Internet of Things

Uldis Žaimis

Tashkent, Uzbekistan, 15-19 May 2023

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Lecture and workshop plan

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Lecture and workshop plan

→ IoT principles and paradigms

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Lecture and workshop plan

IoT principles and paradigms

→ IoT components

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Lecture and workshop plan

IoT principles and paradigms
IoT components
→ some examples of IoT applications

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Lecture and workshop plan

IoT principles and paradigms
IoT components
some examples of IoT applications
→ some examples of digital sensor and signal transmission applications

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Lecture and workshop plan

IoT principles and paradigms
IoT components
some examples of IoT applications
some examples of digital sensor and signal transmission applications
→ some examples of analog sensor and signal transmission applications

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Lecture and workshop plan

IoT principles and paradigms
IoT components
some examples of IoT applications
some examples of digital sensor and signal transmission applications
some examples of analog sensor and signal transmission applications
→ some examples of actuator applications

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Lecture and workshop plan

IoT principles and paradigms
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some examples of IoT applications
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some examples of analog sensor and signal transmission applications
some examples of actuator applications
→ data transmission protocols

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Lecture and workshop plan

IoT principles and paradigms
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some examples of IoT applications
some examples of digital sensor and signal transmission applications
some examples of analog sensor and signal transmission applications
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data transmission protocols

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IoT principles and paradigms



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IoT principles and paradigms



1. Ability to collect, integrate, analyze and visualize continuous data streams in real time

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IoT principles and paradigms

2. Scalable, highly available, fault-tolerant architecture

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IoT principles and paradigms



3. It promises to make any electronic devices a part of the Internet environment

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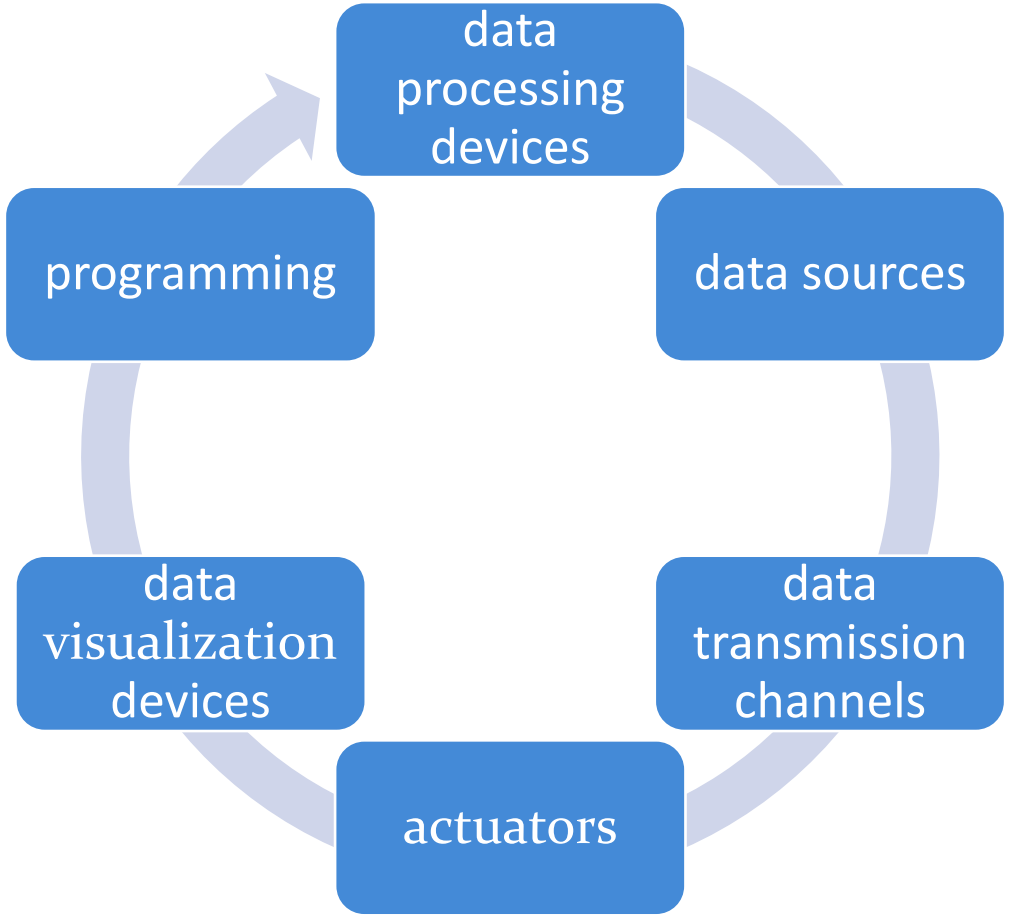
IoT components



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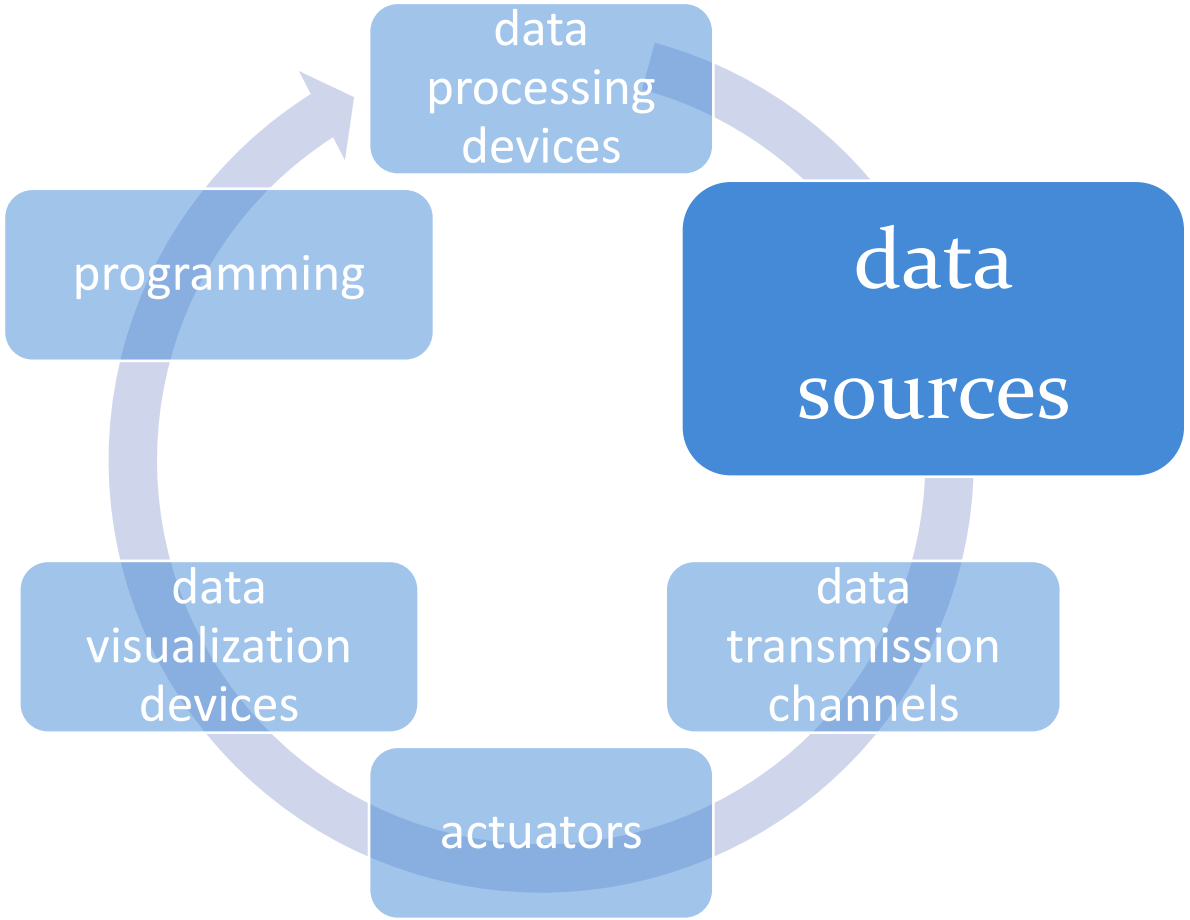
IoT components



Analog sensors – resistive (light, temperature, gas, pressure, force, motion, position, etc.), capacitive (electric field, humidity, etc.), inductive (magnetic field), voltage sensors etc.

