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Sensors

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Abstract: *The availability and wide range of application of low cost sensors have encouraged a demand for improved sensor performance. Integrated sensors are being developed to meet the designer's need for simpler systems. Smart sensors are becoming integral parts of systems performing functions that previously could not be performed or were not economically viable.*

Keywords: Introduction, Methodology, Review, Privacy, Security, Behavior and influence analytics in social computing**,** Results & Discussion, Conclusion, Acknowledgement and References.

I. Introduction

We can find sensors everywhere, and the whole world is full of sensors and their applications. There are many types of sensors available around us, in our offices, gardens, shopping malls, homes, cars, toys etc. These sensors make our lives so easy and comfortable, starting from applications such as switching on the lights, fans, television (TV), automatic adjustment of the room temperature by air conditioning (AC), fire alarm, detecting obstacles when the car is reversing, making a thumb impression etc. A sensor is a device which receives signals as well as responding to a signal or stimulus. The stimulus signals can be defied by the measure, property, or state which is sensed. We also can say that a sensor is a translator that converts a nonelectrical value to an electrical value [1–3]. The output signal of a sensor may be in the form of voltage, current, or charge. A sensor has many forms of input properties and electrical output properties. If there is small change in the sensed quantity, it will cause a small change in the electrical output and the changes can be detected with their measuring capabilities. All the sensors are categorized on the basis of their uses, applications, material used and some production technologies. Some sensors are classified also by their characteristics such as cost, accuracy or range of sensor. There are two main types of sensors: passive sensor and active sensor. A passive sensor does not require any extra energy source and electric signal is produced directly in reply to stimulus of external sources. This means that the sensor converts input energy to output signal energy [1, 4, 5]. Examples of passive sensors include photographic, thermal, electric field sensing, chemical, infrared and seismic. The active sensors need external sources of energy for their response, known as excitation signal. To produce the output signals, sensors adopt necessary changes to these input signals. The active sensors are also known as parametric sensors due to their own properties which can be modified in response to an exterior effect and these properties can be afterward changed into electric signals. Active sensors have a variety of applications related to meteorology and observation of the Earth's surface and atmosphere.

1.1 Infrastructure and Platforms for Intelligent Systems

Upon receiving the input stimuli, the sensor produces output which is obtained from several conversion steps before it produces an electric signal [1, 6–10]. The performance of sensors is described in terms of relationship between input and output signals. Sensors are characterized depending on the values of some of the important parameters. The characteristics of sensors are described here in this section.

1.2 Types of Sensors

There are many sensors commonly used in various applications [1, 11–21]. All these sensors are categorized as per their physical properties like temperature, resistance, pressure, heat flow etc. The following is a brief discussion on different types of sensors.

A. Temperature Sensors

A temperature sensor is used to measure the amount of energy in the form of heat and cold produced by an object and system. It allows one to sense or detect any physical change to that energy and gives the output as analog or digital.

Temperature sensors are used in various applications such as notification of environmental temperature, medical instruments, automobiles etc. According to application and its characteristics, many different types of temperature sensors are available. There are basically two types of temperature sensors, contact temperature sensor and non-contact temperature sensor. In contact temperature sensor, there is physical contact with the object being sensed and to monitor the change in temperature, conduction is used. It is used to sense solids, liquids or gases over a wide range of temperatures. In a non-contact temperature sensor, we use convection and radiation properties to measure the changes in temperature. It uses radiant energy in the form of heat and cold.

