Serial commands

There are three important Serial commands. You can refer to the cheat sheet for these.

- 1) Serial.begin (baudrate);
- 2) Serial.print(value to print);
- 3) Serial.println(value to print);

What is the difference between the last two?

Nyquist Frequency

- In our exercise with the graph paper, we realised that more the number of samples per unit time, the better the representation of the signal.
- But more number of samples per unit time, your need for data storage will also grow proportionately.
- Is there a minimum speed/frequency at which you can sample the signal, without losing information in the signal?
- This frequency is called the Nyquist Frequency.
- Research about this frequency and how it applies to audio transmissions.

What if you disobey the Nyquist Frequency?

- Choose any analog signal which has some frequency.
- Discuss and explain what would happen if you do not follow the rules of sampling according to the Nyquist frequency.

Session 5

Overview of Internet of Things

Layout for the Session

- Introduction to Internet of Things
- Global Scenario of IoT
- Introduction to Cloud Computing
- Web Servers
- API services and Account Services (IFTTT and Thingspeak)

Why are we learning this?

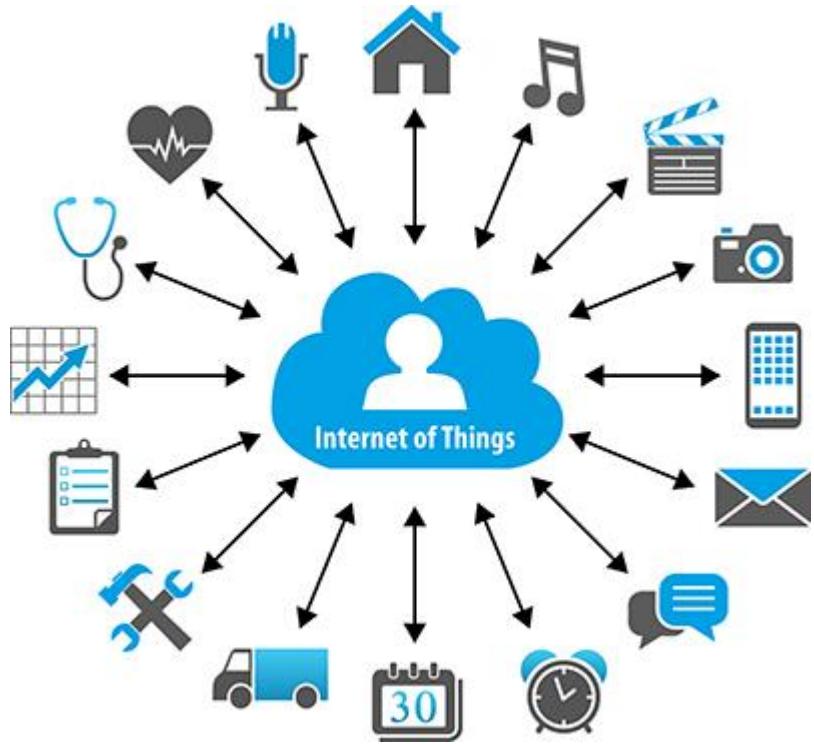
- To understand and comprehend what the Internet of things is
- To look at how big an opportunity it is
- How it can revolutionise the way we live
- How it can bring transparency, better utilisation of scarce resources
- What are the building blocks in an IoT Device
- What are Web Servers and Cloud services

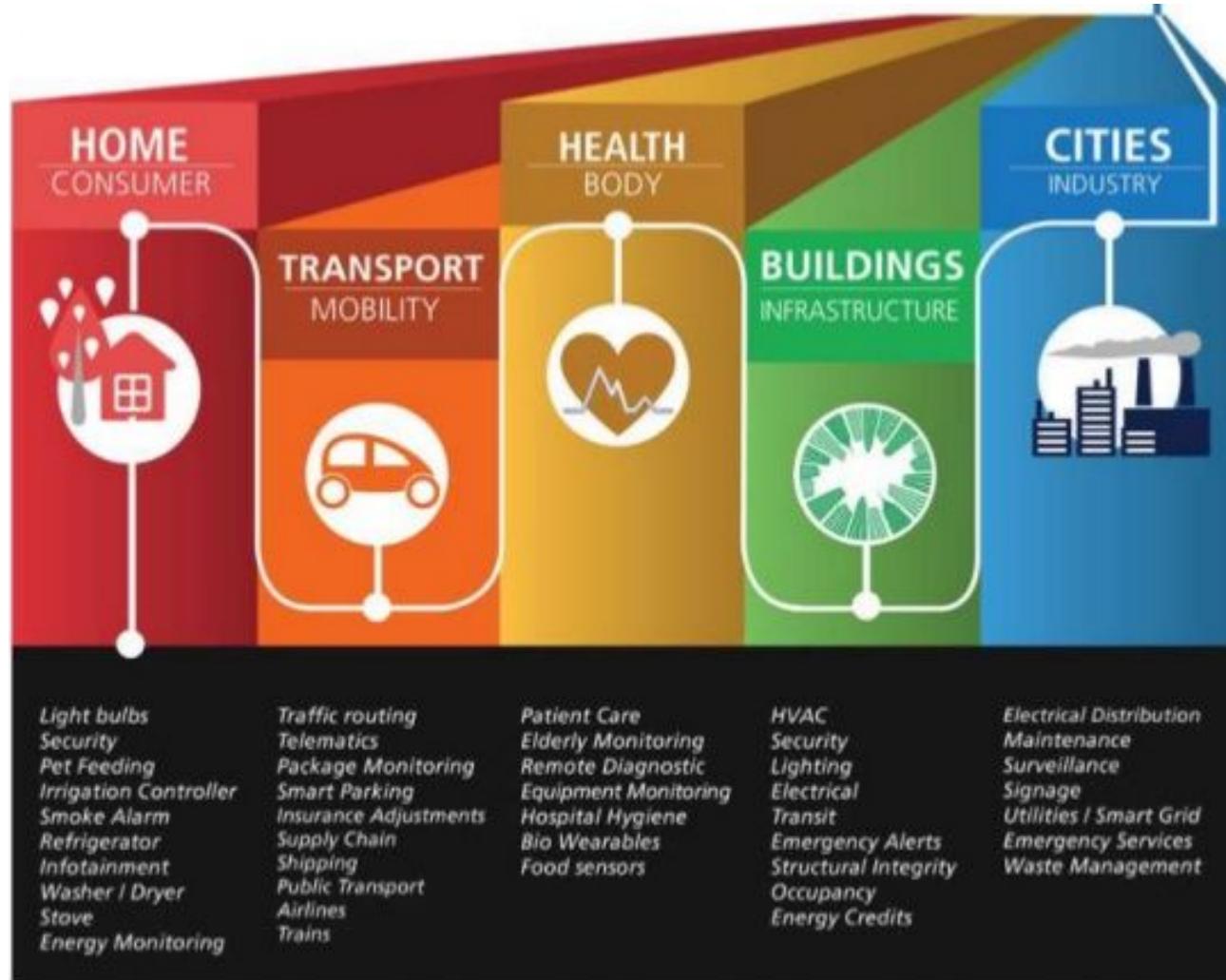
Introduction to IoT

IoT is an abbreviation- it stands for Internet of Things.

The Internet of things (IoT) is the network of **Physical devices, vehicles**, and other items embedded with **electronics, software, sensors, actuators**, and **network connectivity** which enable these objects to **collect and exchange** data.

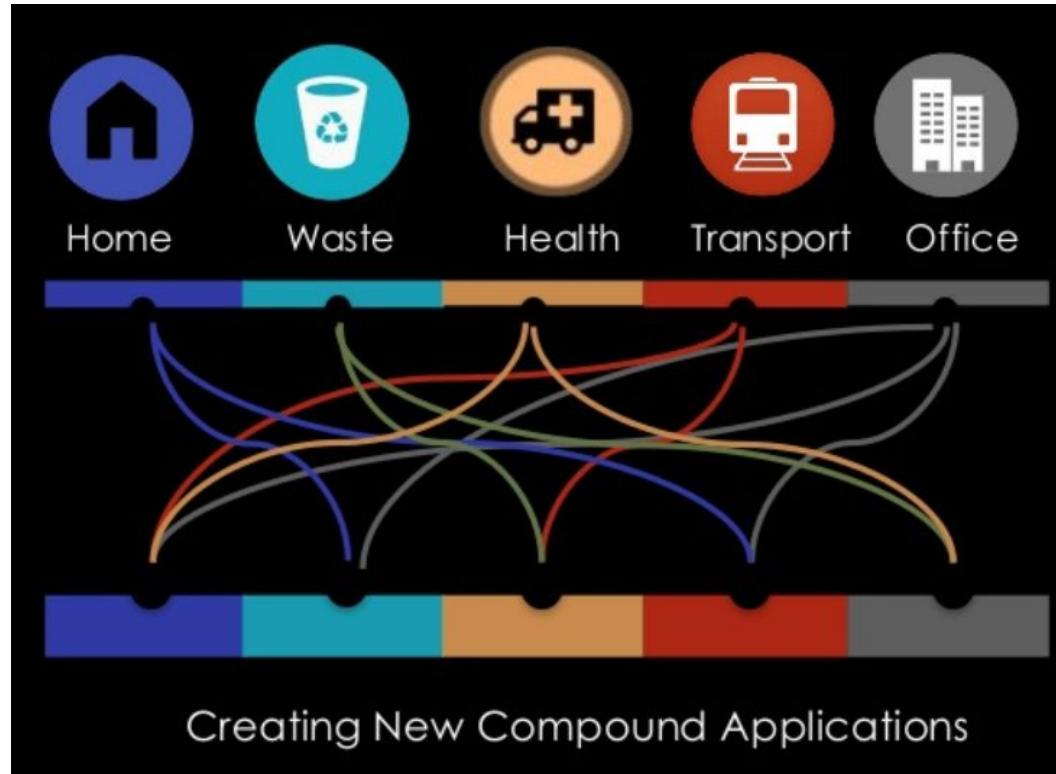
The 30k Feet view



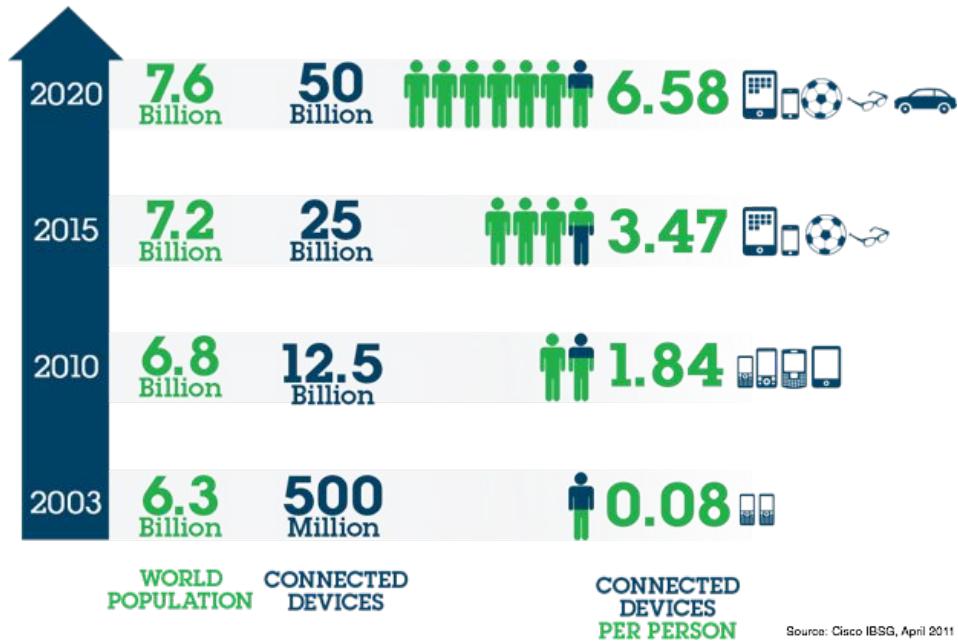




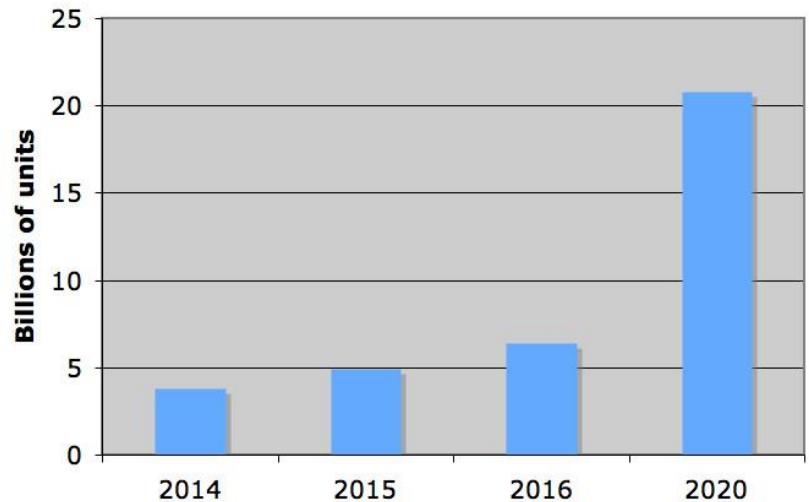
IOT Makes Sense When you Blend Data



How big is this opportunity?