Digital sensors – buttons, all types of sensors with pre-processing, ultrasonic, LIDAR, photo-interrupters, photo/video cameras, GPS receivers, etc.

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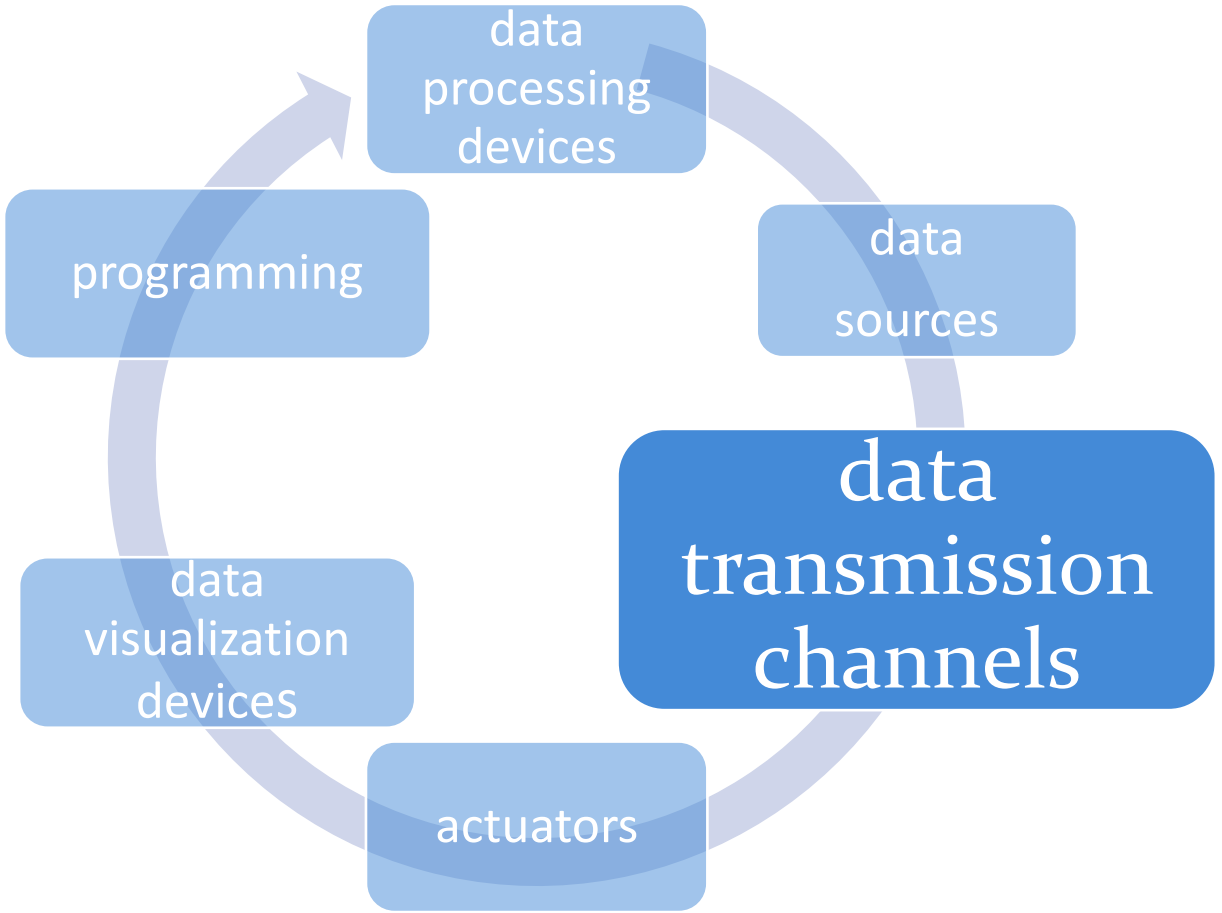
IoT components



Wired connections
Bluetooth
WiFi
RF
LoRa
ZigBee
etc.

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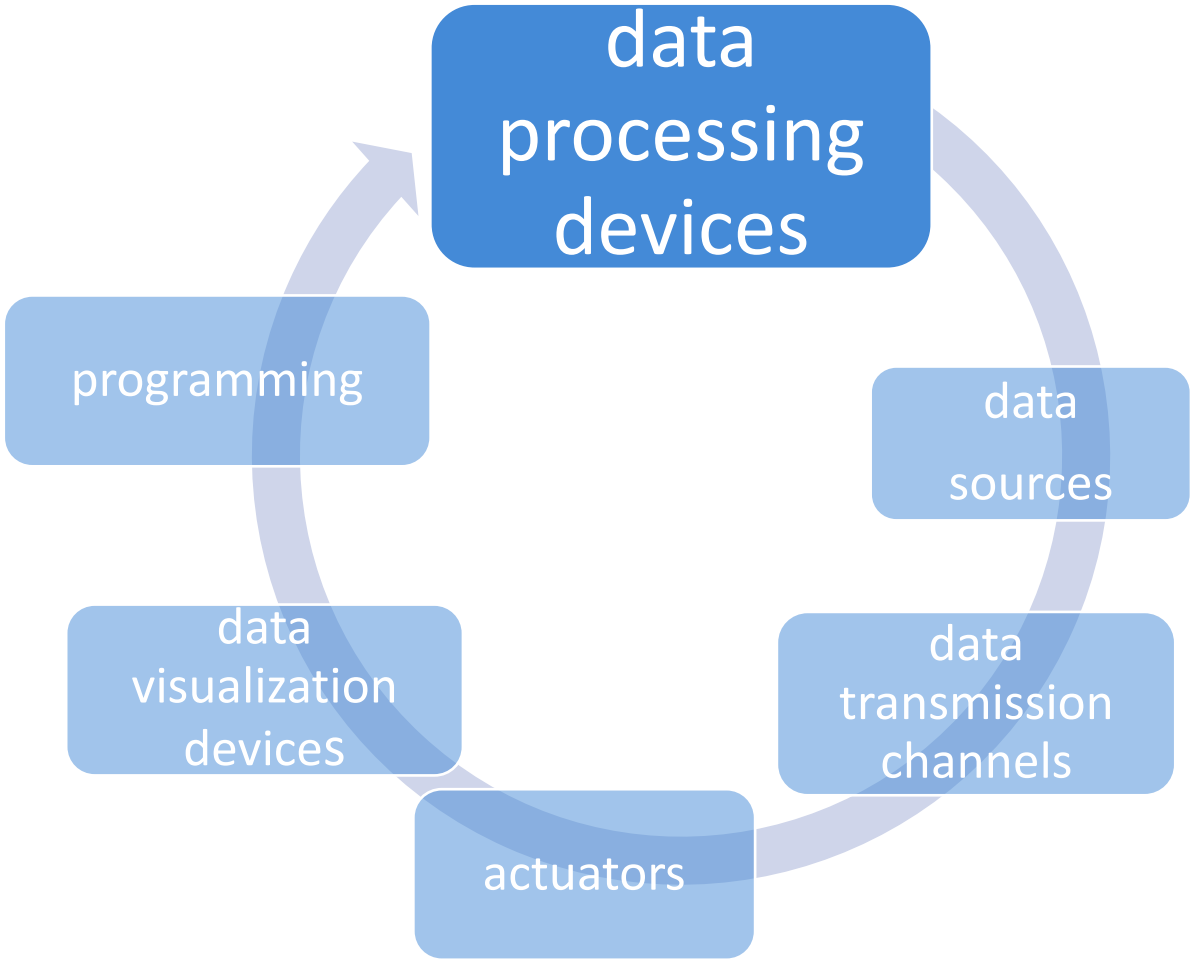
IoT components



Programmable microcontrollers
Arduino, ESP, STM32, etc.

Programmable industrial controllers (PLC) Siemens, Wago, Mitsubishi, etc.

Microcomputers
Raspberry Pi and variations (Banana Pi etc.)