- Thermostat: The thermostat is a kind of contact temperature sensor employing an electro-mechanical component and using two thermally different kinds of metals, nickel, copper, tungsten or aluminium etc, which are stuck together to form a Bi-metallic strip. When it is cold, one of the strips is contracted and its contacts are closed and current passes through the thermostat. When it is hot, one metal strip is expanded and opens the contacts to stop the flow of current.
- Thermistor: The thermistor is another type of temperature sensitive device or resistance whose electrical resistance changes as the object temperature changes. This is made up of semiconductor materials. When temperature of the object or surroundings increases or decreases, resistance will also increase or decrease. How much the resistance will increase or decrease depends on the properties of the semiconductor material. The thermistor is of two types: positive temperature coefficient, (PTC) and negative temperature coefficient, (NTC). In PTC, resistance value increases with an increase in the temperature and in NTC, its resistance value goes down with an increase in the temperature. Thermistors are used for precise temperature measurement, control and compensation. Thermistors are highly sensitive and exhibit non-linear characteristics of resistance versus temperature. Generally, these are made up of manganese, nickel, cobalt, copper and iron.
- Resistive temperature detector: The resistive temperature detector (RTD) is also known as resistance thermometer, and used for measurement of temperature. It is based on the temperature coefficient of sensors and generally composed of high-purity conducting metals like platinum, copper or nickel. These materials are looped into a coil whose changes of electrical resistance depend on a temperature function. The working principle of an RTD is very similar to that of the thermistor.
- Thermocouple: The thermocouple is a device which is used for the measurement of the temperature variation in a measurement of sensors. The thermocouples are coupled with two metals joined together forming a junction. Thus, there are two junctions in the metals, one is called hot junction and other is called cold junction, also referred as measuring junction and reference junction, respectively. These junctions are kept at different temperatures due to the change of EMF (electromotive force) induced in a thermocouple and output voltage obtained with the help of the relationship between the voltage and temperature. When the two junctions are at different temperatures, a voltage is developed across the junction which is used to measure the temperature sensor. The thermocouple is based on three main effects: Thomson effect, Seebeck and Peltier effect. It has broadest range of temperatures of all the temperature sensors, covering from −200 °C to 2000 °C.

B. Position Sensors

The position sensor detects the position of an object either linearly or in rotation with respect to some fixed point or position. Position can be determined by the distance between two points moving away from some fixed points. We can measure the displacement of position in a straight line by linear sensor and angular displacement using rotational sensors. Position sensors are also known as potentiometers and used to measure the displacement of the object. A potentiometer can be an electrical or resistive type of sensor, because its working principle is based on change in resistance of wire with its length. This converts rotary or linear displacement to electrical voltage. The resistance of wire is directly proportional to length of wire. If the length of wire changes then the resistance of wire also changes. Potentiometers are available as rotary and linear potentiometers in the market, and can be used to measure the angular position and linear position, respectively; through voltage division the changes in resistance can be used to create an output voltage that is directly proportional to the input displacement.

The sensors have three terminals, where the one in the middle is known as the wiper, and the other two are known as the ends. The wiper is a movable contact where resistance is measured with respect to it and either one of the end terminals.

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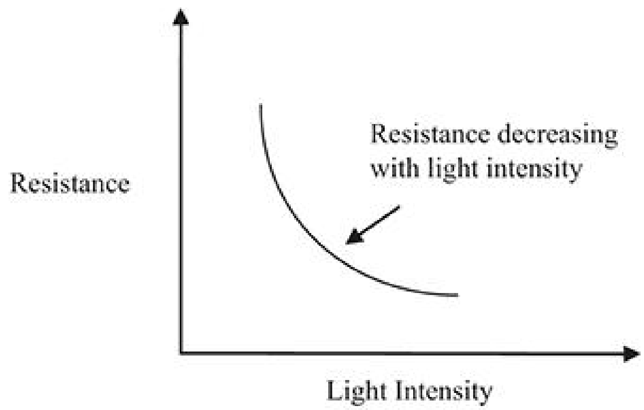
The displacement of the moving object is measured with the help of the sliding element of the potentiometer. When position of the moving body changes then its resistance between two fixed points also changes. The result is obtained in the form of differential output voltage which varies linearly with the movement of core position. The resulting output signal has both the amplitude and polarity. Amplitude is calculated as linear function of the displacement and polarity gives the direction of movement. Major advantages of the potentiometer include user friendly operation, low cost, high amplitude output and the sensors are used for measuring even large displacement, but its operating cycles are limited.

C. Light Sensors

A light sensor is a photoelectric passive sensor which changes the light energy into an electrical signal output. It measures the ambient light which is surrounding light, room light and reflected light. The major component of a light sensor is the light dependent resister (LDR) or photoresistor. It is a resistor that depends on the light which changes its resistance depending on the amount of light incident on it. The sensors are made up of semiconductor materials and therefore when light is incident on semiconductor material it becomes low conductive and therefore has less resistance. When we increase the light intensity, its resistance decreases and vice versa which is shown in figure 1.2. Intensity of light falling on an LDR is measured in lux.



There are different kinds of light sensors such as photoresistors, photodiodes, photovoltaic cells, phototubes, photomultiplier tubes, phototransistors, charge coupled devices (CCDs) etc.