Gartner Inc. forecast, Internet of Things installed base



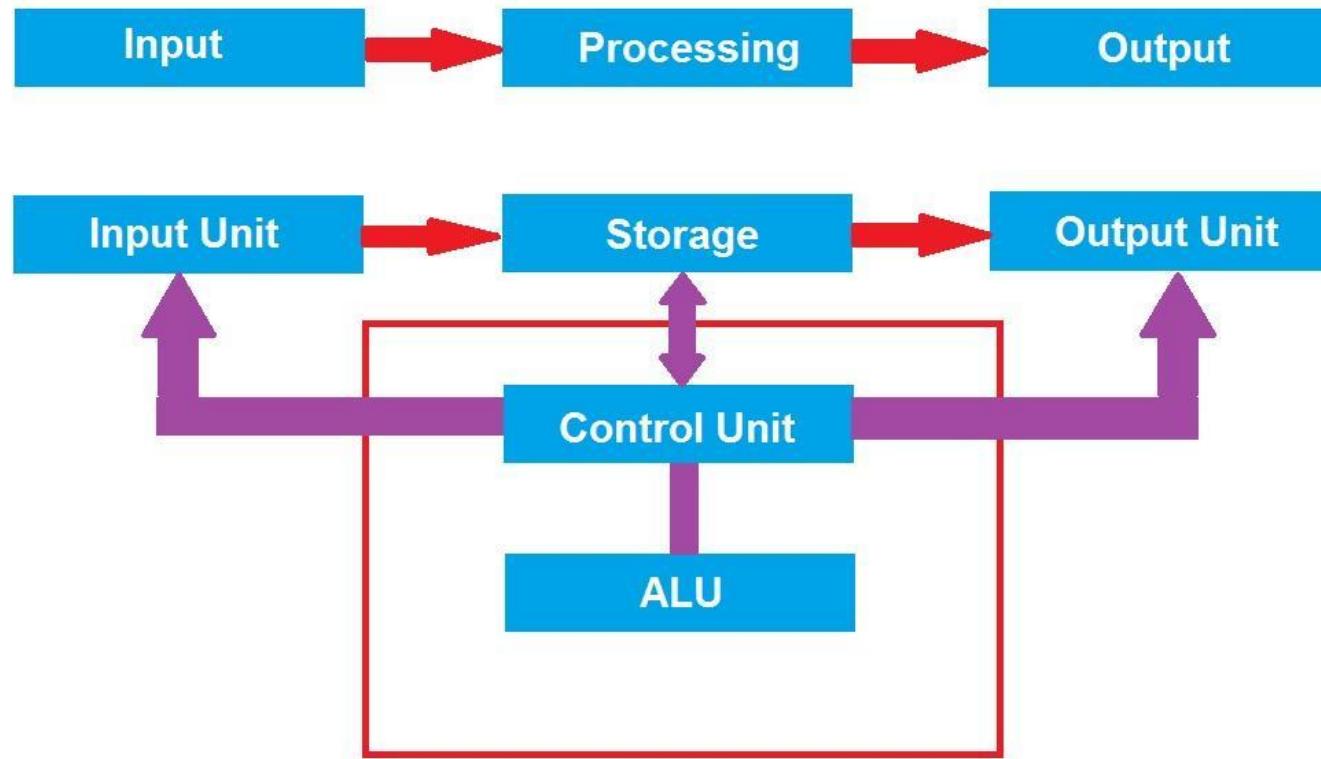
Are we playing a part in this ecosystem?

- 1) Smartphones today are connected devices with sensors, screens and connectivity.
- 2) Smart TV's and Appliances like Air Conditioners have become commercial.
- 3) Voice Assistants (Amazon Echo, Google Home)

So yes, you are playing a important part!

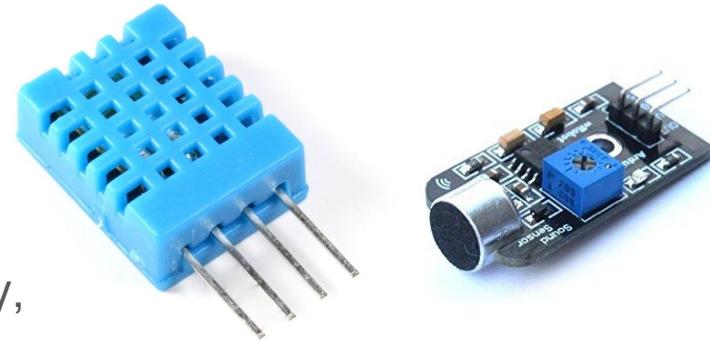


Blocks in an IoT Device- It is a computer!



Sensors (Input Devices)

Sensors are electronic devices that measure a **physical quantity** (speed, acceleration, tilt, temperature, humidity, light intensity, sound intensity, smoke) and convert it to an **electrical signal**.



This electrical signal is processed by the Programmable Logic Device, the **Wemos**.



This roundabout process allows a representation of the physical quantity in software.

This can manipulated by logic and translated into an action.

Actuators (Output Devices)

Actions (turn a light on, turn a motor in clockwise direction, ring a bell) are performed by actuators.

These are output devices, and are controlled by the programmable logic device.

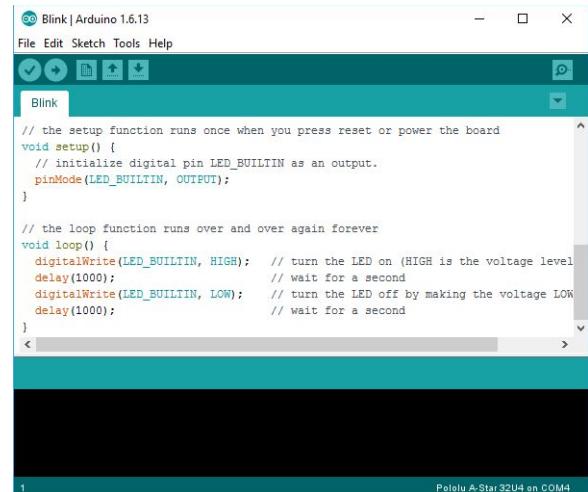


A Programming Environment

Because of the Open Source Nature of **ESP8266**, developers around the world have built software tools that allow both Block based programming environments (**Scratch**, **Blockly** and **Arduino**) and also allow to program in C/C++.



