Why sensors?

Smart cities, smart homes, smart streetlights, smart parking, smart irrigation, smart health monitoring... and the list goes on! "Smart System" is the new buzzword! One might wonder, "What makes a system smart?" And the answer is : Sensors! Be it health, education, agriculture, industry, finance, no sector is left untouched by the sensor technology. Sensors help you sense, measure and respond to a situation by make appropriate decisions. A sensor detects the changes in the environment and sends a signal to the observer. This ability of sensors make them inevitable in the process of making a system smarter and more efficient! MYOSA aims to make this entire process much easier and full of fun! Before we dive deeper into MYOSA, let's take a brief look at all the sensors used in MYOSA!

Humidity sensor

Introduction:

Humidity is the amount of water present in air.
It is different from the moisture sensor. Moisture sensor measures amount of water in any solid or liquid and hence is used to measure moisture present in soil, etc. and not in air.

Types of humidity sensor:

(a) Capacitive humidity sensors: A strip of metal oxide is placed between two electrodes. As the relative humidity of the surroundings change, the electrical capacity of the metal oxide also changes. This way the humidity is measured and the sensors are calibrated.

(b) Resistive humidity sensors: Non-metallic conductors change their conductivity according to the change in the water content. These sensors are usually made up of materials having low resistivity and this material is deposited on the non-metal. This way humidity is measured. Humidity is inversely proportional to resistance.

Applications:

(1) **HVAC systems:** The heating,ventilating and air conditioning systems which are popular today for its less harmful effects on the environment uses humidity temperature as an essential part of it.

(2) Greenhouses: We know that greenhouses are capable of producing water and proper temperature for the plants it nurtures. Modern greenhouses are equipped with humidity sensors to maintain perfect level of humidity required for the plants.

(3) **Weather prediction:** Those weathermen on news channels give various predictions on rain and humidity. How do they do it? The labs and units for measuring the humidity use humidity sensors and various mechanisms to do it.

Pressure sensor

Introduction:

Pressure sensor as the name suggests measures pressure of gases and liquids. Acting as a transducer it generates electric signal as a function of pressure.

How are they calibrated?

Pressure can be measured in various ways and a whole variety of sensors is available in the market based on their type of measurement.

1. Gauge pressure sensor - It measures pressure relative to atmospheric pressure. This type is used in blood pressure measurement
2. Absolute pressure sensor - It measures pressure relative to vacuum that is absolute pressure. For this the sensor contains a container that has vacuum in it. Interesting, isn't it?
3. Differential pressure sensor - It measures pressure difference between both the sides of the sensor. Well, how does it help? It is used in industries to measure fluid levels or flow rates. This is the most widely used pressure sensor type.

Where do you see these sensors?

(1) **Touch screens :** Yes, you are right. The pressure sensor on your mobile phone screens detect pressure of your fingers or stylus and gives output accordingly.

(2) **Bio-med equipments :** In instruments like blood pressure monitors, we use pressure sensors.

(3) **Altitude measure :** In aircrafts, air-balloons, etc. we use pressure sensor to measure the altitude of the object.

What is the type of a barometer?

Experiment:

Aim: Make an automatic doorbell system. When someone steps on the door mat, the alarm/bell will be triggered.

Procedure:

(1) Plug in the pressure sensor (in the kit) to the MYOSA board.
(2) Observe the output of the sensor on the OLED screen.
(3) Set a threshold pressure level (in mbar and mmHg).
(4) Connect the negative end of the buzzer to ground. Connect the positive end of the buzzer to pin 9 of MYOSA board through a 100 Ω resistor.

(5) Apply variations of pressure on the sensor and te st the buzzer. The buzzer would ring on application of pressure above the threshold.

Further, you can safely place this system under the doormat. The alarm rings automatically when someone on the mat. Pretty cool, isn't it!

Temperature Sensor

Introduction:

Of course, from the name it senses and measures temperature, i.e amount of heat energy generated by an object or a system. It allows us to detect any change in temperature.

Types of temperature sensor:

Broadly, there are two types of temperature sensors : Contact and Non-contact Temperature sensor.

