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Research Article

A Guide to Select Sensors for Biomedical Propose

Nuno Domingues*

ISEL-ADEM, Rua Conselheiro Emidio Navarro, Portugal

***Corresponding author:** Nuno Domingues, ISEL-ADEM, Rua Conselheiro Emidio Navarro, Portugal.

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Abstract

After Implementing an external device in a patient, it is crucial to monitor it. The challenge of being inside the patient and the need to perform the chirurgical operation to observe the evolution and state is a major step to do. Also, the communication process is not easy. On the top, the rejection avoidance of a strange body and the critical environment presents an additional motivation. The present paper presents a detailed study sensor for a wide range of biomedical proposes and applications. It aims to explain and synthetize complex technical knowledge in a simple and comprehensible language.

Keywords: Sensor, Monitoring, Nanotechnology, Biomaterials, Implants, Data acquisition, Medical

Introduction

In basic terms, the sensor is a device that makes the detection and responds with an input from the physical environment. But what could be these inputs? The light, heat, motion, moisture, pressure, or any detectable in an environment variable entry are examples. Thus, when a specific sensor receives input from the environment, it sends an output, generally a signal which is capable of being converted to be read by the processor or transmitted electronically through a data network. Sensors are associated with transducers, assembling measurements, supervising and control devices. They are used together. Sensor means a device que detects a change in the physical environment and transforms it into a signal que can be measured and recorded while the term transducer is defined as a device que transfers energy from one system to another, which may be the same as or converted form (other than the original). The sensor is applied to detect itself while the transducer is applied to the sensing element associated with any circuit. Figure 1 shows the cascade chain of the sensoring process [1].

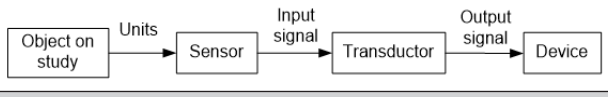

Figure 1: The process of sensoring.

The sensors are used in a variety of applications in industries, services and even for households. Basically, the sensor is a device that has the function to detect and respond to any stimulus efficiency. Various types of sensors respond to different stimulus, such as: heat, pressure, movement, light and others. After the sensor receives the stimulus, its function is to send a signal that can be converted and interpreted by other devices. The choice of sensor depends solely on the purpose of its installation. So, one needs to assess environmental conditions and choose the most appropriate sensor for that activity.

Types of Sensors

Acoustic Sensor

This type of sensor uses the echo return That spreads the speed of sound, one of the sensor types used to capture distances. The acoustic sensor was used in Polaroid camera and is used in many studies That Work with sonar system. Another use of the acoustic sensor is in the parking system of the most modern cars (Table 1).

Table 1: Acoustic Sensor.

Sensor	Signal proprieties
acustic	Wave- amplitude, phase, polarity
	Spectrum
	Wave speed

Electric Sensor

Table 2: Electric Sensor.

Sensor	Signal proprieties
Electric	Load
	Current
	Voltage
	Permitivity
	Condutivity

Electric sensors detect variations in electrical parameters such as an Increase in electric correte or even varying the voltage. These changes cause some sort of signal to change the status of a specific

circuit, the relay switch. Use of this type of sensor is very common in voltage detection circuit, overcurrent or overvoltage protection relays (Table 2).

Magnetic Sensor

Sensors of this type are widely used to detect the opening of doors or windows. The magnetic sensor Consists of a small plastic box That has in its inside two metal blades fractionally spaced. The action of the magnetic field is precisely When They These blades close, allow current flow. This magnetic field is Obtained by a magnet! (Table 3).

Table 3: Magnetic Sensor

Sensor	Signal proprieties
Magnetic	Magnetic field
	Flux
	Permitivity

Inductive sensor

Are Also magnetic sensors sensors Inductive, These sensors create a small magnetic field at its tip and When the metal goes next to it disturbing the magnetic field, the cam sensor to capture this disturbance and sends a signal que can be interpreted by a circuit connected to the sensor (Table 4).