OS based **computers**

Cloud based **executable files**

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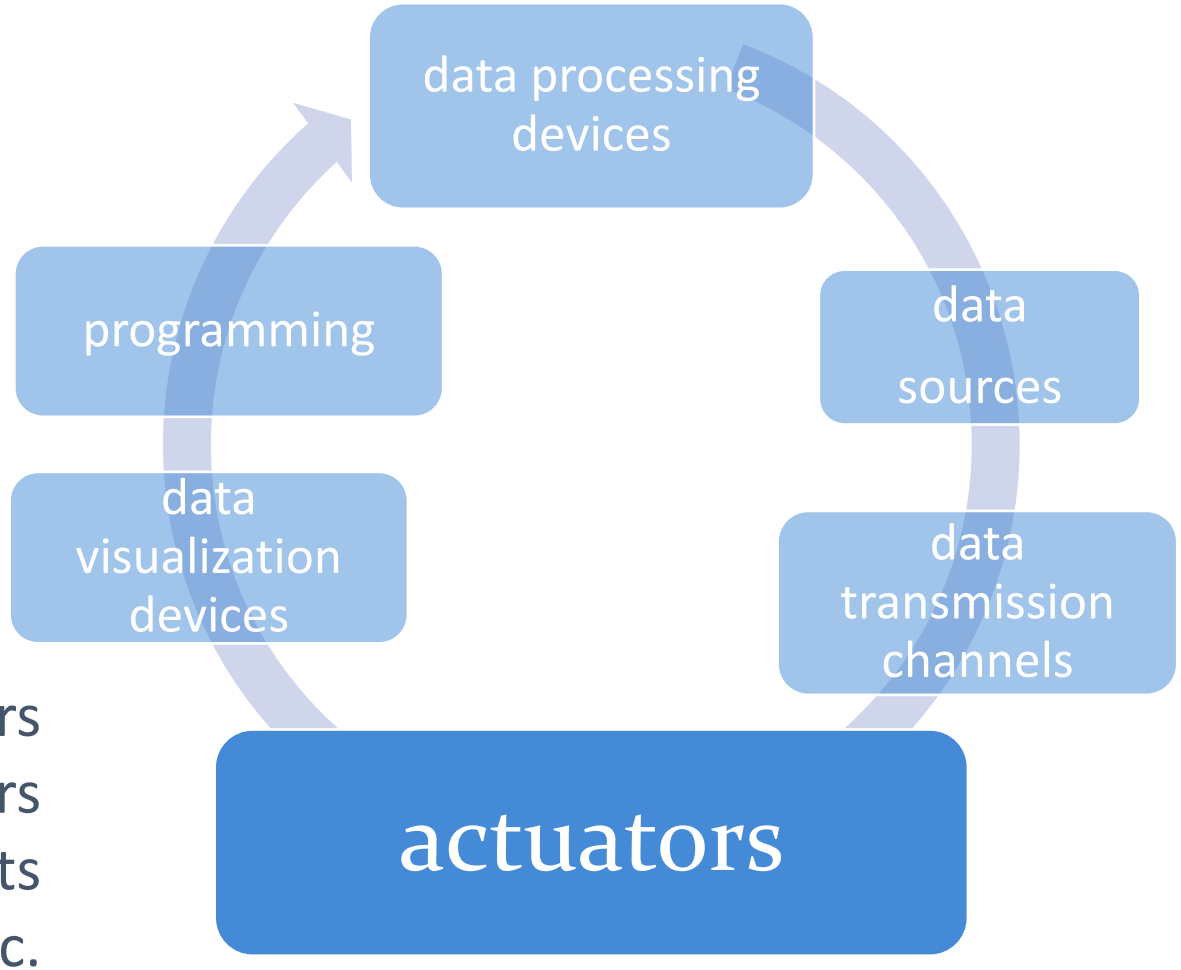
IoT components



Motors – DC, AC, steppers
Heaters, coolers
Lights
etc.

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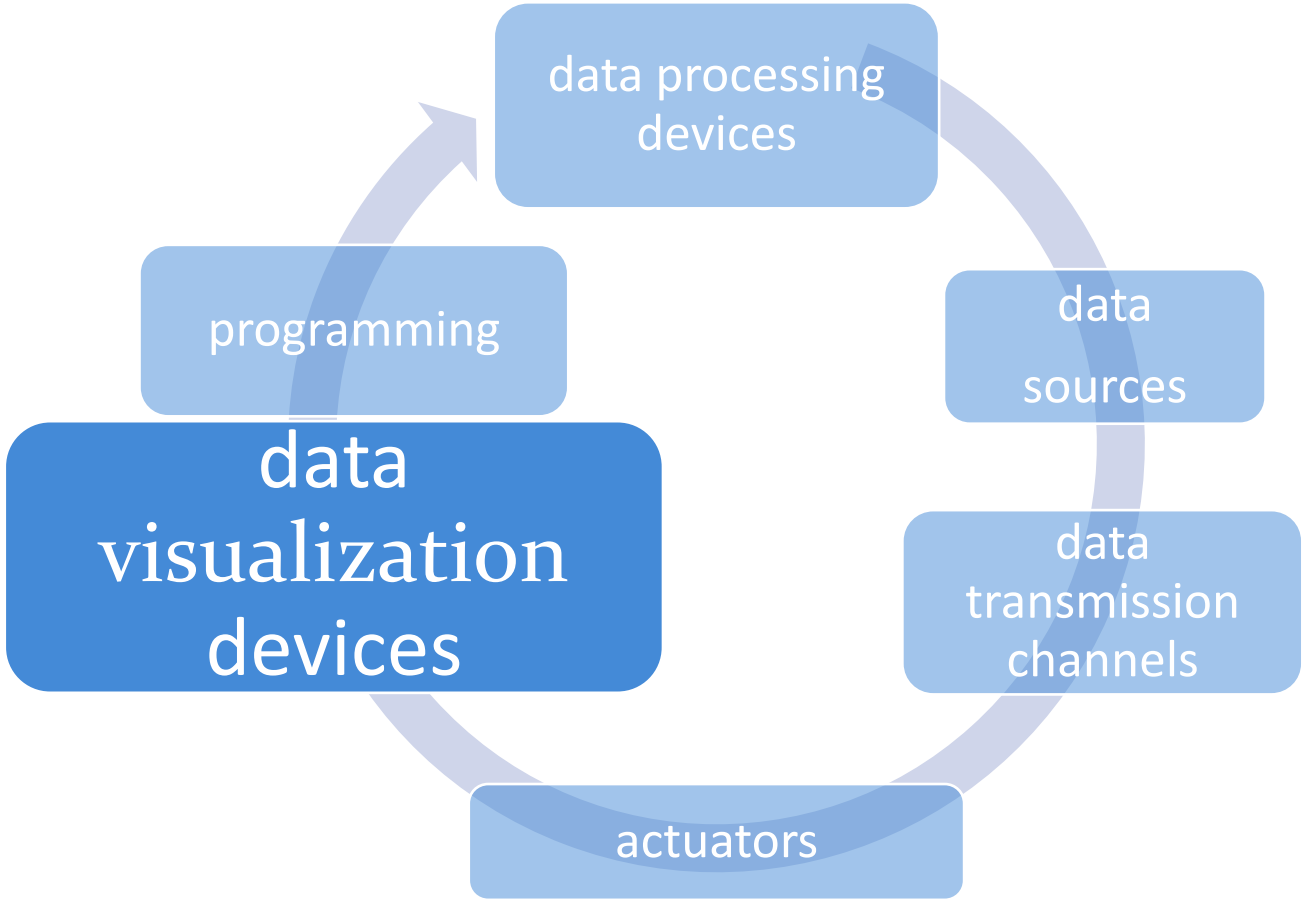
IoT components

Numerical visualization
Colorized 2D, 3D graphs
LED`s, LED strips
Displays
Lights
etc.