Contact temperature sensors need the object to be observed in contact with the sensor. They are classified into -

(1) Integrated Circuits (ICs) - It is a transducer that produces output current proportional to absolute temperature. It is inexpensive and is most linear with temperature in terms of output.

(2) Thermistors - Thermistor = Thermal resistor. A thermistor's resistance is dependant on temperature (much more than normal resistors). By applying voltage to the thermistor and measuring its current gives us the respective temperature.

(3) Resistance Temperature Detectors (RTDs) - This type of sensor gives most precise and accurate output of the change in temperature. It can measure temperature between -200^{o} C to 500^{o} C. It is preferred over thermistors when the system needs the sensor to be stable for many years.

(4) Thermocouples - They are non-linear (hence requires conversion) and less accurate than above types. But they operate in maximum range of temperature and hence widely

used in industries.

(5)Non-contact temperature sensors don't require the object to be in contact. They measure temperature via radiation and convection. They are further divided into Infrared Temperature Detector and Thermopile sensor.

What kind of sensor is the thermometer?

Output:

Applications:

Can you think of anything? Some equipments that you daily use?
Yes, refrigerator and air conditioners.

In refrigerator and ACs the temperature sensors are present for regulating the temperature of the fridge compartments and the room respectively.

Refrigerator: Here, if the temperature decreases beyond a certain limit then the cooling system is switched to normal mode and the refrigerator no more cools the space, it just maintains the temperature.

AC: Similarly, if you set a particular temperature for the AC, the temperature sensor senses the temperature of the room and controls the wind flow and cooling system accordingly.

In industries and chemical reactors: As you would have learnt in chemistry, a particular amount of temperature is required for chemical reactions and heating up. This requirement is fulfilled with the help of temperature sensors.

Light Intensity Sensor

Introduction:

A sensor is a device that is used to detect the changes in the environment and accordingly produce the outputs. The light sensor is a passive device that converts light energy into an electrical signal output. Light sensors are commonly known as

"Photoelectric Devices" or "Photo Sensors" as they convert light energy (photons) into electricity (electrons).

Types of Light Intensity Sensors:

Light sensors fall into four types, depending on how they react to the input (light):

(a) Photoemissive: These sensors release free electrons when struck by light.
(b) Photoconductive: These sensors change their electrical resistance when the light is introduced. These sensors are also called photoresistors.
(c) Photovoltaic: These sensors generate an emf when the radiant light energy is received.
(d) Photojunction: These sensors use light to control the flow of electrons and holes across their PN-junction.

MYOSA light intensity sensor:

MYOSA uses TSL2561 luminosity sensor, which incorporates both infrared and visible light sensors. It is capable of measuring both very small and very large amounts of light. Further information on TSL2561 can be found in the datasheet.

Input and output parameters of the MYOSA light sensor:

Input: Light intensity
Output (on the screen): Intensity in Lux
Note: SI unit for illuminance (light intensity) is the lux.

Sample Real Life Applications of light sensors:

(1) **Home Security System:** A light sensor can be used to trigger burglar alarm in case of intruder attack. These devices work by shining a beam of light from one sensor to another. If this light is interrupted, the alarm will sound.
(2) **Barcode scanners:** The light from the scanner illuminates the barcode, which is read and decoded by the light sensor.
(3) **Street light control system:** A solar lighting system which senses the daylight and turn off the street lights automatically, thus saving power.
(4) **Adjust Brightness:** Light sensors are used in computers, televisions and modern smartphones. These devices use ambient light sensors in order to change the brightness of the screen depending on the surrounding light.

Experiment:

Aim: Make a smart lighting system. LED turns off when there is enough light in the surroundings, while the LED turns on during darkness.

Procedure:

(1) Plug in the luminosity sensor (in the kit) to the MYOSA board.
(2) Note the readings displayed on the OLED screen.
(3) Decide a light threshold (in LUX). The LED should turn off if the light intensity is greater than the threshold. When the light intensity is less than the threshold, the LED should turn on.
(4) Take a breadboard. Connect the positive leg to digital pin 3 (PWM pin) of the MYOSA board. Connect the negative leg of the LED to the ground through a 4.7K resistor.
(5) Modify the code as per the above mentioned requirement.
(6) Test the system by illuminating and dimming the surrounding lights and note the observations.