D. Sound Sensor

A sound sensor is also known as auditory and used to detect the intensity of sound. It converts the acoustic wave into an electrical signal output. These sensors can also detect sound pressure waves which are not within the audible range, making them suitable for a wide range of tasks. Sound sensors are mostly used for security purposes.

E. Proximity Sensor

A proximity sensor can be used for detecting the presence of a nearby object without any physical contact. It emits an electromagnetic field for a beam of electromagnetic radiation as infrared instances and changes in the field returning a signal. The object being sensed is often referred to as the proximity sensor's target. Depending on different types of proximity sensors, different targets are used. For example, an inductive proximity sensor needs a metal object, whereas a capacitive photoelectric sensor is suitable for a plastic target. A proximity sensor has high reliability due to the absence of mechanical parts and lack of physical contact between the sensor and target. It has very short range when used as a touch switch. It is commonly used in industrial applications, manufacturing of food production, mobile phones etc.

F. Accelerometer

This sensor is used to detect the acceleration of an object, and operates by sensing the acceleration of gravity, and the direction of the object is calculated. This sensor is a kind of micro electromechanical system (MEMS), which uses a silicon integrated circuit. These sensors convert the mechanical motion caused in an accelerometer into an electrical signal by using the piezoelectric, piezo-resistive and capacitive components.

G. Infrared Sensor

An infrared (IR) sensor consists of two packs, one is Rx (receiver) and the other is Tx (transmitter). Transmitters are used in transmitting the rays in the infrared spectrum and the receiver receives the IR spectrum range. In the IR spectrum, the voltage is given between its terminals and then it emits rays. The main principle of working of an IR sensor is reflectivity by an object. When an object is placed in front of the transmitter it tends to reflect the rays that are coming from the IR sensor back to the IR sensor. Whenever a ray that is reflected by an object is received by the receiver it generates a voltage level across the terminal. This voltage level depends upon the intensity of light that is reflected by the object. Transmitter and receiver are placed side by side, and the IR transmitter transmits a signal within a limited range and going to a certain distance. When IR rays hit the surface, some rays are reflected depending upon the colour of the surface. The brighter the colour the more IR rays are reflected; similarly, the darker the surface the more IR rays are absorbed by the surface and fewer IR rays are reflected back.

H. Pressure Sensor

Pressure is an external force exerted on a surface in unidirectional areas. We commonly measure the pressure of liquid, air and other gases. A pressure sensor monitors this pressure and is sometimes called a pressure transmitter as it converts pressure into an electrical signal. The most common type of pressure sensor is the strain gauge-based pressure sensor. Conversion of pressure into electrical signal is achieved through the physical deformation of strain gauge which is bound into the diaphragm of the pressure sensor. The strain will produce a change in electrical resistance which is proportional to the pressure. Change in voltage is the result of ambient pressure. A pressure sensor can also be used to measure other variables such as fluid or gas flow, speed, water level, and altitude.

I. Ultrasonic Sensors

An ultrasonic sensor uses ultrasonic waves for the purpose of sensing and measuring the distance of a particular object. Ultrasonic waves are very high frequency waves. The sensors have two main transducers, namely transmitter and receiver. A transmitter uses 40 KHz of frequency wave transmitted in the air and when it is blocked by an object then its gets reflected and bounced back to the sensor. These reflected waves are absorbed by the receiver of the sensor. So, the total time taken by the ultrasonic waves to travel from the transmitter to the object and again from the object to the receiver of the sensor is given by the output of the sensor. Ultrasonic sensors are used in many applications such as robotics, driverless cars, for measuring distance, and also in radar systems etc.

J. Touch Sensor

Touch sensors are sensitive to touch, pressure and force. The sensors operate as switches and when the surface of the sensor is touched the current starts to flow in the circuit just like current flowing in a closed circuit. When there is no contact, it performs like an open circuit and no flow of current is reported. There are two types of touch sensors, capacitive and resistive. The touch sensors are used popularly in modern gadgets such as smartphones, and other handy devices.