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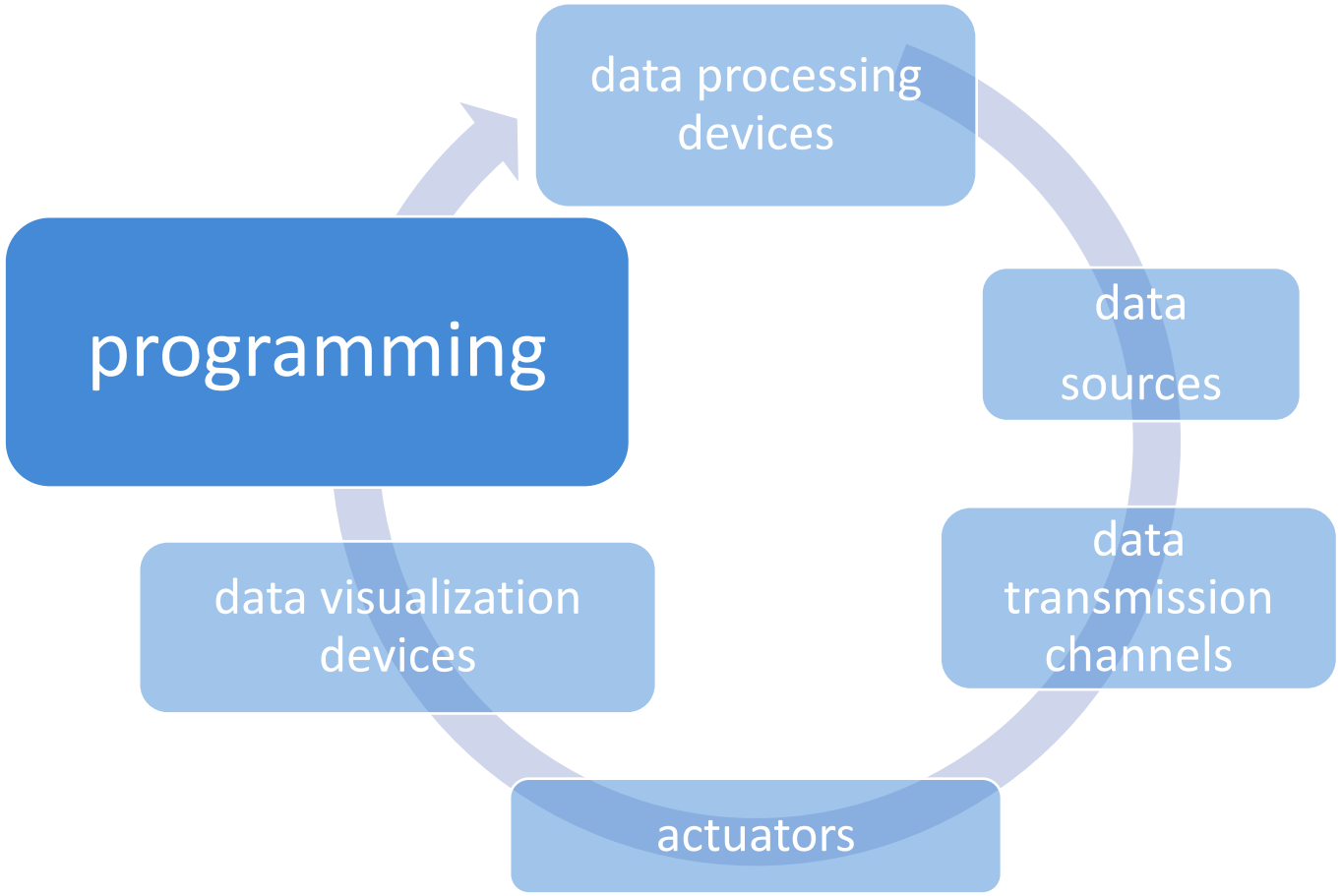
IoT components

1. Algorithm
2. Coding in:

C, C++, C#
Python
Assembler
etc.



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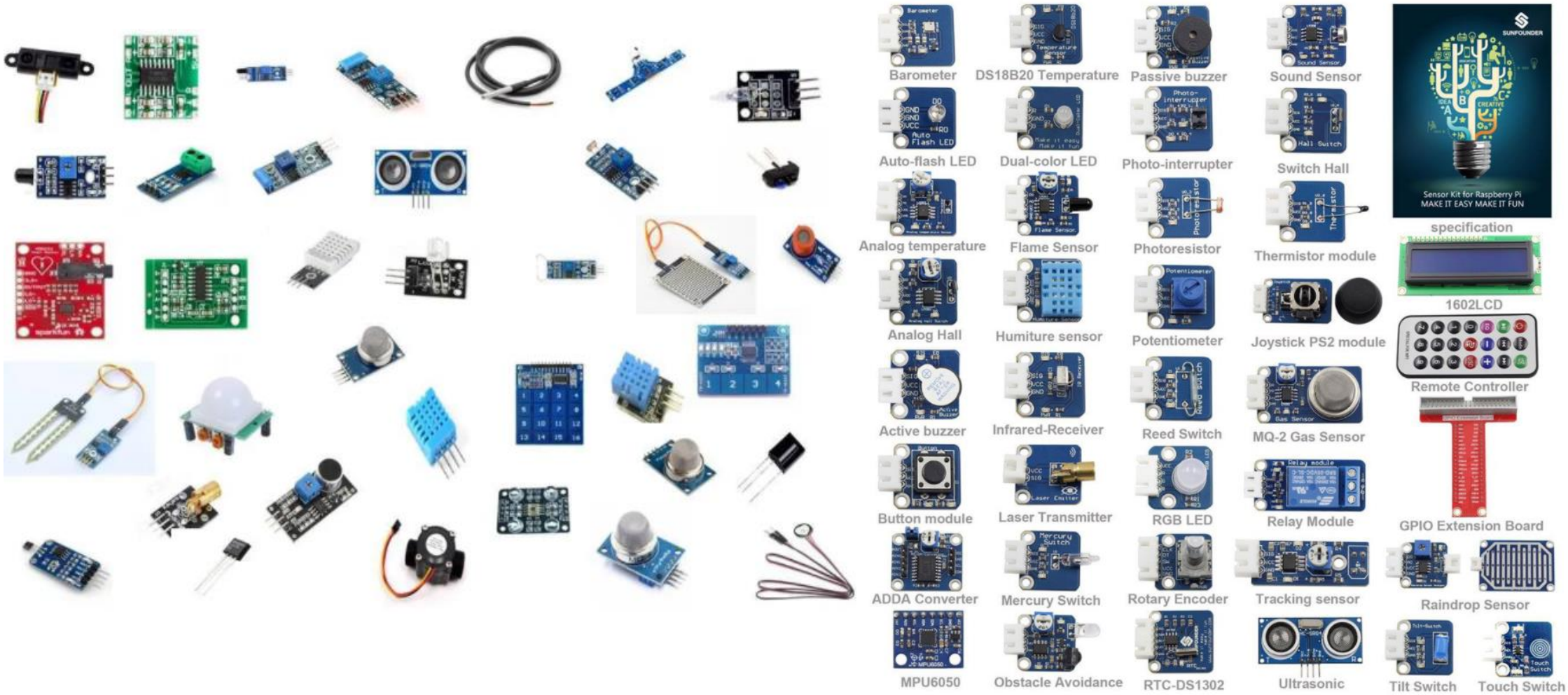
Data sources - sensors



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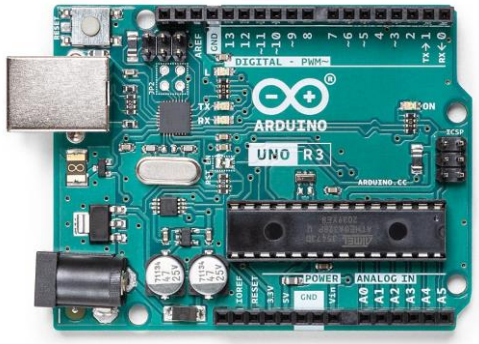
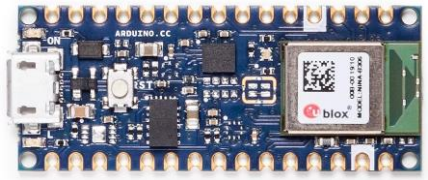
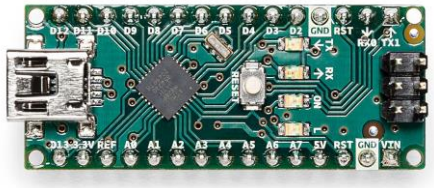
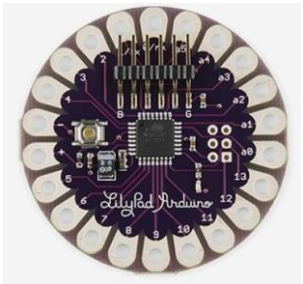
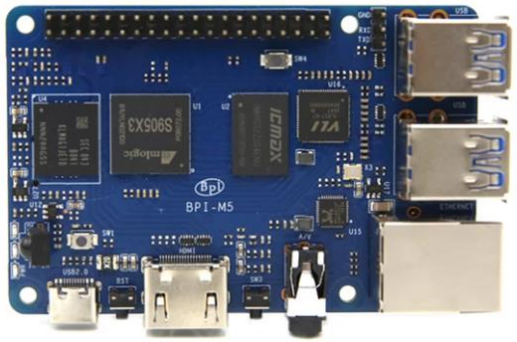
Data processing devices: microcontrollers and microcomputers