Table 4: Inductive sensor

Sensor	Signal proprieties
Inductive	Magnetic field
	Flux
	Permitivity

Mechanic Sensor

These sensors are the ones who have the ability to detect the positions, movements or presence through mechanical means. Among the main applications, we can mention the presence of objects in a Certain place, the detection locks or door openings, and the limit switch sensor is one of the best known. The AIMS limit to Prevent sensing an engine to keep running even after the moving part reach the peak (Table 5).

Table 5: Mechanic Sensor

Sensor	Signal proprieties
Mechanic	Linear position, angle
	Aceleration
	Force
	Mass
	Density
	Momentum
	Torque
	Orientation

Optic Sensor

These sensors are also known as photovoltaic and use the propagation of light for its operation. The optical sensor is used to index objects and can also be used to measure the distance at which the object is in relation to the sensor. This type of sensor is used on elevator doors in computer mouse, bar code reader, in more modern vehicle reversing systems and many others (Table 6).

Table 6: Optic Sensor

Sensor	Signal proprieties
Optic	Wave- amplitude, phase, polarity
	Wave speed
	Refraction index
	Emitivity
	Absorption
	Reflectivity

Thermal sensor

This sensor gives a certain response when subjected to a temperature change. There are various types of thermal sensors and are several applications. The best-known thermal sensor is the thermometer that almost everyone has at home. It is used to measure body temperature. This type of temperature sensor is often used in environments where it is necessary to maintain a certain temperature, such as cold chambers. In this case, the sensor sends a response when it perceives that the temperature is outside of the ideal, and in accordance with this response refrigeration is switched off or activated (Table 7).

Table 7: Thermal sensor

Sensor	Signal proprieties
Thermal	Temperature
	Flux
	Specific heat
	Thermal condutivity

It is important to know that there are specific sensors that fit within these mentioned groups which are the most common. There is a wide range of sensors for the most diverse applications. Following are some examples that may be used in devices embedded in the human body are presented. Indicative prices to be able to have an order of magnitude and make appropriate comparisons are presented [2,3]. The prices presented are based on historic benchmarking and experience of the author.

Proximity and Motion

The Distance ultrasonic sensor is capable of measuring distances of 2cm to 4m with great precision and low price. This module has a ready coupled to a receiver for measurement.

The reflection optical Reflective Phototransistor sensor is coupled in the same device has an infrared sensor (LED) and a phototransistor (receiver). It is specially designed to block light of other bands than the emitter itself, preventing ambient lighting interferences.

The Proximity Sensor Infrared is a photoelectric reflection module which includes an InfraRed (IR) transmitter and an IR receiver. This sensor has a longer range than traditional ones, ranging from 3 to 80 cm with the adjusting screw at the rear of the sensor.

The Absolute Orientation Sensor provides the possible to obtain the absolute position in three axes, useful to set up a project involving virtual reality [4-6].

The PIR Motion Presence Sensor can detect the movement of objects that are in an area up to 7 meters. If something is moving around in this area the alarm pin is activated.

The combined motion sensor on a single chip contains an accelerometer and a gyroscope MEMS type. They have 3-axis accelerometer and 3-axis gyroscope, providing 6 degrees of freedom (6DoF).

The obstacle IR sensor is a circuit composed by a transmitter, an IR receiver, and an IC comparator, which facilitates its connection with Arduino, PIC or Raspberry Pi, since its voltage is 3, 3-5V.

The Reed Magnetic sensor is a switch that works by magnetic field, closing the internal contacts when approaching. When taking the magnet, the contacts open again.

The Encoder speed sensor is used to perform engine speed measurements, pulse count and positioning controller. It can be used with many more drivers and boards such as Arduino, Raspberry Pi and PIC.

The Vibration sensor is designed to detect vibrations. Its applications are numerous but are mainly divided in a useful signal to process and a noise signal to remove. When the intensity is below the preset value (i.e., the value set at the potentiometer), the output is in a high state, otherwise the output is in the low state.

This Hall sensor has high sensitivity based on the Hall effect to measure magnetic fields around them. The magnetic signal is then converted into an electrical signal with high reliability and sensitivity and can be used in a very practical way with an Arduino. Alarms can be used in projects, accountants and other electronic circuits.

The Grove magnetic sensor contains a reed switch on the board and can be used to set up alarm systems and proximity sensors based on magnetic fields.