A Visual Programming Language

A screenshot of the Arduino IDE interface. The title bar says "Blink | Arduino 1.6.13". The menu bar includes File, Edit, Sketch, Tools, Help. The toolbar has icons for file operations. The main area shows a code editor with the "Blink" example sketch. The code is as follows:

```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level
  delay(1000); // wait for a second
  digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```

The status bar at the bottom right says "Polelu A-Star 32U4 on COM4".

Relations and Behaviours

Once an idea is finalised, the next step is to set up **relations** between inputs and outputs. (The specific sensors and actuators are not chosen yet)

The **behaviour** of the outputs is governed by the relations you set up between them and the inputs.

They form the core of your idea execution phase.

Example: If **water level** has reached **90%** of the tank, turn the **motor off**.



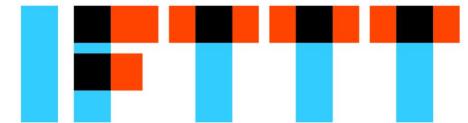
Cloud and Internet Services

IoT devices need to access internet to exchange data.

Cloud and Internet services allow exchange of data **to** and **from** IoT devices.

IFTTT (IF This Then That) and **Thingspeak** are two user friendly Cloud services targeted towards prototyping.

A lot of these are free to use within permissible limits.



Introduction to IFTTT



Recipe

if this then that

Trigger

Action

IFTTT is Cloud Based Rule Engine

IFTTT in simple terms allows you to create **relations** between **triggers** and **actions** online.

You can use a simple combination of events that occur (email received from bank, calendar event starting) to execute actions online (save email attachments in google drive, notify) within a short span of time.

The cloud service can be accessed on www.ifttt.com.

Please create an IFTTT account for us to try during this course.



Automatically set your latest Instagram
as your wallpaper



Upload your screenshots to Dropbox



Turn on your lights when you're near home



Auto-download Gmail attachment(s) to Dropbox &
organize those by sender's email address



**Set lost phone ringtone
volume to 100%**
by caspertek



Post your YouTube uploads to
a Facebook Page

Creating Applets

An applet is one rule/relation you create on IFTTT.

- a) Save new email attachments from Gmail to Google Drive.
- b) Store NASA astronomy picture of the day in a Google Drive folder for later.
- c) When you're tagged in a Facebook photo, save it to Google Drive
- d) Log your completed Uber trips in a spreadsheet

Session 6

Fetch Data from the Cloud

Layout for the Session

- Learn how to find sources of data, structured and unstructured data
- Public Data and Private Data
- Concept of Rate Limiting and DoS attacks
- Filtering Data from the cloud
- Introduction to Chrome Developer tools
- Build a Weather Station

Finding Sources of Data

- Data is the blood that passes through the internet into your device.
- The magnitude and value of the data helps make decisions.
- You may have data open on the web
- Sometimes it requires an account to be created.
- Data is largely divided into unstructured and structured data sets

Structured Data

Structured Data is data that has

- A set pattern explaining what information is.
- A set relation (one to one, one to many, many to many) between different data subsets.
- Is computer readable (in XML format, RSS feeds, JSON format, excel files, comma separated values)
- Is mostly less available, and probably paid.

Examples:Excel files

Unstructured Data

Unstructured Data is data that has

- No set pattern.
- Homogenous
- A lot of unnecessary information
- Has no structure and hierarchy.
- Freely available

Examples: Video and Music, Web Pages, Scanned text from Ebooks

Public Data

- Data available on a website, which anyone can view.
- You can use this source of data without anyone's permission.
- Since it is public, it can change anytime.
- Some governmental organisations publish data about their countries in the public and can be used for research projects
- <https://data.gov.in/> is a website where data about India can be accessed.
- **Data can be public by error, but it may not be something you have the right to view. This has to be reported. Be a good citizen and duly report lapses in security.**

Private Data

- Data locked behind a lot of doors
- Bank account transactions, Credit card numbers etc
- These belong to someone and need explicit permission to be used
- We are not using private data in any of our exercises.
- Your own private data can be used by you to make decisions.
- Health tracker data, weight tracking, your GPS locations, your expenses etc
- Private data belongs to the individual who created the data.
- Never store private data.
- Never identify people with private data. Always aggregate data and present your metric.

Rate Limiting

- If a lot of people start to access public data, then the owner of the website will have to pay big internet bills
- To prevent people from doing this, web site creators limit the number of times you can access public data per unit time.
- Any request to access new data within this time frame is rejected.
- This is called rate limiting.

DoS and DDoS

- DoS stands for Denial of Service Attack.
- DDoS stands for Distributed Denial of Service Attack.

Let's look at a few videos to understand these

<https://www.youtube.com/watch?v=c9EjuOQRUdg>

<https://www.youtube.com/watch?v=YcH7qx6HTII>

Data Filtering

Let us first identify the source of data.

Our Source of Data is

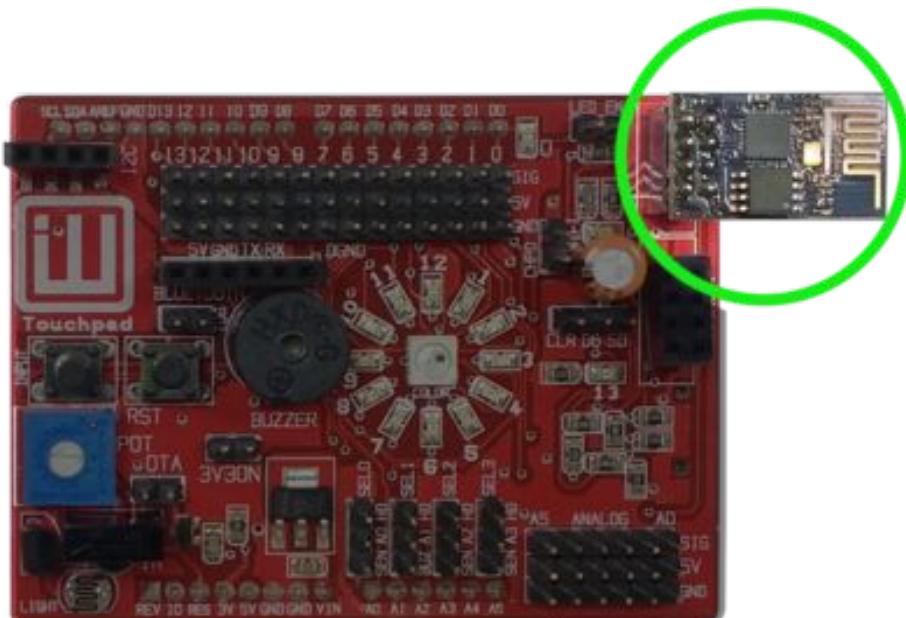
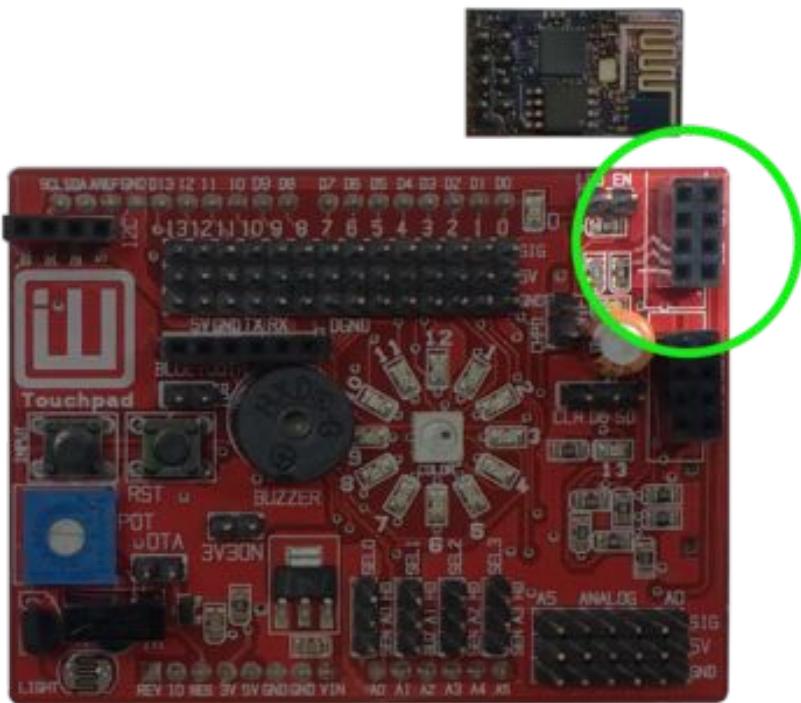
<https://www.accuweather.com/en/in/udupi/193394/weather-forecast/193394>

This shows the current forecast for Udupi, India

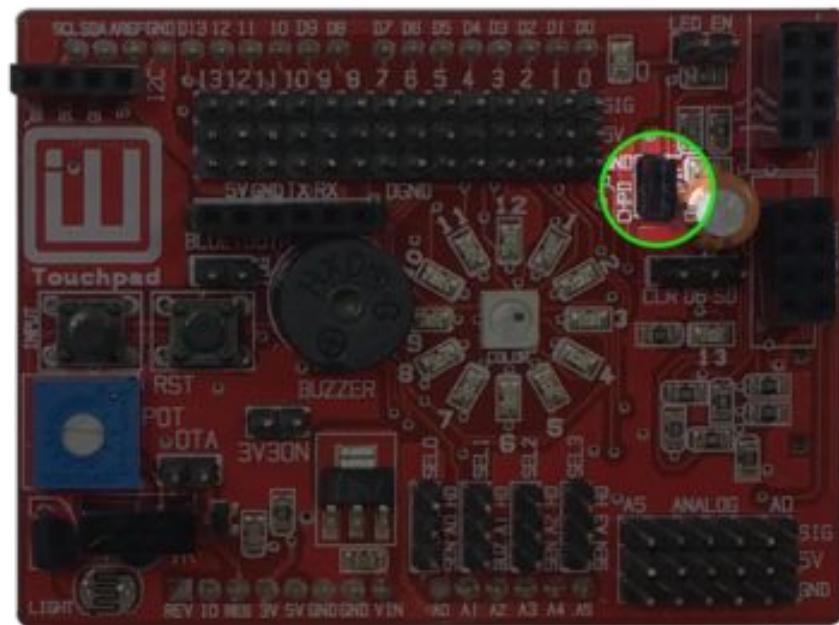
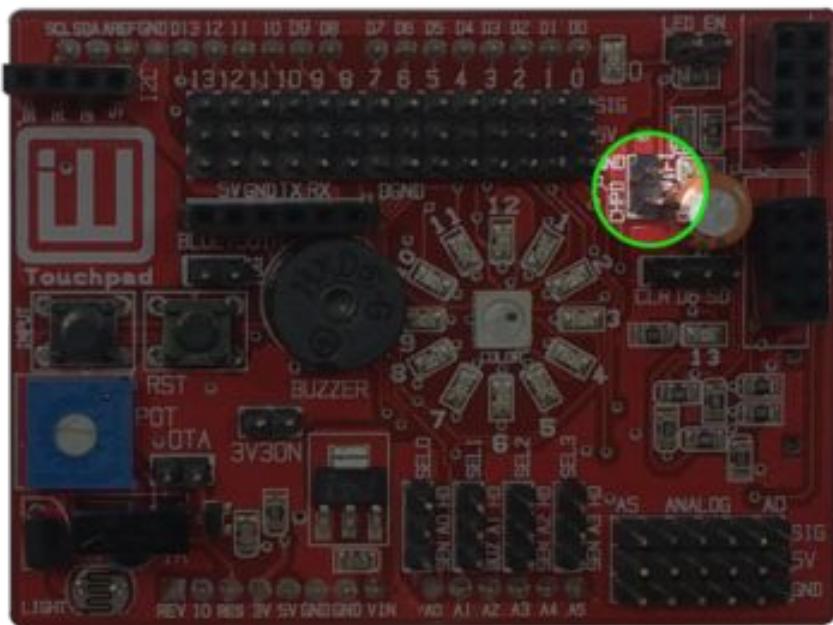
Let's look at a video to understand how to extract information from unstructured data.

<https://www.youtube.com/watch?v=4vKxGHGYOtl>

Hardware Connections



Hardware Connections



Fetching Data using the Idiotware Shield

- The Idiotware shield uses an ESP8266-01 module to allow the Arduino to connect to the Internet.
- The communication is over Serial pins 0 and 1.
- The Library that allows you to interface with the ESP8266-01 is called ELClient. <https://github.com/jeelabs/el-client>
- Let us install this library and learn how to connect to our Thingspeak URL and fetch the temperature.
- The fastest way to get started is to look at an example and modify it to suit our needs. Let's do this.

Session 7

Monitor Bitcoin Price

Layout for the Session

- Building a Gadget to display Live Bitcoin prices
- Add Alarms for Low and High values.
- Display information on an OLED display.

Why are we learning this?

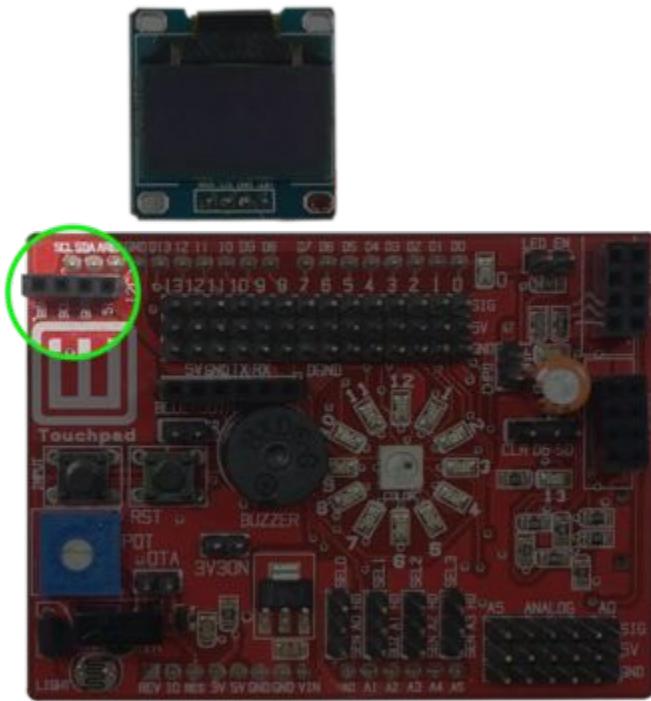
- Understand how to take actions on data.
- Understand and build using a display device.
- How to do data selection on low powered and low memory devices.
- How to work with unstructured datasets.
- Understand how displays use the XY Coordinate system
- Understand how fonts work.

Small OLED Displays

- OLED Stands for Organic LED Display's
- These are pretty inexpensive and are not commonplace in phones and TV's.
- The Idiotware Shield uses an I2C OLED and can be connected directly to it on the OLED header.
- I2C is a serial communication protocol which allows hundreds of devices to be connected on the same two lines SDA (Serial Data) and SCL(Serial Clock).
- Each device has an Fixed address to prevent bus contention.



OLED Connection



Install Library and Run Simple Programs

- The OLED runs with the U8GLIB library, which can be installed inside arduino.
- Let's look at the simple program of showing text on the OLED.

Taking it Forward

- Display the bitcoin price from a source on the web on the OLED
- Set your Low and High Price levels for Bitcoin.
- An alert (Color LED or Buzzer) is shown if the price goes above a certain limit or below a certain limit.
- Lets build this program on top of what we have already built.

Session 8

Log and Monitor Temperature of The Room

Layout for the Session

- Learn how to measure Analog Values in Arduino
- Learn How to report them on the cloud

Session 9

Build a Gadget Day

Layout for the Session

- Learn How to Measure Analog Quantities
- Build a Gadget that helps in either
 - Retail Sector
 - Healthcare Sector
 - Home Automation

Session 10

Open Design Session

Layout for the Session

- Ideate and Design Solutions for your chosen problem
- Sketch
- Build your prototype with Cardboard
- Gather all resources required for your project.
- Identify common problems that may occur if you choose the wrong device or prototype.

Session 11

Introduction to Python

Layout for the Session

- Exposure to Computer Architecture
- Program Flow and Algorithms
- Compiled and Interpreted Languages
- Install Software
- Hello World Program
- Build a Calculator
- Find Primes

Why are we learning this?

- To understand how a computer works at the most fundamental level
- How programs in a desktop computer work, what an algorithm is
- Types of languages, compiled and interpreted
- Write our first python program
- Build a Calculator
- Find Prime numbers

Videos

- Exposure to a Computer and its Architecture
(<https://www.youtube.com/watch?v=AkFi90IZmXA>)
- Introduction to Basics of Programming, Program Flow and Algorithms(<https://www.youtube.com/watch?v=6hfOvs8pY1k>)
- Introduction to Compiled and Interpreted Languages
(<https://www.youtube.com/watch?v=qaj7nO1HUqA>)

Software Installation

- Navigate to Python.org
- Download software for your Operating system
- Install it
- The editor for writing Python Program is called IDLE

Write your First program(Hello World)

- Open IDLE
- Start a New File
- In the file, type `print("Hello World")`
- Save file
- Go to Run > Run Module

Simple Code Example