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Example of IoT application

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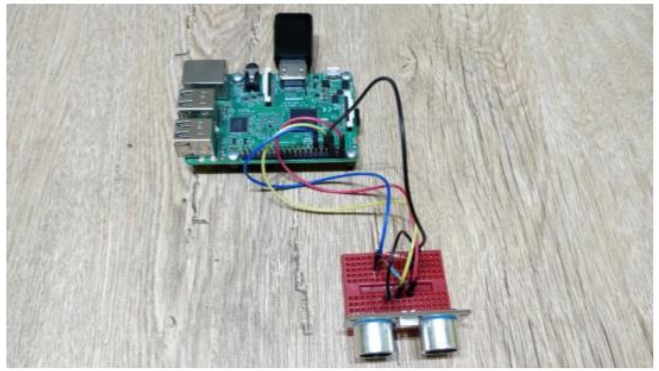
IoT system to identify road pits and to determine the precise technological mass of hot asphalt concrete



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IoT system to identify road pits and to determine the precise technological mass of hot asphalt concrete

Development tools:

data storage

Arduino, Raspberry Pi or computer

programming language Python

data processing

data visualisation

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IoT system to identify road pits and to determine the precise technological mass of hot asphalt concrete

A worker, a self-propelled robot or a drone can be used as a sensor carrier

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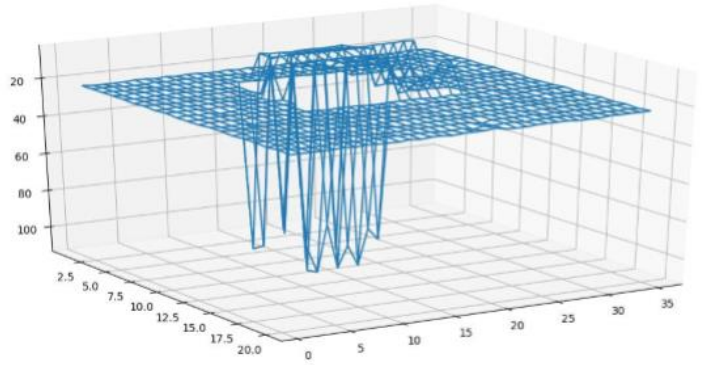
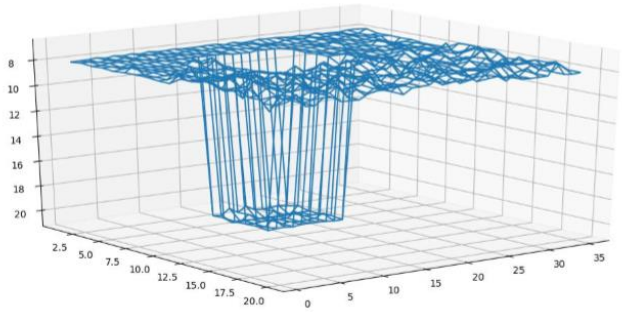
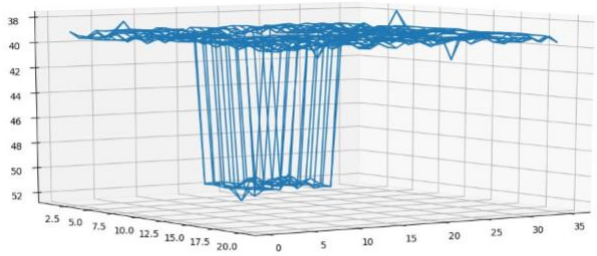
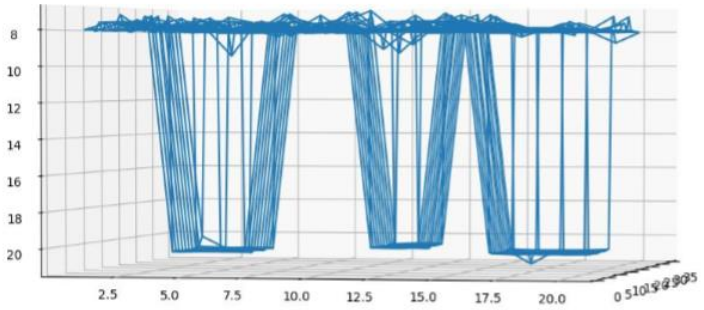
IoT system to identify road pits and to determine the precise technological mass of hot asphalt concrete

Resolution of images is less than 1 cm









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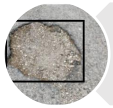
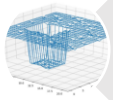
IoT system to identify road pits and to determine the precise technological mass of hot asphalt concrete

Algorithm for calculating the volume of pits

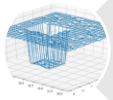


Determine which file's data array is subject to further processing

Determine min and max values



Measurements are sliced down into layers, taking into account the one step (1 cm)



The pit binary image is created

Calculate the volume

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Acquisition and transmission of digital data

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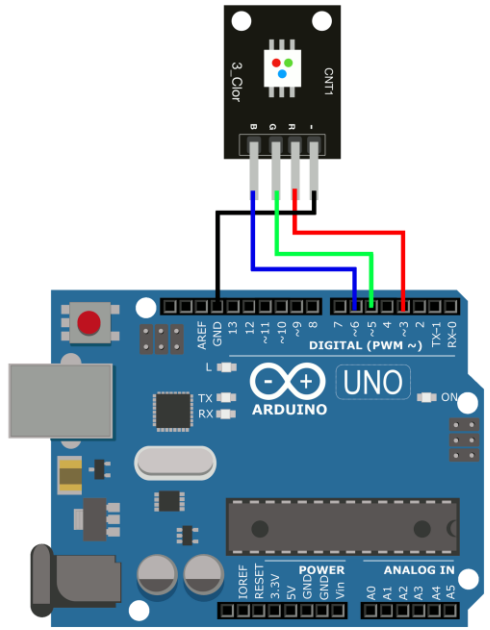
Task 1

Create an Arduino circuit with an LED that turns on / off alternately every 1 second

```
const int PIN = 3;

void setup() {
pinMode(PIN, OUTPUT); // define 3 pin as output
}

void loop() {
digitalWrite(PIN, HIGH);    // LED on
delay(1000);    // 1 sec.
digitalWrite(PIN, LOW);    // LED off
delay(1000);    // 1 sec.
}
```



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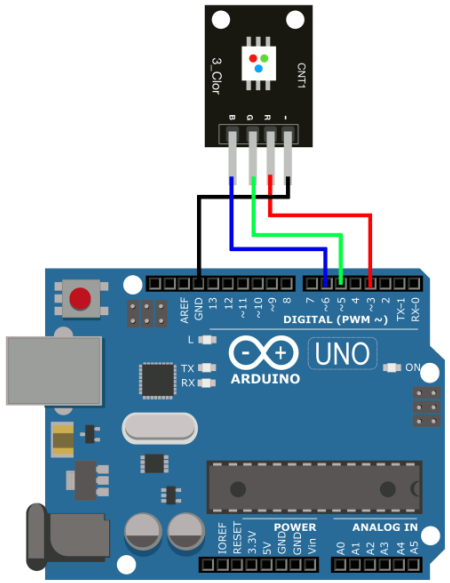
Task 2

Create an Arduino circuit with 3 color LEDs that work in traffic light mode



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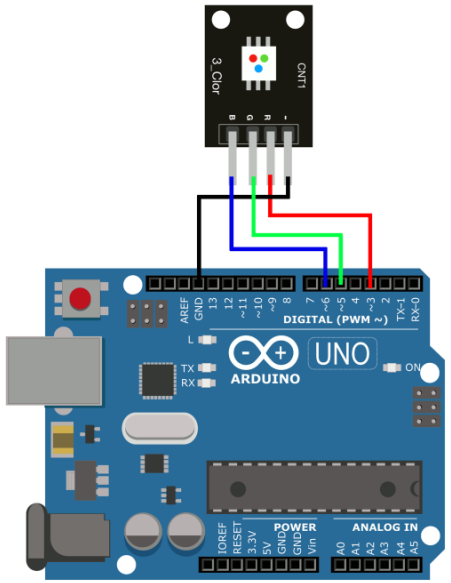
Task 2