Magnetometer

Introduction:

Earth is surrounded by lines of magnetic flux which vibrate at the different frequencies. A magnetometer is a device with a sensor that detects and measures this magnetic flux. The flux is directly proportional to the magnetic field strength. Thus the magnetometers are capable of measuring the magnetic fields. Any object which distorts this magnetic field is detected by magnetometer.

Types of magnetometer:

Magnetometers are divided into two basic types:

(a) Scalar magnetometer: It measures the scalar value (only magnitude) of the magnetic flux intensity with very high accuracy. Eg: Quantum magnetometer.

(b) Vector magnetometer: It measures both, the magnitude and direction of the magnetic field. Eg: Fluxgate magnetometer.

MYOSA magnetometer:

MYOSA uses a Triple Axis Magnetometer: HMC5883L. Detailed information can be found in its datasheet.

Input and output parameters of the MYOSA magnetometer:

Input: Constantly changing surrounding magnetic field.
Output (on the screen): Milligauss (mG)
Note: SI unit of magnetic flux density is Gauss

Sample Real Life Applications of magnetometer:

(1) **Archaeological exploration:** Used as metal detectors to detect the archaeological sites and search for buried/submerged objects.
(2) **Military applications:** Used by the navy to detect the underwater submarines and take appropriate actions.
(3) **Monitoring pipelines:** Detecting the corrosion/damage of the underground pipelines.
(4) **Smartphones and tablets:** Used to detect the orientation of the phone with respect to the Earth's magnetic north. This the tilts and movements of the phones can be sensed.

Possible Experiments:

Aim: Calculate the rotation per minute (RPM) and speed of a fidget spinner using a magnetometer.

Basic concept: A metallic fidget spinner is rotated (spinned), keeping it near a strong neodymium magnet. This process disturbs the surrounding magnetic field. Such a disturbance is sensed by the magnetometer (attached to the MYOSA board). This helps in measuring the rotations per minute of the fidget spinner and thus leads to the calculation of the speed of the spinner. This entire experiment is originally based on the "Hall Effect". The Hall effect is seen when a conductor (here: the metallic spinner) is passed through a uniform magnetic field. A cool experiment for a cool toy, isn't it!

Accelerometer

Introduction:

Acceleration is the rate at which velocity changes. Accelerometers are devices that can measure acceleration. They can sense the static as well as dynamic forces of acceleration and based on that they measure the acceleration. Gravity is a static force while other vibrations and movements form dynamic forces. An accelerometer is capable of measuring acceleration on one, two, or three axes, depending on its type. As the sensitivity of the device increases, it becomes easier to detect acceleration.

Types of accelerometer:

Common accelerometers belong to:

(a) Piezoelectric accelerometer: In a piezoelectric accelerometer, charge accumulates on a crystal. They are then translated and amplified into either an output current or voltage.
(b) Capacitive accelerometers: Capacitive Accelerometers sense a change in electrical capacitance in response to acceleration. Thus as acceleration changes, the capacitance changes in proportion.

MYOSA accelerometer:

MYOSA uses MPU6050 accelerometer. It is a smart low-power, three-axis accelerometer. For further details, please refer to the datasheet.

Input and output parameters of the MYOSA accelerometer:

Input: Motion experienced by the sensor.
Output (on the screen): Acceleration in x, y and z direction in terms of g.
Note: Acceleration of gravity: g = 9.8 m/s/s

Sample Real Life Applications of accelerometer:

The sensor can be implemented in any system that detects velocity, position, shock, vibration, or the acceleration of gravity to determine orientation.

(1) **Aircrafts and missile:** Determine the pitch orientation for safe take offs and landings.
(2) **Smartphone and tablets:** To change the orientation of the screen. The screen is rotated in accordance to the movement of the phone. An accelerometer is used to detect the movement and motion of the device.
(3) **Earthquake Detection:** The accelerometer senses the very minute vibrations and motions of the seismic waves and can give an earthquake alert.