The Vibration sensor Tilt Grove is used to detect movements and make the sign reading in a microcontroller as Arduino, Raspberry or Beaglebone plates and other applications in electronics design. The sensor can be used in monitoring systems and alarms systems, for example.

The gestures and RGB sensor are a plate with a sensor that provides ambient light measurement approach and signals. With Gesture Sensor and RGB it is possible to control a project, a computer design or a robot using only the movement of the hands.

The Distance Laser sensor is different from all the others: it uses a thin and invisible laser light source, and a circuit for detecting how long the light took to reach an object and return to the sensor. It can measure distances of between 30 and 1000mm with high degree of accuracy, has I2C and accepts power from 3 to 5V.

The analog line IR sensor varies the output value according to the amount of infrared light reflected to the sensor. When more light is detected by the IR receiver, the lower the voltage at the analog output.

The accelerometer module is a 12-bit resolution device with low power consumption, perfect for a virtual reality design using microcontrollers.

The Inductive Proximity Sensor is an NPN sensor capable of detecting metal objects up to 4mm away and generate a signal in the sensor output, which can be read by a microcontroller like Arduino.

The IR digital line sensor triggers the digital output according to IR light (infrared) received by the sensor. It is ideal for systems with only I / O available digital pin.

The 3-axis accelerometer has a new version provided now with a built-3.3V voltage regulator.

A Photo Interrupter Breakout Board was developed for easy connection to the component's microcontroller.

For complex projects involving accelerometer, gyroscope and magnetometer it is used an Absolute Orientation Sensor 9-DoF. It can be challenging to extract the necessary data of these sensors and convert them to a 3D world, requiring consolidating the data from these sensors, send them to I2C interface and saving work assemble complex algorithms or perform fine adjustments to extract the data needed.

For even more complex projects a 10DoF Sensor with Barometer, accelerometer, magnetometer and gyroscope is used. This is a powerful sensor IMU (Inertial Measurement Unit) that reaches 10 DOF, with 3-axis gyroscope, 3-axis accelerometer, 3-axis magnetometer and the pressure sensor and temperature.

Expected Price in March 2019 from €1.90 to €267.90

Temperature

The waterproof temperature sensor will allow you to take measurements in wet environments and wet with only one interface of one wire.

The regular temperature and humidity sensor allow temperature readings from 0 to 50° C and humidity 20 to 90%, widely used for projects with Arduino. The wider range temperature and humidity sensor allows temperature readings from -40 to +80° C and humidity from 0 to 100%, and very easy to use Arduino, Raspberry and other microcontrollers because it has only one output digital pin.

The temperature sensor with I2C communication is an accurate sensor, with typical accuracy of ± 0.25 ° C from -40° C to + 125° C + and resolution of 0.0625° C. The Temperature sensor is a sensor easy to use, communicating with the microcontroller via the I2C interface and sending temperature information in digital form, unlike traditional analog sensors. The Sensor Type K thermocouple with measuring range of -50 to 400° C is for use in multimeters and measurement equipment.

The temperature sensor can be a great option when looking for precision, and has easy communication with microcontrollers such as Arduino, PIC, ARM and Raspberry Pi. Widely used for home automation projects or even industrial.

The thermistor is a temperature sensor projects with widely used in microcontrollers, performing measurements in the range of -40 to 125° C based on a 10K Ohm NTC thermistor.

The temperature sensor Grove using a NTC thermistor for measuring the ambient temperature, generating an output voltage which is sent to the microcontroller.

The IR temperature sensor is a high-precision component that detects body temperature or objects by infrared without direct contact with the sensor is needed. It has already been calibrated at the factory and detects temperatures between -40 and 125° C with a precision of 0.5° C, still having multiple configurable user calibration methods.

The temperature and humidity sensor, for Sonoff is capable of measuring temperature and humidity providing data through its digital output. With its plug 4-pole, the sensor is perfectly compatible. The temperature and humidity sensor Son off have a resistive sensor capable of measuring temperature and a capacitive humidity sensor. Data is provided through its digital output. With its plug, the sensor is compatible with Sonoff TH10 / TH16. Sonoff is an affordable WiFi smart switch that provides users with smart home control.

The temperature sensor Waterproof Sonoff allows the functions similar to a thermostat, which can control any equipment according to the temperature.