- Capacitive sensor: The capacitive sensor has an important element as a capacitor. Parallel capacitors are generally placed like top and bottom plates at some certain distance and between these parallel capacitor plates there is a dielectric medium. The main principle of change in capacitance is used such that it may be caused by change in overlapping area, change in distance between two plates and change in dielectric constant. Changes of these parameters can be made by the physical variables like displacement, force, pressure and flow of liquid. Capacitance and output impedance are measured with a bridge circuit. An extremely small force is needed to operate them and hence they are very useful for a small system. The sensors are highly sensitive with good frequency response and high output. As force requirement is small, thus the power requirement is also less to operate the sensors. The metallic parts of the sensor must be insulated from each other in order to reduce the effect of stray capacitance.
- Resistive sensor: The resistive sensor is based on the change in resistance of the material and is used to measure temperature, displacement, moisture etc. A slider is free to move between two points and at a certain point we get the zero output and at some other point we get the maximum output. The output voltage is obtained between these two points and it is directly proportional to displacement. So, the change in length of the wire causes the change in the value of the resistance. This property is utilized to measure the changes in displacement using resistivity and

resistance. When the fixed voltage is applied across end terminals of the sensor, a proportional voltage is generated across the slider and this voltage can be calculated using voltage divider rule. As distance increases, the output voltage will also increase. The resistive technique used in this sensor can be used to sense or measure linear displacement.

K. Humidity Sensor

Humidity is the amount of water present in the surrounding air and a hygrometer is the device which measures humidity directly. Humidity is a non-electrical quantity that is converted into electrical quantity by using resistance, capacitance and impedance properties. There are various parameters that change due to humidity. There are five basic types of humidity sensor: resistive hygrometer, capacitive hygrometer, microwave refractometer, aluminium oxide hygrometer and crystal hygrometer.

- Resistive hygrometer: In a resistive hygrometer, the main element is a material whose resistance changes with the change in humidity or relative humidity. A wire or electrode coated with hydroscopic salt (lithium chloride) can be used for measurement of the humidity. Resistance of salt changes with humidity because hydroscopic salt absorbs moisture and its resistance decreases.
- Capacitive hygrometer: In a capacitive hygrometer, the changes in humidity are caused by the changes in the capacitance. Dielectric medium is used in the capacitor and the capacitor consists of two electrodes or plates and a dielectric medium is there between the plates. There is also some hydroscopic material which exhibits the change in dielectric constant with the change in the humidity. Therefore, such hydroscopic material or salt can also be used for construction of a capacitive hygrometer. If the change is very small, then the capacitor includes a frequency determining element in the oscillator and another frequency is produced by the beat frequency oscillator. This frequency is heterodyned and the difference in frequency is a measure of relative humidity.
- Microwave refractometer: A microwave refractometer consists of two cavities, each coupled with Klystron. Klystron is a material which produces microwaves in which one cavity is filled with dry air and another cavity is filled with a mixture whose humidity is measured. In the mixture, water vapour will be present and due to the presence of water vapour, there will be a change in dielectric constant, and frequency of one of the oscillators changes consequently. If there is no change in dielectric constant, its frequency is going to be constant, whereas in the mixture water vapours are present, and there is change in dielectric constant which results in change in its frequency. Frequency changes are measured as the measure of humidity.
- Aluminium oxide hygrometer: In an aluminium oxide hygrometer, aluminium oxide is coated on anodized aluminium and this aluminium oxide exhibits a change in the dielectric constant with respect to changes in humidity. There are two electrodes in which one is the inner electrode and the other is the outer electrode made from a very thin layer of material like gold. Some pores are presents in the inner layer. Due to the change in humidity, dielectric constant changes and this change can be measured to measure the humidity by bridge or electric method. The errors are much reduced and the response time is small and therefore the response is very fast.
- Crystal Hygrometer: In a crystal hygrometer, crystals are coated with hydroscopic materials (hydroscopic polymers). These crystals are used as frequency determination elements in the oscillator, and therefore just like with the capacitive hygrometer, if there is change in humidity then frequency also changes. Frequency changes due to the humidity as the mass of the crystal changes with amount of water absorbed by the coating. This change in frequency is measured. Humidity sensors are used in industry, agriculture, the medical field, environment monitoring etc.

L. Colour Sensor

A colour sensor is used to detect and identify various colour patterns and convert them into desired frequency as output. It consists of four photodiodes of red, green, blue and clear (no colour). All these photodiodes are connected in parallel and work as filters. For example, if we have to detect red colour, we use red colour filter for this purpose. Colour light signals are sensed by the photodiodes and we get the square wave signals with the frequency directly proportional to light intensity and that is transferred to the microcontroller and we get the result of colour.