```
#this is a comment
x = 34 - 23 #Subtraction
y = "Hello" # Strings!
z = 3.45 # Decimals aka Float
if z == 3.45 or y == "Hello": #comparisons
    x = x + 1 # value update
    y = y + "World" # String concatenation.
print(x) # display the values
print(y)
```

Build a Calculator

- Accept User Input
- Convert Strings to numbers and vice versa
- Add two numbers
- Complete Calculator by adding features of subtraction, division and Multiplication
- Is there a condition in which your program is inherently buggy?

Python Lists and Applications

- Creating a List
- Control Statements if Condition and for loop
- The For Loop and Accessing Elements in a Lists
- Adding and Deleting Elements in a list

Creating a List, Printing and Length of List

```
#Creating a List
anyListName=["a", "b", "c", "d", "e"]

#List of Numbers
numberList=[100, 200, 300, 400, 500]
```

```
#Accessing List Values by index
print(numberList[1])
```

```
# Print whole List
print(numberList)
```

```
# What is the Length of the List?
lengthOfList= len(numberList)
```

Control Statements: For Loop and If condition

```
# What is the Length of the List?  
lengthOfList= len(numberList)  
  
# Traversing through all elements and printing them  
for i in range (0,lengthOfList) :  
    print(numberList[i])  
  
#OR alternatively, if your list expands and contracts,  
for element in anyListName:  
    print(element)  
  
#Writing a conditional statement  
if (numberList[3]==400):  
    print ("The Third Number is 400")  
else:  
    print("The third Number is not 4")
```

Adding and Deleting Elements

```
#Add an Element to the List using append  
numberList.append(10);  
print(numberList)
```