The Digital Temperature Sensor performs temperature measurements accurately using only one pin of the controller.

The temperature and humidity sensor Grove is a module that contains a sensor on plate being connected to the microcontroller through a standard 4-pin cable Grove. This sensor comes pre-calibrated and is characterized by low power consumption and ease of use.

Expected Price in March 2019 from €2.40 to €80.90

Luminosity

The Brightness 5mm LDR (Light Dependent Resistor) sensor is a component whose resistance varies with the intensity of light. The lighter falls on the component, the lower the resistance. The light sensor can be used in projects with Arduino and other microcontrollers for alarms, home automation, motion, etc.

The Infrared (IR) receiver is useful in electronic projects such as motor control, lighting, alarms and circuits in general. It is user friendly with microcontroller circuit using Arduino, PIC or Raspberry Pi.

The IR Receiver Module is used in electronics design, remote control systems and alarms, for example.

The ambient light sensor module is a simple module to use but very powerful, as it has greater precision than standard modules using LDR (light dependent resistors). The sensor used is NPN phototransistor and the module has an analog output signal that can be read for example by a plate as Arduino. The higher the incidence of light, the higher the value in the output.

The photo Switch is an optical switch that operates with infrared, and on one side have an LED IR emitter establishing a light beam which is detected by the IR receiver on the opposite side. The distance between the transmitter and the receiver is 10mm.

The LDR Light Sensor (Light Dependent Resistor) is designed to detect light and has a digital and analog output that can be connected directly to a microcontroller as the Arduino.

The Infrared Phototransistor LED 5mm receiver is sensitive to infrared light and acts as a receiver of this type of light for use in electronics design as motor control, lighting, alarms and circuits in general. It is easy use with microcontroller circuit using Arduino, PIC or Raspberry Pi.

The UV Sensor is capable of detecting UV solar radiation using a simple chip. It can be easily configured for projects with Arduino to monitor UV Index, analyze UV-A lamps or DIY projects as plant growth analysis.

The Lux Light sensor can determine the amount of light (measured in lux), which is focusing on the sensor, and show that result in a display or trigger microcontroller ports in certain situations to light. Expected Price in March 2019 from €0.90 to €85.90.

Moisture

The humidity sensor Grove is composed of a rod and sends information to the microcontroller according to the humidity level detected by the sensor.

The Hygrometer Humidity Sensor is designed to detect the humidity changes, and when it is dry the sensor output is in the high state and low state when in wet.

The Rain Sensor is used to monitor a variety of weather conditions, but it can be used in liquid drops. When the surface is dry the sensor output is in a high state and when there is a liquid drop the sensor, output is in down state. Expected Price in March 2019 from €9.90 to €13.90.

Temperature and Moisture

The Temperature and Humidity High Precision Sensor and I2C communication with the microcontroller for use in electronics design, weather stations, room temperature control and medical equipment, among others. The sensor has 14-bit resolution and accuracy of 2% humidity and temperature of 0.2° C, providing accurate and reliable information as well as an extremely low power consumption in sleep mode. Expected Price in March 2019 around €65.00.

Chain

The Current Sensor Non-Invasive is an optimal device to measure AC current and is not invasive. It is widely used in projects with home automation Arduino like electrical current meters, protection of AC motors, lighting and others, but the non-invasive propriety is a boost to medical application.

The Current sensor performs current measurements accurately since it uses the Hall effect to detect the magnetic field generated by a current generating at the module output (OUT pin), a proportional voltage 66mV / A.

The DC Current Sensor provides measurements in circuits with DC voltage between 0 and 26V with DC current sensor, a I2C communication module and easy integration with devices such as Arduino, and other I2C interface. Expected Price in March 2019 from €26.90 to €58.90.

Touch

The Touch Sensor Capacitive is a component capable of detecting touches. Its operation is very simple: by touching the indicated region, the output of the sensor is activated. Without touching the sensor, there is no activity on output. It can be used as replacement of a push button.

The flexible sensor is a sensor of Sparkfun whose resistance varies as the sensor is bent. The greater the force applied, the greater the resistance in the sensor output.