Experiment:

Aim: Vehicle accident prevention

Procedure:

(1) Plug in the accelerometer(MPU6050, in the kit) to the MYOSA board.
(2) Check the outputs in all 3 axis on the OLED screen.
(3) Set a threshold for acceleration.
(4) Connect the negative end of buzzer to the ground via a resistor. Connect the positive end of buzzer to pin 9 of MYOSA board.
(5) Modify the code such that the buzzer is triggered when the acceleration crosses the threshold. This alert is an indication to the driver to slow down for a safer ride.

Extension: Attach a camera module to the MYOSA board. When the acceleration exceeds a particular limit, when there are high chances of an accident, the camera starts clicking pictures of the surrounding. This could help the police department to study the exact case in future.

Gyroscope

Introduction:

Gyroscopes are devices that sense angular velocity. Angular velocity is the change in rotational angle per unit of time. Thus gyroscopes can sense rotational motion and change in orientation of an object.

Types of gyroscopes:

Various types of gyros like vibration gyros, fibre optics gyros, ring laser gyros, fluid gyros etc are available. Amongst these, Vibration gyroscopes are most widely used.

MYOSA gyroscope:

MYOSA uses MPU6050 triple axis gyroscope to detect rotation. It detects the rotation along all three axis: x, y and z at the same time. Being a triple axis MEMS gyroscope, it gives a very accurate measurement and has high sensitivity. Further details can be found in datasheet.
Note: MEMS stands for Micro Electro Mechanical Systems

Input and output parameters of the MYOSA gyroscope:

Input: Any kind of rotational movement
Output (on the screen): Rotation in degrees.

Sample Real Life Applications of gyroscopes:

(1) **Robot Balance Control:** To detect and measure the tilt and rotation of a robot and thus control its movement. Eg: self balancing robots.
(2) **Vehicle Stability Control:** Develop anti-skid systems for cars by sensing the movements of car and taking appropriate measures.
(3) **Game Controller:** Motion sensing in the video games.
(4) **Radio controlled drones:** Measuring the altitude and rotation of the flying drones and preventing falls.

Experiment:

Aim: Change the brightness of LED as per the tilt of the sensor.

Procedure:

(1) Plug in the gyroscope(MPU6050, available in the kit) to the MYOSA board.
(2) Take 3 differently coloured LEDs.
(3) For each LED, connect the negative end to the ground through a resistor and connect the positive end to the MYOSA board pins: 9, 6, 5 respectively.
(4) On tilting the sensor, it gives the amount of tilt (in degrees) on the screen in x, y and z directions.
(5) Customise the code such that the brightness of the LED1, LED2 and LED3 are changed in proportion with the the amount of tilt in x, y and z axis respectively.
(6) Start tilting the sensor and observe the changes in the brightness of all the LEDs.

The more you tilt, more the brightness. Look at the variating LEDs!

How to use MYOSA

MYOSA provides a multipurpose multisensor board. It has inbuilt, coded-programs for the following sensors:

(1) Luminosity sensor (TSL2561)
(2) Temperature and Humidity sensor (SI7021)
(3) Pressure sensor (BMP180)

(4) Accelerometer and Gyroscope (MPU6050)
(5) Magnetometer (HMC5883L)

Note: Every MYOSA board needs to be connected to a power source. It can directly be powered from a USB port of one's PC or through a power bank.

Elementary use:

The board is given a plug-in slot. For using any sensors, one has to simply plug the sensor (available in the kit) in the slot of the board and see the output readings on the OLED screen. One does not have to worry about the correct connection or orientation of the sensor, we simply have to plug it in and it will work. At a time, 128 sensors can be plugged in and plugged out. MYOSA follows the 'cascade method' for plugging sensors. For using multiple sensors, we can plug a sensor at the end of another one i.e. sensors can be cascaded (each sensor is provided with four equivalent slots).