```
#Delete an element in the list  
del numberList[4]  
print(numberList)
```

Algorithm for Finding Prime Numbers

- Independently research an algorithm to find prime numbers
- Using knowledge of lists, printing and loops, find prime numbers between 2 and 100, using the program

Session 12

Searching, Sorting and Regular Expressions

Layout for the Session

- Searching and Sorting
- Regular Expressions
- Time Complexity of Algorithms
- Text Searching and Pattern Matching

Why are we learning this

- Searching and Sorting are primary operations.
- Regular Expressions allow you to search through text
- Time Complexity of Algorithms
- Text Searching and Pattern Matching

Playing a sorting game

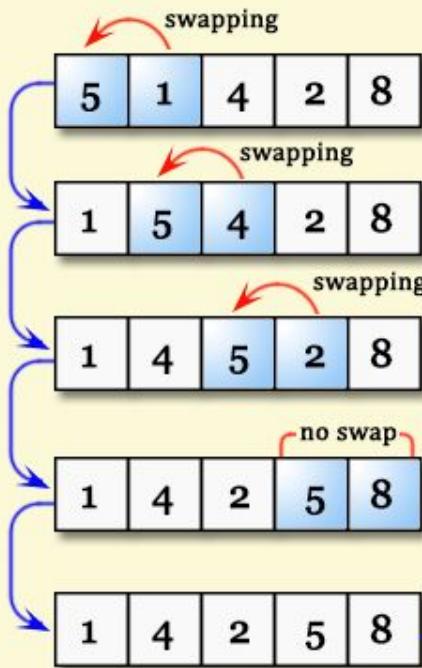
- Let us play a sorting game
- We need 8 volunteers, we need one questioner, we need one verifier.
- The 8 volunteers stand in random order of height
- The questioner can ask only one question, the answer to which is a yes or no.
- The verifier verifies the answer to the question.
- The questioner executes a task which leads to sorting.

Sorting A List

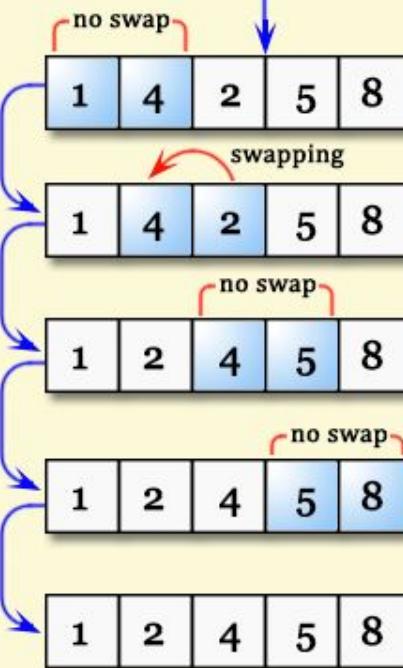
- If given a list of unsorted numbers, how do you sort the list?
- Write a program that can do it.

Bubble Sorting

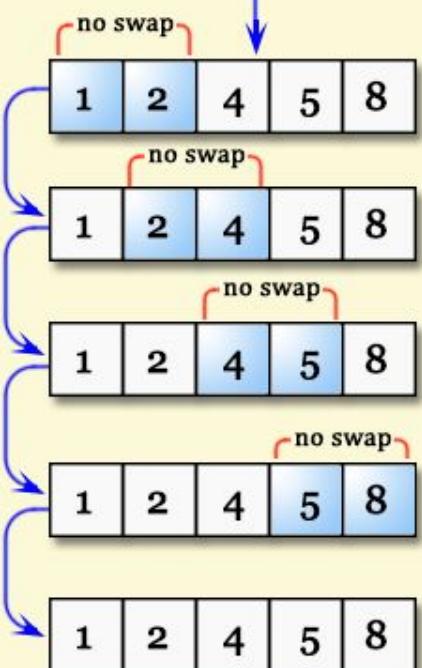
First Pass



Second Pass



Third Pass



© w3resource.com

Binary Search

- The Binary Search Algorithm is one of the fastest method to search through an ordered list.
- Let us play a game on searching using Binary Search

Binary Search Game

- We need 15 Volunteers, 1 Questioner and 1 Verifier
- Instructor is going to give you a number to search for.
- The volunteers all have a number in their hand.
- The questioner and the verifier have to read up on the Binary Search Algorithm and play the game.

Writing a Program for Binary Searching

- Let us write a program for Binary Searching through a list

Algorithmic Complexity

- Algorithmic Complexity is how complicated an algorithm is
- It is measured in the number of steps required to finish doing what the algorithm must do.
- It is measured mathematically for some combination of inputs, say n .

If I had “ n ” numbers in my list, how many steps does it require to sort a list?

Time Complexity of Algorithms

God, grant me patience, but please hurry up!

The Currency in Computers

The central part of a computer is its CPU or the processor.

Manufacturers like Intel and AMD make these processors that are running our desktop computers and laptops, and computers on the web.

The processor has a high frequency signal called the clock of the processor, connected to it externally, sometimes also called the heartbeat of the processor.

Every computation inside the CPU is synchronised to the clock(except interrupts, that occur any time)

Computer Time is the key parameter which has to be optimised while writing programs.

The Problem Statement

You have been given a list of numbers, which are sorted, the highest number on the right.

You also have been given a “result” number.

Instruct a computer to find out if there exists two numbers in the list whose sum add up to the “result” number.

Examples

List	Result	Sum Exists?
1, 2, 3, 4, 5, 6, 7	8	Yes
100, 200, 300, 400	7	No

How are we optimising?

You can count the following operations as “steps”

- 1) Comparison between numbers
- 2) Addition, Subtraction, Multiplication or Division

- The purpose of the exercise is to reduce the number of steps.
- This in turn allows the program to return the result in a shorter time.

How to express your program?

- 1) Choose the First element in the list
- 2) Add it to the next unpaired element in the list.
- 3) Is the sum equal to the result?
 - If yes, print the “result has been found”. Terminate the program.
 - If no, go to step 2
- 4) If the last number has been reached, print “no sum exists” and terminate the program.

If you had 4 numbers in your list, how many steps will this program take?

Manual Calculation of Steps

- Assume Initial List is [1,2,3,4], result is 8.
- The steps the program goes through are in the table alongside.
- Notice that there is a fair probability you may encounter the result early on.
- The worst case scenario is chosen, in which the program has to forcibly compute everything, and may still not yield a result.

What if you had a 1000 Numbers in your list?

Number Combination	Is Equal to Result?
1 and 2	No
1 and 3	No
1 and 4	No
2 and 3	No
2 and 4	No
3 and 4	No

Mathematical Model

Essentially the table above is about

**How many different pairs of things (numbers)
can be made from a list of 4 things (numbers),
where the order doesn't matter?**

The Formula for this is shown alongside.

Here n=4 and r=2, which yields 6.

$${}^nC_r = \frac{n!}{r!(n - r)!}$$

$$C(n, r) = C(4, 2)$$

$$= \frac{4!}{(2!(4 - 2)!)}$$

$$= 6$$

Simplifying further

You can express the time complexity function $O(n)$ of the algorithm as follows

Here n is count of unknown numbers in list, but $c=2$. When substituted

$$\begin{aligned} O(n) &= n! / (2! (n-2)!) \\ &= (n) \times (n-1) \times \cancel{(n-2)!} / (2) \times \cancel{(n-2)!} \quad (\text{cancelling similar terms}) \\ &= (n \times n-1)/2 \end{aligned}$$

For very large n , the terms n and $n-1$ are almost equal, this formula becomes

$$O(n) \sim (n^*n) / 2 , \text{ hence } O(1000) \sim 1000^* 1000/2 \sim 500,000$$

What does all this mean?

It is a good starting point.

A Time Complexity in computer algorithms that exhibits polynomial growth (n^*n) will grow fast as the data size grows, and will become a bottleneck.

We need to find out and evaluate a faster way to solve this trivial problem.

You have 15 minutes to think of one.

Hints: 1) The list is sorted 2) You can subtract numbers. 3) You can combine two algorithms if needed.

Method 2: Using Binary Search

Binary Search is a algorithm to find if a number exists in a **sorted list**.The basis of the algorithm is: **Divide and Conquer**.

- 1) Divides the list in half.
- 2) Compare the number in the middle of the list with the number being searched for, which we will call **C (for center)** and **S(for searched)** respectively.
- 3) If **C > S**, then the number **S** may exist in the lower half of the list. Go to Step 1 with the Lower half of the list.
- 4) If **C < S**, then the number **S** may exist in the upper half of the list. Go to Step 1 with the upper half of the list.
- 5) If **C=S**, number has been found.
- 6) If only two elements exist in list, then exit.

If searching for 23 in the 10-element array:

2	5	8	12	16	23	38	56	72	91
---	---	---	----	----	----	----	----	----	----

23 > 16,
take 2nd half

L	2	5	8	12	16	23	38	56	72	H
2	5	8	12	16	23	38	56	72	91	

23 < 56,
take 1st half

2	5	8	12	16	L	23	38	56	72	H
2	5	8	12	16	23	38	56	72	91	

Found 23,
Return 5

2	5	8	12	16	L	H	38	56	72	91
2	5	8	12	16	23	38	56	72	91	

The Time Complexity of Binary Search

Since every time the list becomes half, the time complexity should have some relation to the number 2.

After every comparison, the list is halved.

The number of halves in a list of n numbers is $\log_2 n$

If we had 1024 numbers in the list, the worst case scenario is

$O(1024) = \log_2 1024 = 10$ comparisons.

How to Solve the Original Problem?

- 1) Choose a number from the list, in sequence. Let's call it **Q**.
- 2) Subtract the chosen number **Q** from the “result”, let the subtraction yield an intermediate result called **X**. ($X = \text{result} - Q$)
- 3) If **X** is negative, ignore. Go to step 6.
- 4) Search for **X** in the rest of the list, **using Binary Search**. If **X** is found, then **Q+X** equals our desired “result”. Stop the Program
- 5) Else Go to Step 1.
- 6) Exit.

Time Complexity of Second Method

The Time Complexity is the product of

- 1) Choosing each number from the list for the test, whose time complexity is n .
- 2) Doing a binary search from the remaining sorted list, which is $\log_2 (n-1)$

So $O(n)=n \times \log_2 (n-1)$

$$\text{Hence } O(1000) = 1000 * \log_2 999$$

$$= 1000 * 9.964$$

= 9964 comparisons

So how far did we optimise?

In method 1, the comparisons required were 500,000.

In method 2, the comparisons were 9964, giving us a $500000/9964=50x$ speed improvement.

For a list of 1 Million numbers, this is a staggering 50000x speed improvement!

But, is this enough?

Method 3

The Method 3 relies heavily upon the fact that the list is sorted, and a sum is required which needs two numbers. It assumes two such numbers exist.

This is how it works

- 1) Add the largest number and the smallest number in the list. Let this sum be called **Z**.
- 2) If **Z**=result, print that a pair exists.
- 3) If **Z** > result, Goto Step 1 with the number immediately smaller than the larger number in Step 1
- 4) If **Z** < result, Goto Step 1 with the number immediately larger than the small number in Step 1
- 5) Exit if you have reached the center of the list.

Time Complexity of Method 3

The Method 3 is similar to Method 1 in some aspects, but it differs in the following ways

- 1) Instead of doing a sequential test with each number pairs, Method 3 uses the constraints of the problem to do a more educated search.
- 2) It shrinks the search faster because it attack the list from two sides.

So $O(n)$ is simply adding and comparing n numbers. Hence its complexity is n .

For 1000 numbers $O(1000) = 1000$.

Summary of Time Complexities

Assuming that it takes 1 second to search through the list of 1000 numbers in method 3.

Method	Time Complexity	Time to Compute Result
3	1000	1 second
2	9946	9.946 Seconds
1	500,000	8 min 20 seconds

Regular Expressions

- Let's say you want to find out all email addresses or all phone numbers in a text file
 - Email addresses can have any combination of letters and numbers.
 - Phone numbers can have formats as follows
- | |
|----------------|
| 206-555-1212 |
| (206)555-1212 |
| (206) 555-1212 |
| 206.555.1212 |
| 2065551212 |

Patterns and Not specifics

- When presented with a problem like this, we try to search by pattern and not look for specific email addresses.
- A regular expression is a string of characters and symbols that help you form a pattern.
- You can then test an unknown string against this pattern.
- The regular expression library in Python will provide you with the matches it finds in the string, that resemble that pattern.

Session 13

Introduction to Raspberry Pi and Configuration

Layout for the Session

- Introduction to Raspberry Pi Computer
- Configure a Raspberry Pi computer from scratch
- Introduction to SSH and its use
- Introduction to the Linux Operating system
- Navigating the File System on a Linux Computer
- Introduction to Git
- Create Repository, Commit code, Clone Repositories and Push Changes

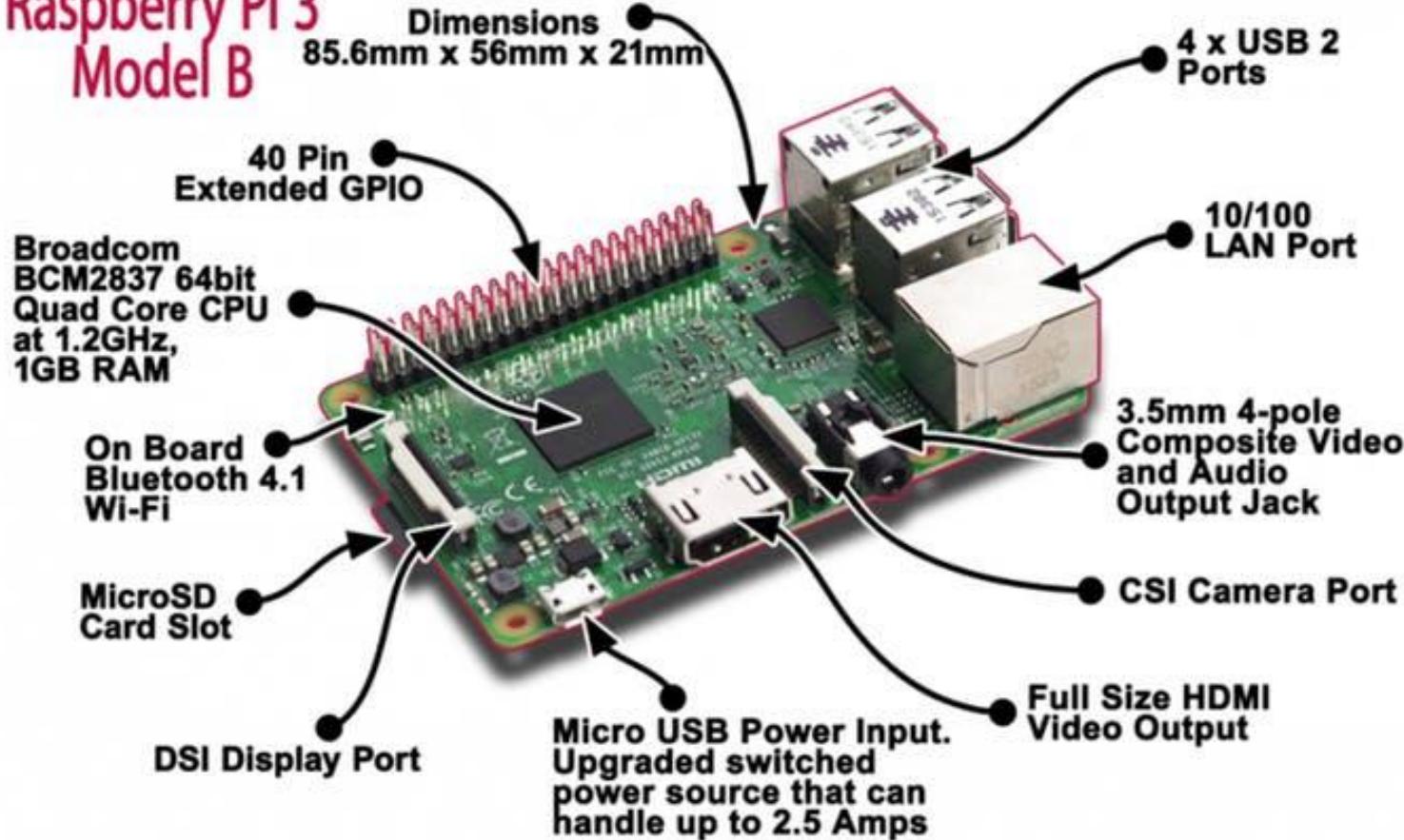
Why are we learning this?

- The raspberry Pi is a powerful computer, but no one knows how to configure it well.
- You will learn and appreciate how a network operates
- What an Adhoc Network is
- What flashing a operating system is, and what tools are required
- How do you update a linux system
- How to configure networking on a Linux system
- How to share code with the Raspberry Pi
- Version Control and its Advantages

Introduction

- Low powered Linux Computer
- Access to Wifi/Bluetooth out of the box
- More than capable to do menial tasks
- Comparatively low cost and Low Power

Raspberry Pi 3 Model B



Download OS/Softwares (MacOS)

Raspbian OS

<https://www.raspberrypi.org/downloads/raspbian/>

SSH Client

Use Terminal application provided in Mac OS. Example command ssh <username>@<IP>

Etcher to Install OS images on SD card.

<https://etcher.io/>

IP Scanner to lookup IP address of Raspberry Pi

<https://itunes.apple.com/in/app/ip-scanner/id404167149?mt=12>

Download OS/Softwares (Windows)

Raspbian OS

<https://www.raspberrypi.org/downloads/raspbian/>

Putty Client

<https://www.chiark.greenend.org.uk/~sgtatham/putty/download.html>

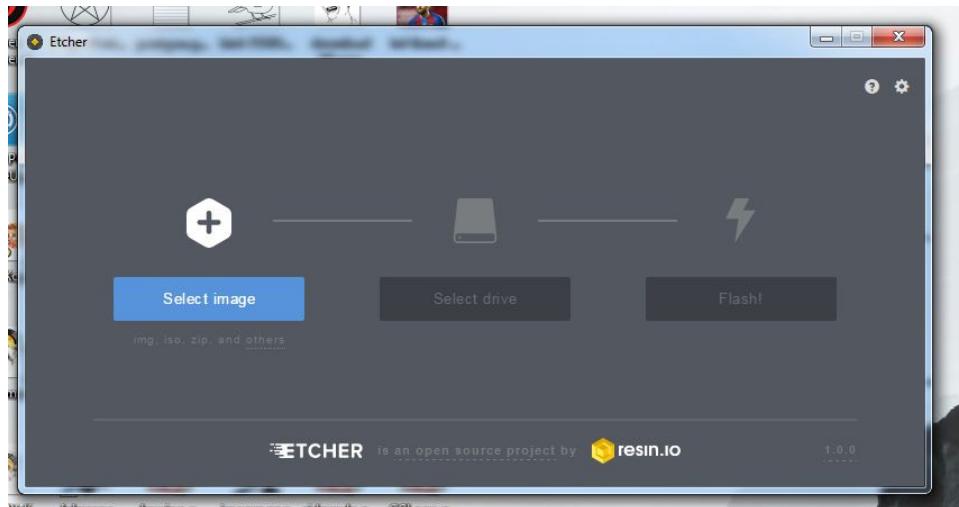
Win32 DiskImager

<http://sourceforge.net/projects/win32diskimager/>

Advanced IP Scanner

http://download.cnet.com/Advanced-IP-Scanner/3000-18508_4-10115592.html?part=dl-&subj=dl&tag=button&lang=en

Write image to SD Card (MAC)



Software used: **Etcher**

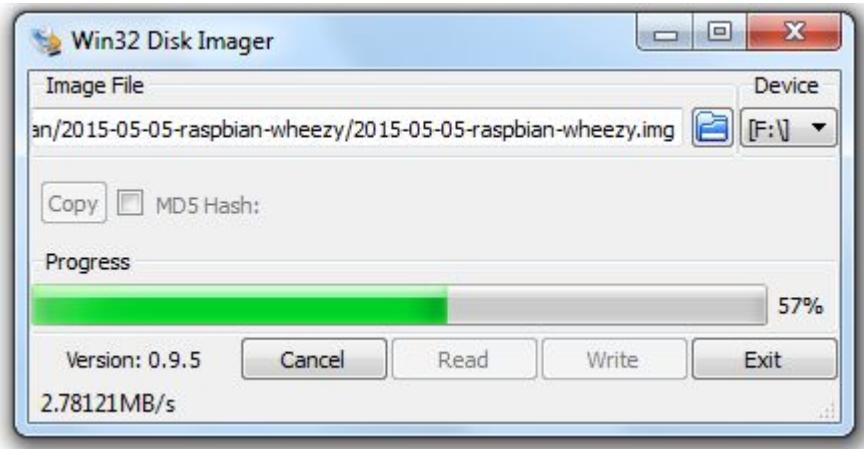
Choose correct drive for SD card

Choose .img file downloaded in earlier step

Click Write

Once process finishes, click **Exit**.

Write image to SD Card (Windows)



Software used: **Win32 DiskImager**

Choose correct drive for SD card

Choose .img file downloaded in earlier step

Click Write

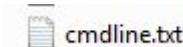
Once process finishes, click **Exit**.



This slide applies only to computers with an Ethernet Port

Edit cmdline.txt

Lookup a file cmdline.txt in the SD card



Open with any text editor

```
dwc_otg.lpm_enable=0 console=ttyAMA0,115200 console=tty1 root=/dev/mmcblk0p2 rootfstype=ext4 elevator=deadline rootwait
```

Add **ip=10.0.0.10** at end of line. Save file.