The Force Sensor Resistive can make measurements between 100 g and 10 kg, depending on the force applied in the detection area (approximately a 15mm circle). Expected Price in March 2019 from €8.90 to €74.90.

Biometric

The Heart Rate Sensor allows to obtain data very useful when riding an exercise routine, studying daily physical activity or even for teaching purposes. The heart monitor pulse sensor performs reading of the heartbeat using an optical sensor amplified and sends this data to the microcontroller as the Arduino via a single signal pin.

The MyoWare Power Shield is a card designed for use with the Muscular Sensor MyoWare and uses two batteries. The Fingerprint Sensor can be used in projects with high complexity existing in this process.

The Muscular Expander Electrodes MyoWare Sensor allows you to place up to two electrodes directly on the board, being an interesting option for wearable designs (wearables). However, you often need a larger number of electrodes, or more distance between the electrodes and the sensor, and that's where the Expander MyoWare electrodes. With Expander Electrodes Myoware, you can connectup to three electrodes using the cable MyoWare sensors (not included) connected to the expander through a P2 plug.

The Biomedical Electrode is the component responsible for forwarding to the sensor the electric signal captured during the movement of muscles. It can be connected directly to the Muscular Sensor or cable sensors.

The Sensor Muscular Myoware is a control device with the strength of your muscles. This is a plate designed for use with Arduino and using a sensor electromyography (EMG), which measures the electrical activity of a muscle. Muscular Myoware sensor generates at the output a voltage between 0 volts, and Vs, where Vs is the sensor voltage. The greater muscle activity, the higher the voltage at the output.

The cable Sensor is an accessory to be used in conjunction with the Expander electrodes and allows you to connect up to 3 electrodes in muscle sensor.

The strike sensor and Heartbeat Oximeter is a module consisting of two LEDs and a photodetector circuits that detect heart beats and indirectly measure the amount of oxygen in the blood. The sensor is suitable for projects in the medical field, fitness and wearables, among others. Expected Price in March 2019 from €12.90 to €374.90.

Barometric

The Pressure and temperature sensor have gains in terms of accuracy and power consumption beyond the size 63% smaller, making common their use in mobile and portable devices.

The Pressure and temperature sensor are fully compliant in terms of firmware and interface, including using the same Arduino library. It is a compact sensor with low power consumption (about 0.5μA), being a good choice for projects powered by batteries.

The Air Pressure Sensor measuring range of 0 to 40kPa and using MEMS technology miniaturization of components in a package DIP (dual in-line package). Expected Price in March 2019 around €20.00.

Others

TThe Water Flow Sensor measure water flow for your electronic projects is now no longer a problem with this Water Flow Sensor. It is installed in line with the pipe to measure the amount of water flowing through it, sending PWM pulses to your Arduino and Raspberry Pi for example. Expected Price in March 2019 around €35.00.

The Load Cell Weight Sensor uses the weight sensor load cell together with the module and build its own scale based on Arduino, Raspberry, or other PIC microcontroller. Expected Price in March 2019 around €20.00.

The Water Level Sensor is a liquid level sensor for use in water tanks, reservoirs, tanks and other containers. The level sensor functions as a power switch that can trigger switches, pumps, lamps or send a signal to the microcontroller as the Arduino, Raspberry Pi or Pic. Expected Price in March 2019 around €15.00.

The Color sensor detects the color of objects quickly and accurately with the color recognition sensor. The sensor recognizes light levels RGB (Red, Green and Blue, or red, green and blue) and sends this data to a microcontroller as Arduino, Raspberry, PIC and other models, allowing you to create efficient color detection systems. The Color RGB sensor with IR filter can recognize colors quickly and effectively. Based on chip, this sensor has RGB light sensors which together with the IR filter minimizes the influence of the IR spectrum, such as lights, leaving a much more accurate measurement. Expected Price in March 2019 around €65.00.

The sound sensor Grove is a plate with a microphone that detects the sound system and generates a variable signal at the output

according to the intensity of the captured sound. Expected Price in March 2019 around €40.00.

Conclusions

There is a wide range of diferente sensors with diferente applications, advantages and strenghts. Knowing what best suits a real situation is crucial to extend life long. Also, it is important to understand how the sensor communicates the acquired data in order to find the appropriate acquisition and processing signal board.

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