Advanced use:

The board of MYOSA is programmable and all the codes are customizable. On using MYOSA without any modification, one can simply observe the output readings of the sensors on the OLED. But for using MYOSA more extensively in your own projects, the codes of each needed sensors have to be modified. The board has been provided with the necessary pins for further modifications. (For pin details, please refer to the MYOSA specifications module).

The basic procedure for any sensor-based project is to take the readings of the sensors, make some calculations based on the readings and use them to take appropriate actions. The circuit also changes as per the need of the project. To accomplish this goal using MYOSA, simply make the following modifications in the code:

(a) Software modifications: Using the values from the output pin of the board, in the existing code, write an additional code snippet for further actions (based on the project requirement).

(b) Hardware Modifications: Additional resistors, capacitors, LED's etc can be added to the circuit using the board's input/output pins. This newly made circuit can fulfill the requirement of the needed circuit.

Using the above mentioned method, any type of multisensor project can be conducted successfully using MYOSA.

Advanced use (Short):

The board of MYOSA is programmable. For advanced projects, the codes of each needed sensors have to be modified. The board has been provided with the necessary pins for further modifications. (Refer to Specifications)

(a) Software modifications: Using the values from the output pin of the board, in the existing code, write an additional code snippet for further actions (based on the project requirement).

(b) Hardware Modifications: Additional resistors, LED's etc can be added to the circuit using the board's input/output pins.

MYOSA mobile application:

For easy and handy access of the sensors readings and data, the MYOSA mobile application has been developed. The data observed on the OLED screen is uploaded to the application via a WiFi module. The data is transferred after every fixed, small interval of time. Changing trends of the sensor readings can be studied using the graphs available on the application.

Common questions regarding light sensors:

(Q1) How exactly should I use the MYOSA light sensor?

(Q3) How much light can the MYOSA luminosity sensor bear?

(Q4) What care should we take while using the light sensor?

Can I attach my own sensors?
What if I want to change the units?
Can I attach LEDs, resistors, etc to the MYOSA sensors?
Can I use a completely different code for operating the MYOSA board?
Can I reuse a sensor for multiple applications? If yes, for how long?
What precautions should I take while using MYOSA?

SPECIFICATIONS OF MYOSA BOARD

Key features of the board:

(i) 14 digital input/output pins (of which 6 can be used as PWM outputs).
(ii) 6 analog inputs
(iii) USB connection
(iv) Reset button

Detailed Description:

(1) Power:

- Every MYOSA board needs a way to be connected to a power source. The board can directly be powered from a USB port of computer or a from a power bank.
- The USB connection is also needed for loading a code onto the MYOSA board.

Caution: Do NOT use a power supply greater than 20 Volts as might overpower and damage the MYOSA board. The recommended voltage for most MYOSA boards is between 6 and 12 Volts.

(2) Voltage Regulator:

The MYOSA board is incorporated with the feature of voltage regulation. The voltage regulator is not accessible to the users, but it is an essential part of the board. Here is a brief description of its task:

The voltage regulator does exactly what it says – it controls the amount of voltage that is let into the MYOSA board. Think of it as a kind of gatekeeper; it will turn away an extra voltage that might harm the circuit. Thus it safeguards your board from excessive consumption of voltage and prevents damage. Of course, it has its limits, so don't hook up your MYOSA board to anything greater than 20 volts.

(3) Reset Button

On pushing the reset button, it temporarily connects the reset pin to ground and restarts any code that is loaded on the MYOSA board. This can be very useful when your code doesn't iterate on its own, but you want to test it multiple times.

(4) PIN Specifications:

(i) GND: Short for 'Ground'. There are several GND pins any of which can be used to ground your circuit.

(ii) 5V & 3.3V : As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.

(iii) DIGITAL PINS (D0 TO D13): These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).
(iv) PWM PINS: These pins act as normal digital pins, but can also be used for "Pulse-Width Modulation" (PWM). These are also included in the digital pins: 3, 5, 6, 9, 10, and 11 with tilde (~) sign. They are able to simulate an analog output (like fading an LED in and out).

(v) ANALOG PINS(A0 TO A5): These pins can read the signal from an analog sensor (eg: Temperature sensor) and convert it into a digital value that we can read.