```
rootfstype=ext4 elevator=deadline rootwait ip=10.0.0.10
```

Plug SD card in Raspberry Pi. Do not power on.



This slide applies only to computers with an Ethernet Port

Network Setup (MAC)

Set static IP address on Ethernet Port (if available)

- 1) Use the IP Following IP address -
- 2) IP Address: 10.0.0.2
- 3) Subnet Mask:255.255.255.0



This slide applies only to computers with an Ethernet Port

Network Setup (Windows)

Navigate to

Control Panel> Network and Sharing Center>Change Adapter Settings>
Choose Local Area Connection

Under Properties> Internet Protocol Version 4 >Properties, set the following details

- 1) Use the IP Following IP address -
- 2) IP Address: 10.0.0.2
- 3) Subnet Mask:255.255.255.0



This slide applies only to computers with an Ethernet Port

Network Setup (Windows)

The image shows two windows from the Windows Control Panel:

- Local Area Connection Properties**: Shows the "Networking" tab selected. It displays the "Connect using:" section with "Realtek PCIe GBE Family Controller" and a "Configure..." button. Below it, the "This connection uses the following items:" list includes:
 - Client for Microsoft Networks
 - QoS Packet Scheduler
 - File and Printer Sharing for Microsoft Networks
 - Internet Protocol Version 6 (TCP/IPv6)
 - Internet Protocol Version 4 (TCP/IPv4)
 - Link-Layer Topology Discovery Mapper I/O Driver
 - Link-Layer Topology Discovery Responder
- Internet Protocol Version 4 (TCP/IPv4) Properties**: Shows the "General" tab selected. It includes fields for IP address (10 . 0 . 0 . 2), Subnet mask (255 . 255 . 255 . 0), and Default gateway (. . .). It also includes sections for DNS server addresses and an "Advanced..." button.



This slide applies only to computers with an Ethernet Port

Power On Pi

Connect Ethernet Jack of Pi to Computer using standard ethernet cable.

Plug the SD card if not done yet.

Connect Power to USB micro port on Pi, and turn on.

Wait for Pi to boot- Flashing green Light indicates Pi is booting and working as expected

An unidentified network will show up, with no Internet Connection.



This slide applies only to computers with an Ethernet Port

Connect to Pi Using Terminal (MAC)

Open Terminal
Type
SSH pi@<ip>
Follow onscreen
instructions

```
girishnair ~ pi@RaspberryPi9: ~ ssh 80x24
Last login: Fri Jun 16 12:10:53 on ttys000
Girishs-MacBook-Air:~ girishnair$ ssh pi@192.168.1.30
The authenticity of host '192.168.1.30 (192.168.1.30)' can't be established.
RSA key fingerprint is 6a:7d:9c:2b:b0:51:64:75:52:83:d4:1c:dd:03:5e:00.
Are you sure you want to continue connecting (yes/no)? y
Please type 'yes' or 'no': yes
Warning: Permanently added '192.168.1.30' (RSA) to the list of known hosts.
pi@192.168.1.30's password:

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Thu Jun 15 13:04:48 2017 from 192.168.1.2
pi@RaspberryPi9: ~ $
```



This slide applies only to computers with an Ethernet Port

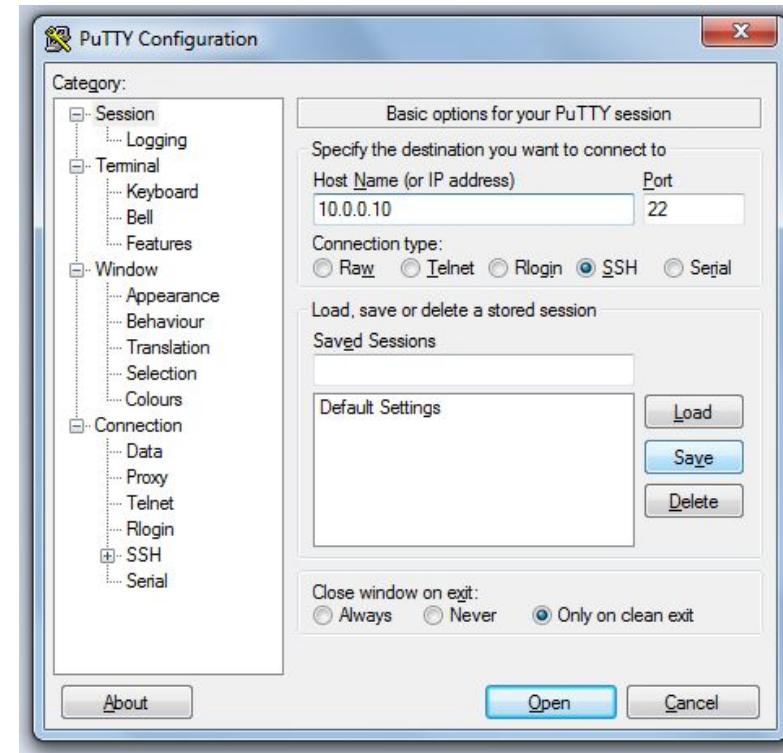
Connect to Pi Using Putty

Open Putty

Set IP as 10.0.0.10

Select SSH

Click Open



SSH into Pi

Click yes in the dialog.

```
pi@raspberrypi: ~
login as: pi
pi@10.0.0.10's password:
Linux raspberrypi 3.18.11+ #781 PREEMPT Tue Apr 21 18:02:18 BST 2015 armv6l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.

NOTICE: the software on this Raspberry Pi has not been fully configured. Please
run 'sudo raspi-config'

pi@raspberrypi ~ $
```



Username:pi
Password: raspberry

Set Wifi Credentials

Select Compatible Wifi Adapters http://elinux.org/RPi_USB_Wi-Fi_Adapters
issue command `sudo nano /etc/network/interfaces`

```
allow-hotplug wlan0  
auto wlan0
```

```
iface wlan0 inet dhcp  
    wpa-ssid "ssid"  
    wpa-psk "password"
```

Ctrl-X, to save changes. Issue `sudo reboot` to reboot pi. It will now connect to wifi router. Unplug ethernet cable, remove `ip=10.0.0.10` from `cmdline.txt` file.

Upgrade Raspberry Pi Installation

```
sudo apt-get update && sudo apt-get upgrade ( Requires Internet Connection)
```

Running Python Programs on RaspberryPi

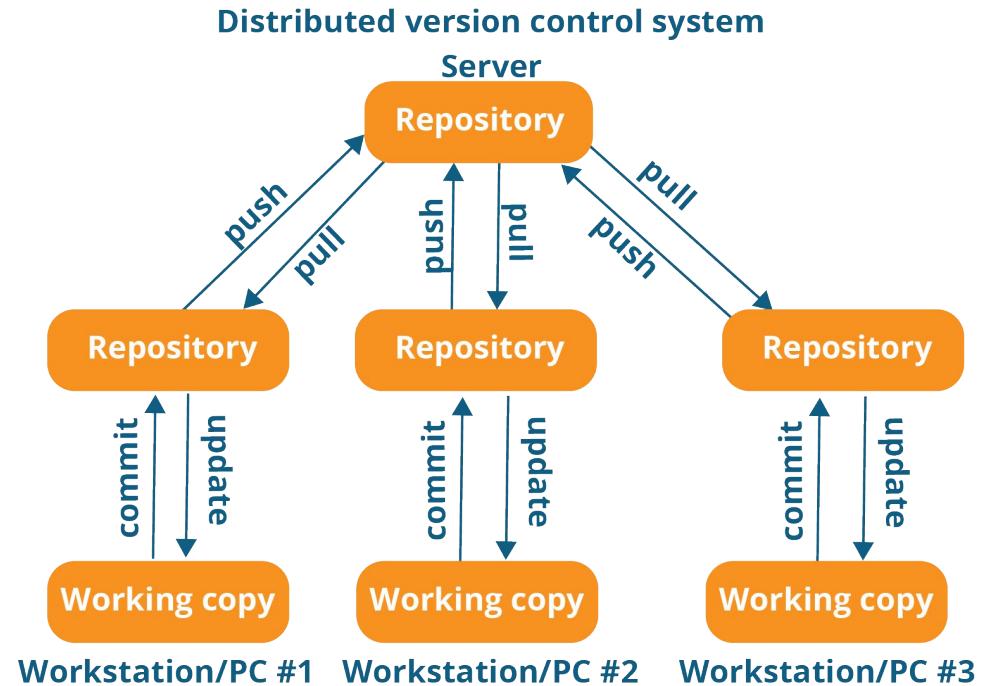
- As an exercise we will run every Python program we have written on the RaspberryPi.
- Let us first understand how we can transfer files between the RaspberryPi and your computer.
- You can directly transfer files between your computer and the RaspberryPi, but there is a better way to do it.

Introduction to Version Control

- Working in teams is essential to build bigger things
- When building software, multiple team members could be working on same file or systems
- There will be good reasons that “conflicts” occur.
 - Two developers are working on the same file, independently. Both of their changes are to be considered, but each does not have a copy of the change the other has made. So copy past has to be done.
 - After copy paste, it is possible the code of one developer has bugs and has to be removed.
 - You will realise that with multiple developers and system, this will become cumbersome.
- The way this is resolved is using a Version Control system

Introduction to Git

- Git is a distributed version control system.
- There are central stores of files, code, images etc called repositories, or repos
- The Server repo is always managed to be bug free and tested code.
- Local repos contain recent changes each developer made.



How do developers manage code?

- Developers needs to “commit” code to local repo as frequently as possible.
- They “Update” local repos from Server Repos to capture changes from other developers. This makes their local code as recent as possible.
- When all necessary changes have been incorporated on a local repo, it is “pushed” to the server repo.
- This process of Push and Commit keeps all changes “merged” between developers.

Account Creation and Software Installation

- You can open github.com, and create an account with an email.
- Once an account is created, you can create a repo with a name "Asset Summer Program". This is your server repo
- We will share this code for others to also download, and use its link as a documentation.
- Also install a software called "Github Desktop", this helps you manage your local Repo.
- Once created, start saving files in this repo for your Arduino programs.
- Let us look at How to do this.

Downloading Code to the Raspberry Pi

- You can copy any repo and start to use code of that repo using cloning.
- On the Raspberry Pi Terminal, you can issue a command