Create an Arduino circuit with 3 color LEDs that work in traffic light mode

```
void setup() {
Serial.begin(9600);
pinMode(3, OUTPUT);   // red
pinMode(5, OUTPUT);   // yellow
pinMode(6, OUTPUT);   // green
}

void loop() {
digitalWrite(3, HIGH);   // red on
delay(3000);             // waits 3 seconds
digitalWrite(3, LOW);    // red off
digitalWrite(5, HIGH);
delay(1000);
digitalWrite(5, LOW);
digitalWrite(6, HIGH);
delay(3000);
digitalWrite(6, LOW);
}
```



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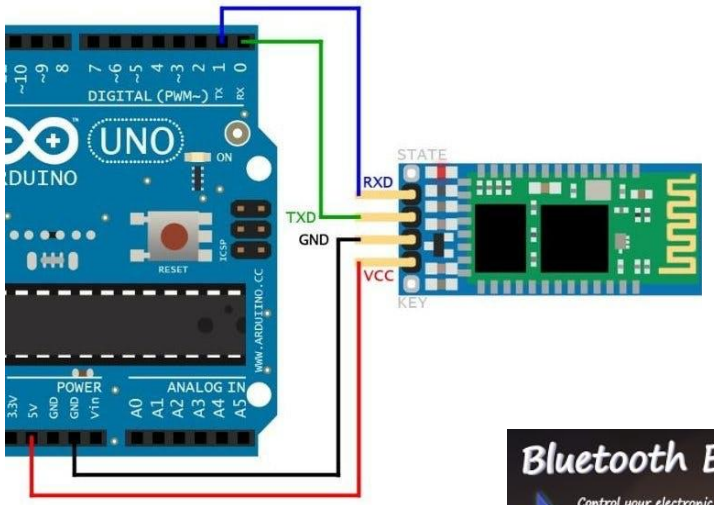
Task 3

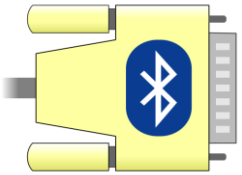
Output information via serial port

```
int k = 0;

void setup() {
Serial.begin(9600);    // inicialize serial port
Serial.print("Hello, world!");
}

void loop() {
k++;    // k = k+1
Serial.println(k);
delay(500);
}
```





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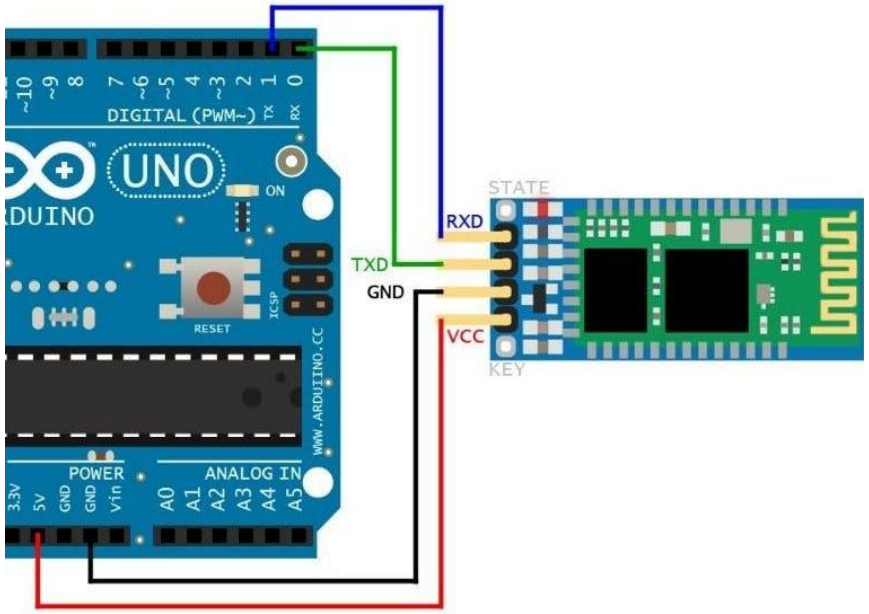
Task 4

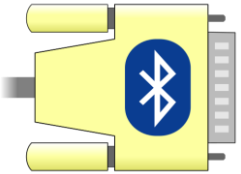
Input information via serial port from monitor or Android application

```
char k;    // int k;

void setup() {
Serial.begin(9600);
}

void loop() {
if(Serial.available() > 0){
   k = Serial.read();
   Serial.println(k);
}
}
```





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Task 5

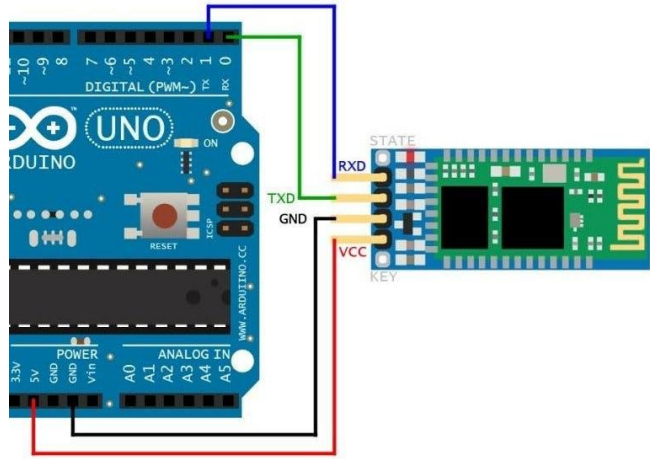
Create a circuit, algorithm and program for turning on the 3-color LED, switching each color from the serial port, where:

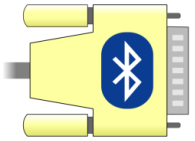
RED only is turned on by entering "1"

GREEN only - by entering «2»

BLUE only - by entering «3»

all lights go out by entering "0"





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Acquisition and transmission of analog data

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Task 6

Create an Arduino circuit with a light sensor module; get readings (data) in 3 formats:

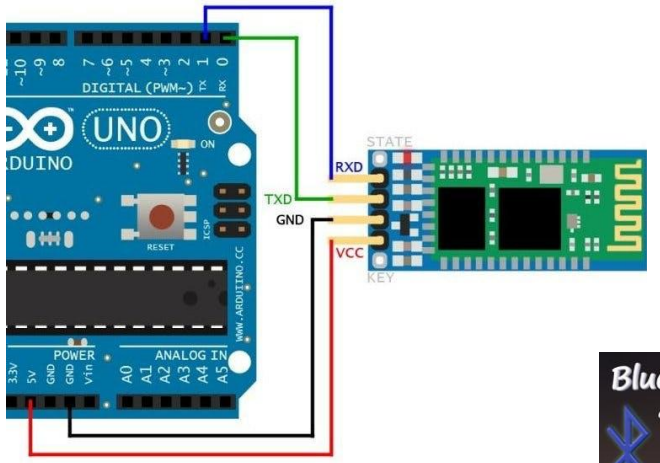
read level number;

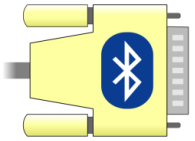
level on the scale (0...100)% value;

level with floating point (decimal number) from 0 to 20, unit

create a graph for one of the formats

transfer data to a tablet or smartphone





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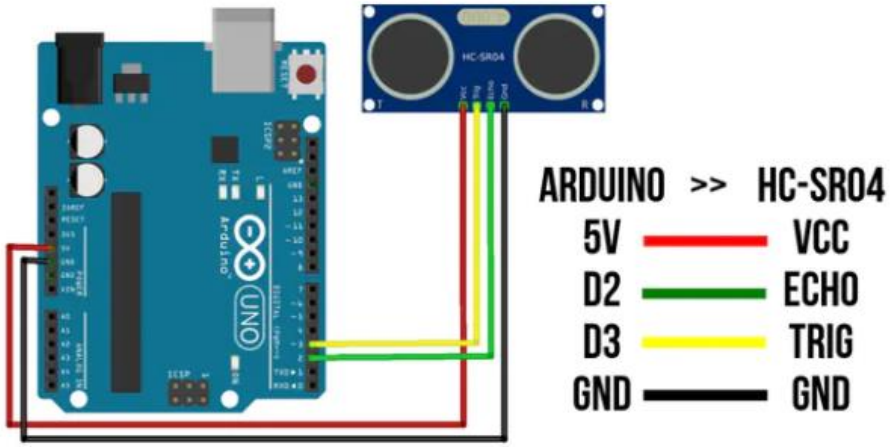
Task 7