```
git clone <repo Name>
```

- This will download all code in the Repo in a folder on the RaspberryPi.
- You can then view and run the code on the RaspberryPi.
- Let us do this step and execute your Prime Program here.

Session 14

Python Essentials- JSON and File I/O

Layout for the Session

- Introduction to JSON
- JSON Parsing using Python
- File Operations in Python
- Access Filesystem in Python
- Save files after writing to them
- Reading files

Why are we learning this?

- JSON is one of the prevalent data exchange formats on the web.
- Reading to and from files is an important skill to know, because it is fast.
- Writing files allows you to save data when you do not have an internet connection

What is JSON?

- JSON stands for Javascript Object Notation
- Javascript is the core scripting language for the web
- Because almost all websites and services share data over JSON, it has now become accepted by all programming languages.
- Fortunately, Python has a robust JSON library.

JSON Structure

- JSON has a key-value pair structure
- Each Key refers to some attribute or property of the data
- Every key has value. (Name :Rupin)
- Each key can also have multiple values (Hobbies: Reading, Coding, Making)
- Let us look at how is this represented.

JSON Structure

```
1  {
2      "first_name": "Rupin",
3      "last_name": "Chheda",
4      "hobbies": ["cycling", "swimming", "reading", "woodworking"],
5      "travelogue": [
6          {"location": "Leh-Ladakh, India", "year": "2017"},  
7          {"location": "Connecticut, USA", "year": "2010"},  
8          {"location": "Bali, Indonesia", "year": "2013"},  
9          {"location": "Goa, India", "year": "2018"}  
10     ]  
11 }
```

Saving JSON Files

- You can type JSON in any text editor.
- Save the file with the .json extension.
- You can check if your JSON is “well formed” by using online JSON viewers.

<http://jsonviewer.stack.hu/>

Reading JSON

- The action of reading JSON files or string variables is called JSON Parsing.
- Let us do a simple example
- We will store a small JSON string in a variable
- We will then parse the JSON variable
- Once parsed, you can extract information out of the JSON.

JSON Parsing

- JSON Parsing Requires the JSON library.
- It is installed by default, but you can install it using pip3.
- Once installed, you can do *import json* to include the library.

File Edit Format Run Options Window Help

```
import json

myJSONDetails='{"first_name":"Rupin","last_name":"Chheda"}'
myJSON=json.loads(myJSONDetails)
print(myJSON["first_name"])
print(myJSON["last_name"])
```

File Edit Shell Debug Options Window Help

```
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:16:59) [MSC v.1900 32 bit (Intel)] on win32
```

```
Type "copyright", "credits" or "license()" for more information.
```

```
>>>
```

```
===== RESTART: D:/Asset-Summer-Program/SimpleJSONParser.py =====
```

```
Rupin
Chheda
>>> |
```

Reading Text Files

- Files are a primary way that information is stored on computers.
- They allow you to segregate information by file names.
- Files are also searchable in the operating system.
- The location of the file (also called path) is important information required.

Reading a File

- Open a File to read
- Read each line of the file into a variable
- Close the File.
- Process contents of the file.

Asset-Summer-Program ▶ fileHandling and JSON

New folder

	Name	Date modified	Type	Size
ReadFile.py	ReadFile.py	12-04-2018 01:53	Python File	1 KB
travelogue.json	travelogue.json	12-04-2018 01:15	JSON File	1 KB

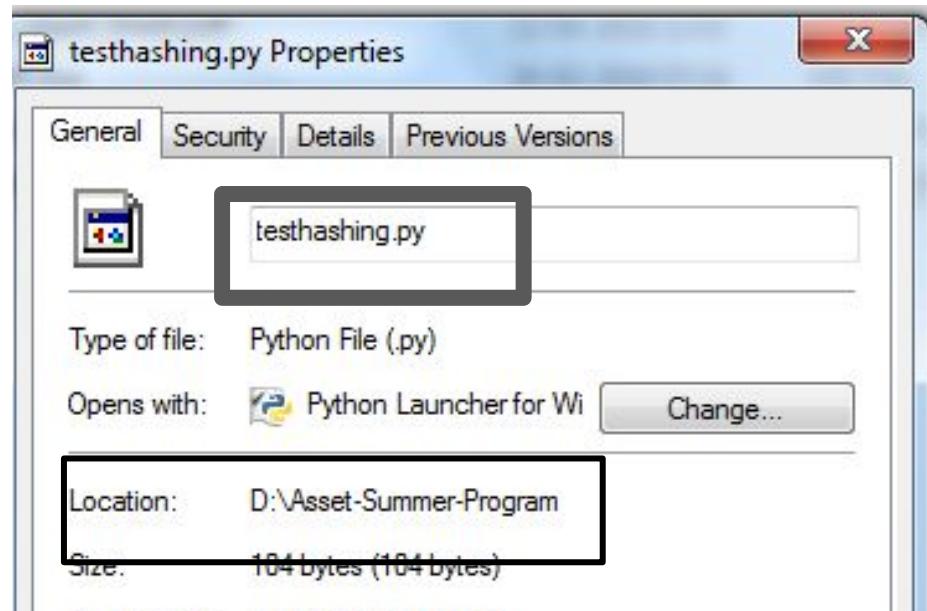
ReadFile.py - D:/Asset-Summer-Program/fileHandling and JSON/ReadFile.py (3.5.0)

File Edit Format Run Options Window Help

```
fileHandle=open("travelogue.json", "r") # Open file to read
fileContents=fileHandle.read() # read contents of file in a variable
print(fileContents) #print file contents
fileHandle.close() #close the file
```

Absolute File Path

- File path referenced from the root of the drive is called the absolute path.
- Absolute Paths start with the Drive letter



Relative File Path

- The relative file Path is in relation to the current path of the python file.
- Files in the same folder as the python file can be directly accessed using the file name.
- Files present inside a folder need to have the folder name, then the file name
- Files outside the current folder are access using two dots (../)

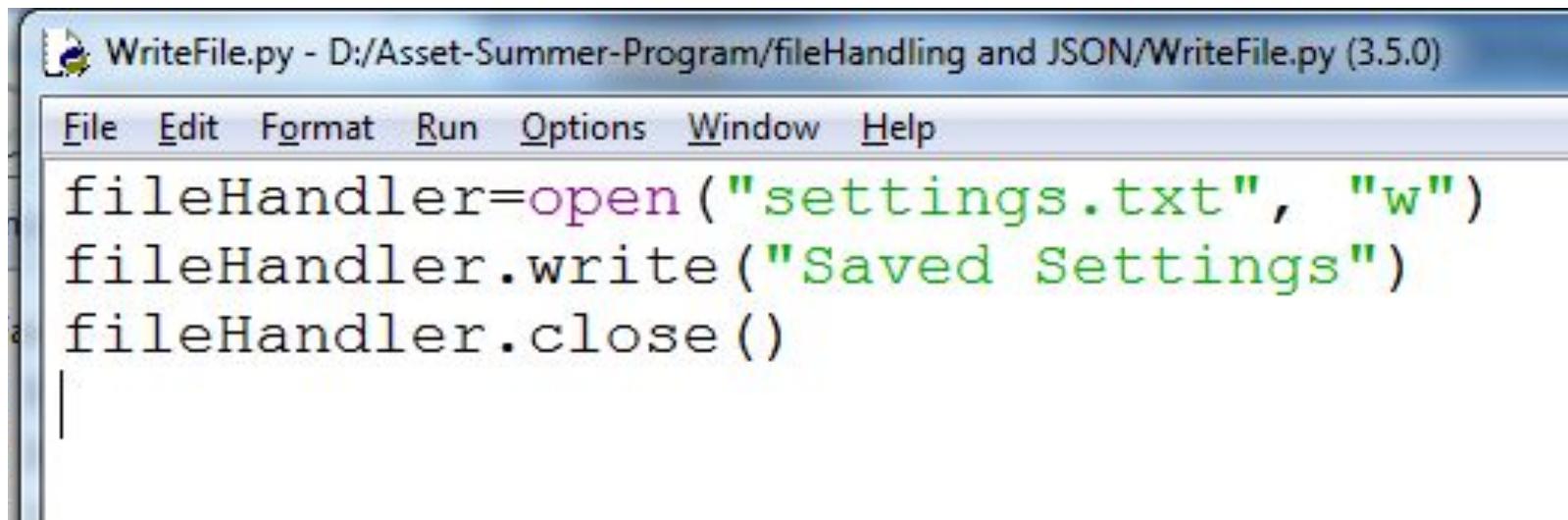
Computer > Local Disk (D:) > Asset-Summer-Program

Organize	Open	Include in library	Share with	New folder
Favorites	Name	Date modified	Type	
Desktop	3D Designs	21-02-2018 05:23	File folder	
Downloads	generateRandomText.py	20-02-2018 07:17	Python File	
Recent Places	musicStatistics.json	22-02-2018 01:31	JSON File	
Libraries	passwordFile.txt	20-02-2018 07:23	Text Document	
Documents	python_cheat_sheet.pdf	12-04-2018 12:42	Adobe Acrobat Document	
Music	README.md	20-02-2018 07:18	MD File	
Pictures	SimpleJSONParser.py	12-04-2018 01:22	Python File	
	testhashing.py	20-02-2018 07:06	Python File	

Local Disk (D:) > Asset-Summer-Program > 3D Designs

Organize	Include in library	Share with	New folder
Favorites	Name	Date modified	Type
Desktop	Camera Mount RPI.stl	21-02-2018 05:23	STL File
Downloads	Camera Mount.123dx	21-02-2018 05:30	Autodesk 123 File
Recent Places	Camera Mount.stl	21-02-2018 05:22	STL File

Writing to Files



WriteFile.py - D:/Asset-Summer-Program/fileHandling and JSON/WriteFile.py (3.5.0)

File Edit Format Run Options Window Help