Create an Arduino connection with the ultrasonic distance sensor HC-SR04

```
#define echoPin 2 // attach pin D2 Arduino to pin Echo of HC-SR04
#define trigPin 3 //attach pin D3 Arduino to pin Trig of HC-SR04
long duration; // variable for the duration of sound wave travel
int distance; // variable for the distance measurement

void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  Serial.begin(9600);
}
void loop() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = duration * 0.034/2;
  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");
}
```



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Application of some actuators

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Task 8

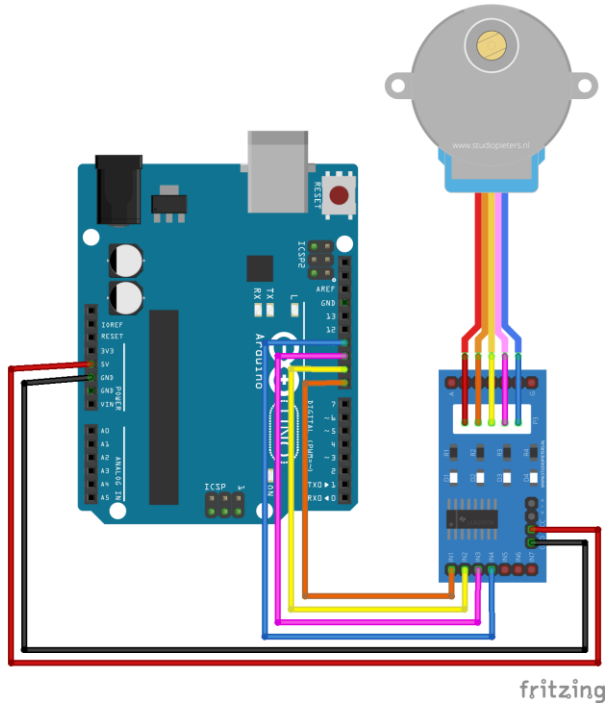
Create an Arduino circuit with a stepper motor

```
#include <Stepper.h>

const int stepsPerRevolution = 200;
Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);

void setup() {
  myStepper.setSpeed(60);  // set the speed at 60 rpm:
  Serial.begin(9600);
}

void loop() {
  Serial.println("clockwise");
  myStepper.step(stepsPerRevolution);
  delay(500);
  Serial.println("counterclockwise");
  myStepper.step(-stepsPerRevolution);
  delay(500);
}
```



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Task 9

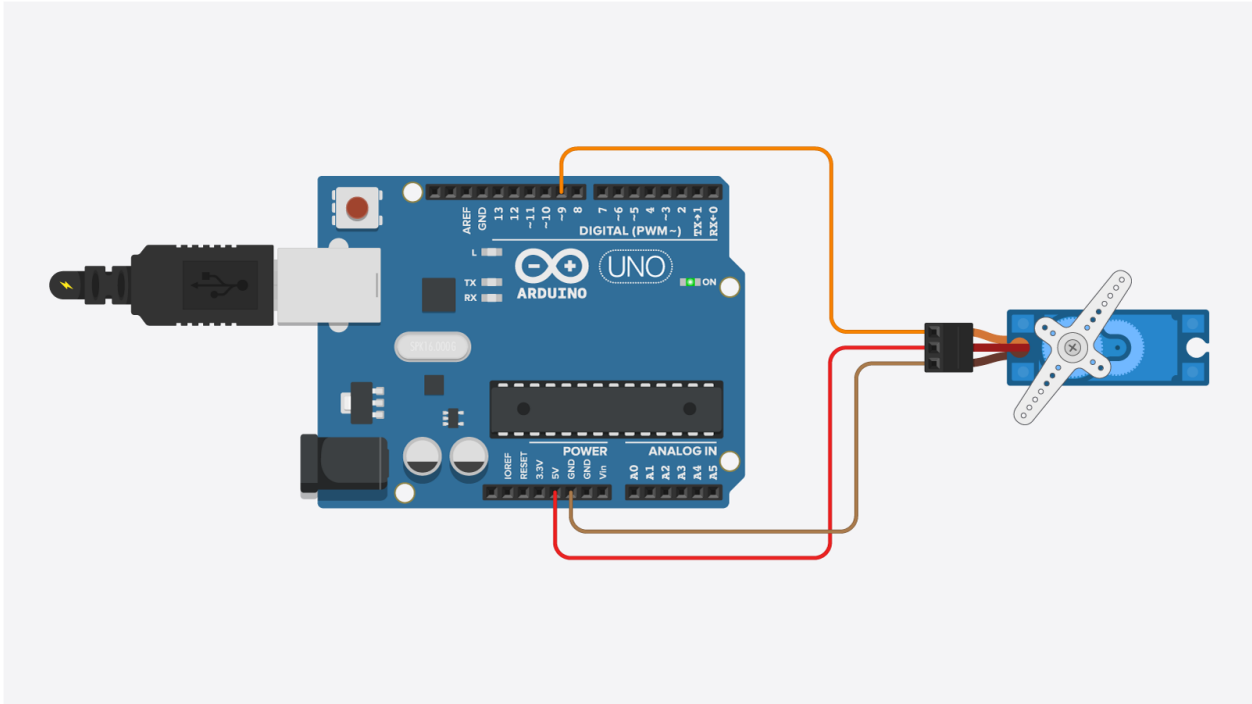
1. Create an Arduino circuit with a servo motor
2. Achieve smooth LED on/off

```
#include <Servo.h>
Servo myservo;
#define servoPin 9
int angle = 0;

void setup() {
  myservo.attach(servoPin);
}

void loop() {
  myservo.write(90);
  delay(1000);
  myservo.write(180);
  delay(1000);
  myservo.write(0);
  delay(1000);

  for (angle = 0; angle <= 180; angle += 1) {
    myservo.write(angle);
    delay(15);}
  for (angle = 180; angle >= 0; angle -= 1) {
    myservo.write(angle);
    delay(30);}
  delay(1000);
}
```



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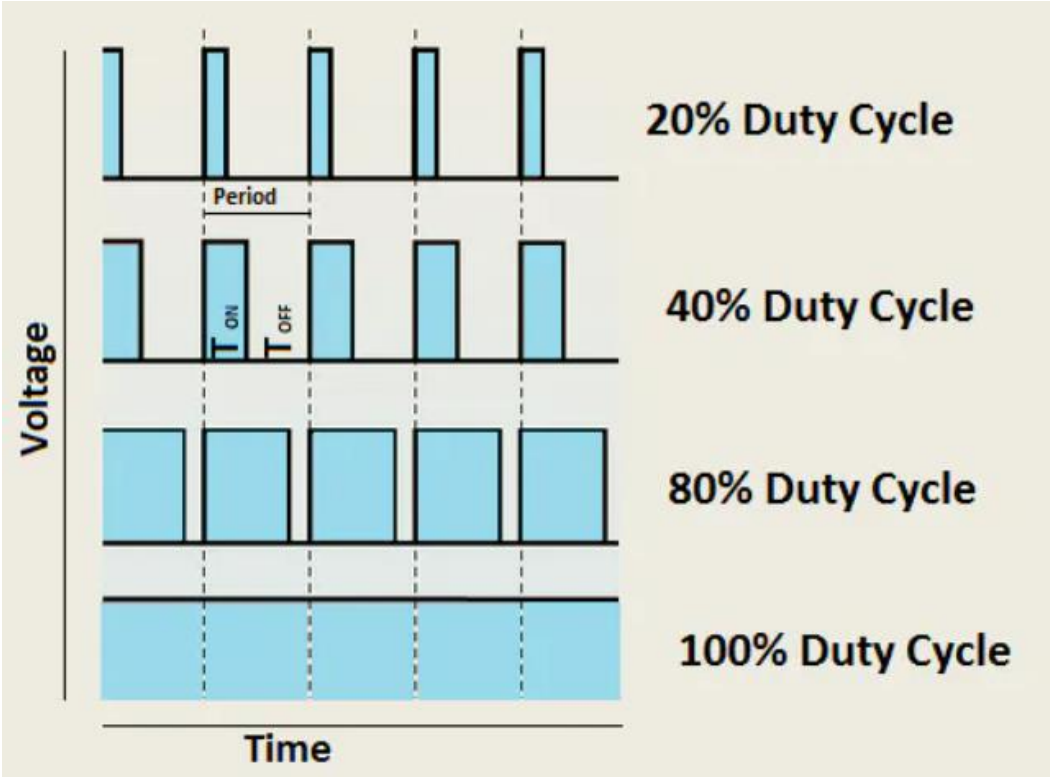
Task 10

1. Create an Arduino UNO circuit with LED PWM output (3,5,6,9,10,11)
2. Achieve smooth LED on / off

```
void setup() {
pinMode(5, OUTPUT);
}

void loop() {
for(int i=0;i<=255;i++){
  analogWrite(5, i);delay(10);}
for(int i=255;i>=0;i--){
  analogWrite(5, i);delay(10);}
}
```



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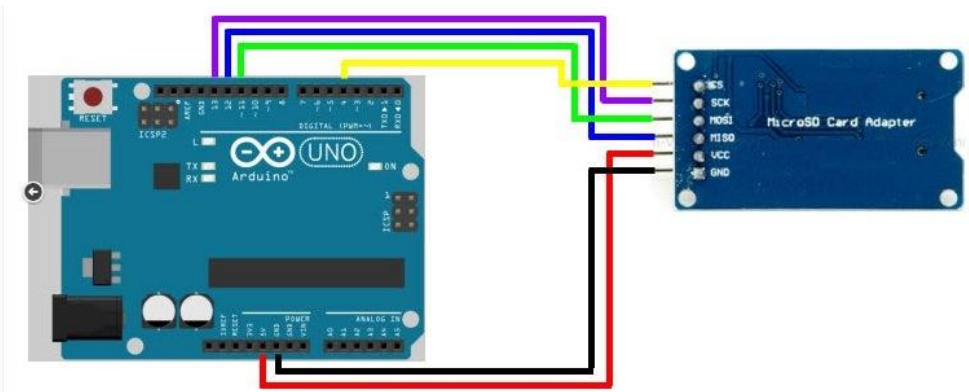
Task 11

1. Create an Arduino UNO connection with a light sensor and a memory card (SD) module
2. Open the saved data in MS Excel, get a graph




```
#include <SPI.h>
#include <SD.h>
const int chipSelect = 4;
int light;
void setup(){
  Serial.begin(9600);
  if (!SD.begin(chipSelect)) {
    Serial.println("SD card error!");
    return;}
    Serial.println("SD card found!");
    delay(1000);
   }
void loop(){
  light = analogRead(A0);
  File file = SD.open("Light.txt", FILE_WRITE);
  if (file) {
    file.println(light);
    file.close();
    Serial.println(light);}
  else {
    Serial.println("Unable to open file File.txt");}
  delay (1000);
  }
```

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Data transmission protocols

	I2C protocol	SPI protocol	UART protocol
	Inter-Integrated Circuit	Serial Peripheral Interface	Universal Asynchronous Receiver/Transmitter
synchr/asynchr	synchronous	synchronous	asynchronous
communication	serial	serial	serial
# of wires	2	4	2
max speed	up to 5 Mbps	up to 10 Mbps	up to 115200 baud
# of Masters	unlimited	1	1
# of Slaves	1008	unlimited*	1

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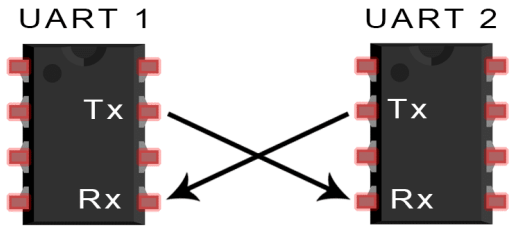
Data transmission protocols



	UART protocol
	Universal Asynchronous Receiver/Transmitter
synchr/asynchr	asynchronous
communication	serial
# of wires	2
max speed	up to 115200 baud
# of Masters	1
# of Slaves	1

ADVANTAGES	DISADVANTAGES
Only uses two wires	The size of the data frame is limited to a maximum of 9 bits
No clock signal is necessary	Doesn't support multiple slave or multiple master systems
Has a parity bit to allow for error checking	The baud rates of each UART must be within 10% of each other
The structure of the data packet can be changed as long as both sides are set up for it	
Well documented and widely used method	

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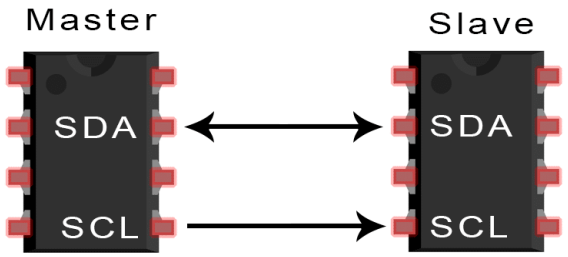
Data transmission protocols



	I2C protocol
	Inter-Integrated Circuit
synchr/asynchr	synchronous
communication	serial
# of wires	2
max speed	up to 5 Mbps
# of Masters	unlimited
# of Slaves	1008

ADVANTAGES	DISADVANTAGES
Only uses two wires	Slower data transfer rate than SPI
Supports multiple masters and multiple slaves	The size of the data frame is limited to 8 bits
ACK/NACK bit gives confirmation that each frame is transferred successfully	More complicated hardware needed to implement than SPI
Hardware is less complicated than with UARTs	
Well known and widely used protocol	

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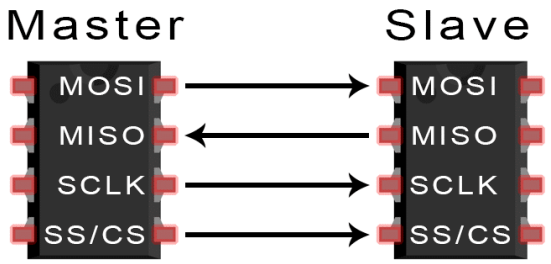
Data transmission protocols



	SPI protocol
	Serial Peripheral Interface
synchr/asynchr	synchronous
communication	serial
# of wires	4
max speed	up to 10 Mbps
# of Masters	1
# of Slaves	unlimited*

ADVANTAGES	DISADVANTAGES
No start and stop bits, so the data can be streamed continuously without interruption	Uses four wires (I2C and UARTs use two)
No complicated slave addressing system like I2C	No acknowledgement that the data has been successfully received (I2C has this)
Higher data transfer rate than I2C (almost twice as fast)	No form of error checking like the parity bit in UART
Separate MISO and MOSI lines, so data can be sent and received at the same time	Only allows for a single master

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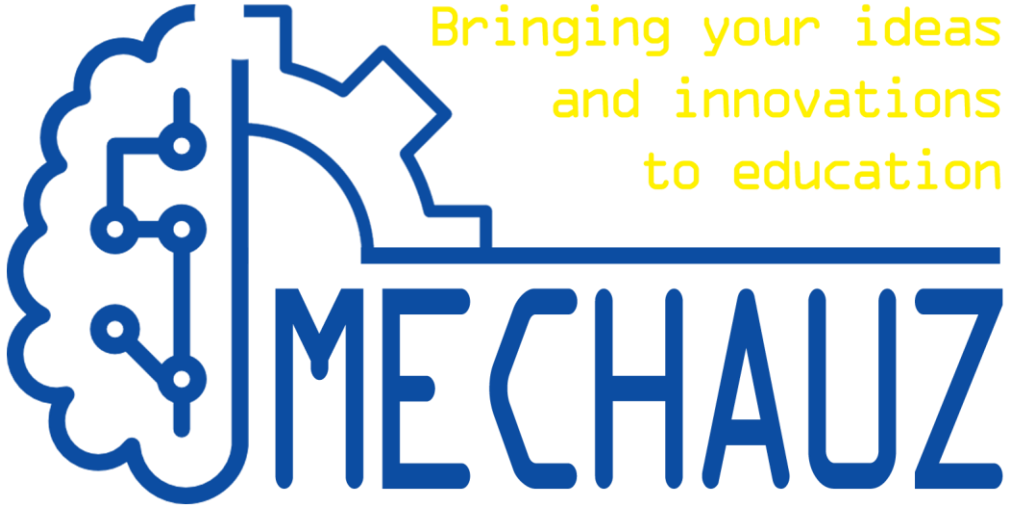

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FOR YOUR ATTENTION

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