```
fileHandler=open("settings.txt", "w")
fileHandler.write("Saved Settings")
fileHandler.close()
```

Writing JSON to file

- You can write a json string to file using the file writing method.
- You can also create a Python Object, assign properties to it, and then write that object to file.

Session 15

Machine Vision with Amazon Rekognition

Layout for the Session

- Key concepts in Machine Vision
- Introduction to the Raspberry Pi Camera
- Introduction to Amazon Rekognition
- Configure the Amazon CLI
- Install Boto3 Library, run a test program.

Why are we learning this?

- Understand how computers can extract information from images.
- How we can interface the Raspberry Pi with a camera and extract images from it.
- How the Amazon Rekognition Cloud service be used to extract information from images.
- Understand how to use the Boto3 library to talk to Amazon Rekognition.

How does a computer recognise images?

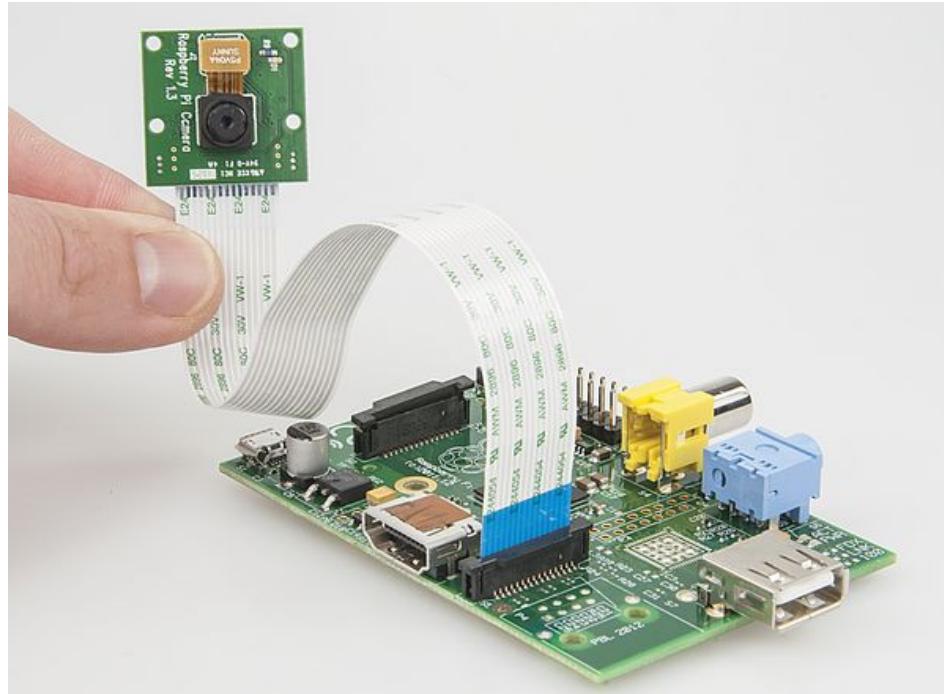
- It initially does simple image operation.
 - It will first reduce the resolution of the image, to speed up processing time.
 - It may convert the image to grayscale, and ignore the color information
 - It may do operations like edge detection, then try to find out features by shape.
 - It may do a process called convolution.
 - It may do pattern matching.
- Post conversion it applies an algorithm to find out features in the image.

Use case: Find out a circle in an image

- How do we do it?
- What kind of properties of a circle can you use to find out a circle?
- Looking for an easier way?
- Assumptions

Introduction to the Raspberry Pi Camera

- The Raspberry Pi has a Camera Serial Interface (CSI) on which a camera can be connected.
- This camera is a 5MP color camera, and can be used to capture both photos and videos.
- It can also be used to capture timelapses.



Protecting the Raspberry Pi Camera

- The Raspberry Pi Camera is a delicate device
- A 3D Printed enclosure for the camera is provided, which should be used
- Let us fit the camera inside this case, fit the screws, and tighten them



The right way to connect the camera

<https://www.youtube.com/watch?v=DosQ0V39WAA>

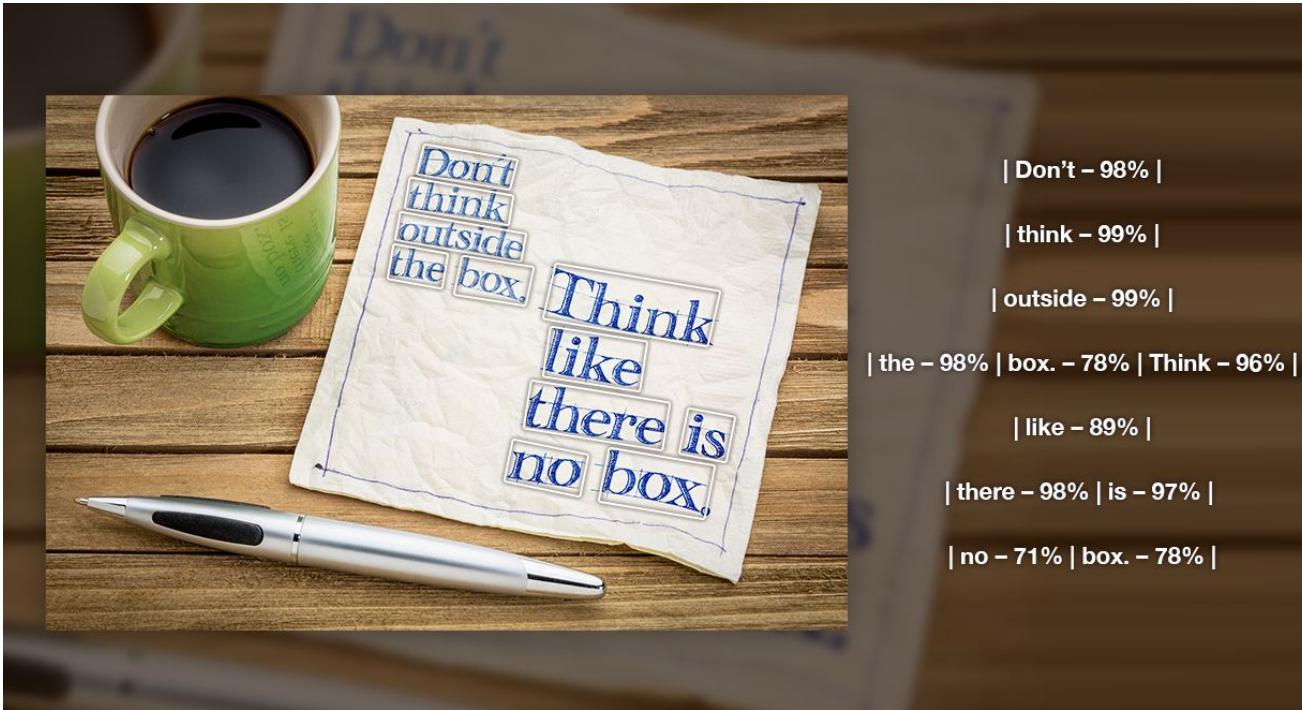
<https://thepihut.com/blogs/raspberry-pi-tutorials/16021420-how-to-install-use-the-raspberry-pi-camera>



Introduction to Amazon Rekognition

- Amazon Rekognition makes it easy to add image and video analysis to your applications.
- You just provide an image or video to the Rekognition API, and the service can identify the objects, people, text, scenes, and activities
- Amazon Rekognition also provides highly accurate facial analysis and facial recognition.
- You can detect, analyze, and compare faces for a wide variety of user verification, cataloging, people counting, and public safety use cases.

Read Text



| Don't – 98% |

| think – 99% |

| outside – 99% |

| the – 98% | box. – 78% | Think – 96% |

| like – 89% |

| there – 98% | is – 97% |

| no – 71% | box. – 78% |

Person Tracking



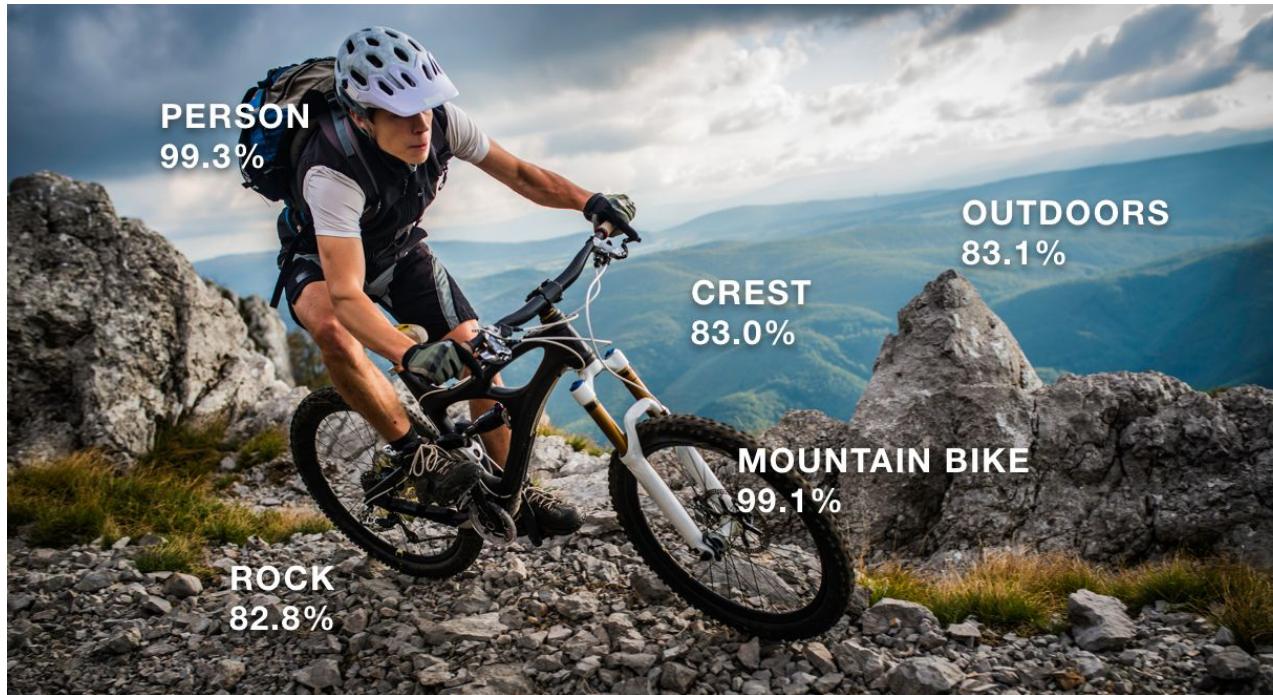
Facial Analysis



Facial Recognition



Object Scene and Activity



Getting Started with Amazon Rekognition

- You need to create an Amazon Developer Account
- Use of Amazon Rekognition is free for upto 5000 images per month.
- You need a credit card added to the Amazon system for your account to be activated.
- We will use the Amazon account created by CuriosityGym to make our requests for Image Recognition.
- To not share our password, we have created a Secret ID and Secret Key.
- I will share with you secret Keys and ID via email. Each participant is expected to have their own keys and ID.

Amazon CLI

- Amazon provides a Command Line Interface (CLI) which allows you to enter the Secret ID and Password for the account.
- These are securely stored in the operating system, away from prying eyes.
- Never have these keys in code, and in plain text.
- On the Raspberry Pi, you can install the Amazon CLI using the following command
 - *pip install awscli --upgrade --user*

Add Amazon Credentials to the Raspberry Pi

- I would need to add your names to Amazon Account, so all of you can use the Amazon Rekognition service.
- Let us do that in sequence.
- Once I have them added, I can send you your ID and Secret, which we can add to the Raspberry Pi.

```
$ aws configure
AWS Access Key ID [None]: AKIAIOSFODNN7EXAMPLE
AWS Secret Access Key [None]: wJaLrXUtnFEMI/K7MDENG/bPxRfCYEXAMPLEKEY
Default region name [None]: us-west-2
Default output format [None]: json
```

Install Boto3 Library

- The Boto3 Library allows simplified access to Amazon Rekognition.
- Install the Boto3 Library using the command

sudo pip3 install boto3

Test Program to Validate Setup

- Let us build a program using online documentation
- Documentation can be accessed here (search for “amazon rekognition boto3”)

<http://boto3.readthedocs.io/en/latest/reference/services/rekognition.html>

Session 16

Boto3 Deep Dive

Layout for the Session

- Boto3 Functions and Interfaces
- Integrate Raspberry Pi Camera and Boto3
- Parsing JSON received from Amazon Rekognition
- Discussion on Projects that require image recognition

Why are we learning this?

- Understand all features of the Boto3 Library
- Understand how can errors be handled in rekognition.
- Plan project on how it will handle Amazon Rekognition

Session 17

Apple or Pineapple? You tell me!

Layout for the Session

- Given an Apple or a Pineapple, determine which it is.
- Extend example to 5 more common objects.
- Look outside to find them.
- Make a story why you chose that object

Why are we learning this?

- Build an application to determine between an apple and a pineapple.
- Extend the example to 5 different objects.
- Suggest and write a short description on why the 5 objects were chosen.

Session 18

Open Design Session

Layout for the Session

- Start documenting the progress of the project
- Understand what are the practical needs of the problem and address those.
- Start building communication between the Arduino and Raspberry Pi, if any
- Design, paint and make something look presentable

Session 19-25

Project Tune-Up, Documentation and Presentations