M. Chemical Sensor

A chemical sensor is a device which transmits chemical information from a chemical reaction. The chemical information may be of composition, concentration and chemical activity which originates from a chemical reaction or from physical activities. It has different applications such as for home appliances and the chemical industries. The chemical sensor usually contains two basic components, which are a chemical resonance system known as the receptor and a physical chemical transducer. The receptor interacts with analytic molecules and the transducer sends the electric signal. A test sample is given to the receptor which checks composition connected with the transducer. The transducer collects the information from the receptor and sends it to the signal amplifier. This amplifies the signal from the transducer and sends it as output signals. There are two types of chemical sensors used to detect the composition: optical sensor and electro chemical sensor.

- Optical sensor: In the optical sensor, there are an emitter and a detector as the main elements. The emitter senses the light to the optical sensor and the light rays fall on the analyte and these rays may be reflected or refracted. These reflected or refracted lights are passed through the detector. Now the detector receives these lights and according to their intensity, the chemical compound present is analysed. Operation of an optical sensor is very simple and it uses absorption coefficient characteristics of the medium and path length travelled by the rays.
- Electrochemical sensor: The electrochemical sensor operates by acting on gas molecules of interest and produces an electric signal proportional to the compound present in the gas. It consists of sensing modules and electrodes, separated by a thin layer of electrolyte. There are two plates and the centre is filled by electrolytes. One plate is the cathode and the other plate is the anode. An external membrane is introduced in solution and it is absorbed by certain ions from the solution. Therefore, chemical properties of the solution change and the electromagnetic field will also change; and consequently change in the electromagnetic field ensures that the chemical composition is present in the gas.

N. Seismic Sensor

A seismic sensor measures small movements of the ground and also amplifies and records these small movements. It is also known as a seismometer, and is mostly used in measuring the details of earthquakes, volcanic eruptions and other vibrations. There are two types of seismic sensor, inertial seismometer and strain meter or extensometer seismic sensor.

- Inertial Seismometer: The inertial seismometer consists of a weight suspended from a frame by a spring. The frame moves due to the vibration being measured but the mass is held stationary due to the spring. It is used to measure a large-scale vibration such as an earthquake. Now the movement of mass is converted for output as a digital electric signal. Since both types of seismic sensors most commonly output an electric signal, calibration is necessary to derive a relationship between the input and output.
- Strain meter or extensometer seismic sensor: In a strain meter seismic sensor, a strain gauge is used to measure the motion relative to the various points. It generally is used for smaller scale measurement and movement of mass is converted for output as a digital electric signal.

O. Magnetic Sensor

Magnetics sensors respond to the presence or interruption of a magnetic field like flux, strength and direction by producing a proportional output. It converts magnetic information into an electrical signal for processing by the electronic circuit. A magnetic sensor is used in different types of application such as sensing position, velocity and movement of an object. There are different kinds of technology used to design a magnetic sensor. Fluxgate, Hall effect, resistive, inductive, proton processing etc, have a dissimilar approach of using magnetic sensors. A resistive magnetic sensor keeps the electrical resistance of the magnetic field and an inductive magnetic sensor uses coils surrounding its magnetic material, which have the ability to detect changes within the Earth's magnetic field. A fluxgate magnetic sensor uses the approach of changing flux parameters. Each type of technology focuses on a specific area for identifying measurements to be detected. Sensitivity of the magnet is increased by combining layers of magnetic alloys and the magnetic field is surrounded by an electric current, and variation within the field is detected. The output of a magnetic sensor increases with a strong magnetic field and decreases with a weak magnetic field.

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II. Comparison of Different Sensors

This section presents a tabular comparison of different types of sensors [1, 10, 18–30] in terms of advantages and disadvantages, as shown in table 1.3.

Table 1.3. Comparison of different sensors.

Sensors	Advantages	Disadvantages
Temperature sensors	• Reference temperature not required • Large response time • Easy display • Durable	• Self-heating error from applied power • Difficult to calibrate
Position sensor	• Accurate, reliable, and predictable measurement • Higher switching rate • High susceptibility to noise	• Sensing range depends on the type of metal of the target object
Sound sensor	• Used in speech recognition software • Easy to manipulate sound in real time • Does not require cabling compare to wired mic	• Sound files require more memory size • Interference cancelation is required • Limited coverage area
Light sensor	• Requires very small power and voltage • Available in different shapes and sizes • Easy to integrate with a lighting system • Quick response time and low cost	• Nonlinear characteristics • If applied voltage exceeded, it will cause irreversible damage to the photo resistor • Temperature sensitive • Vulnerable to surges and spikes
Accelerometer	• Good response at higher frequencies • Withstands high temperature • Small size	• Sensitive to high frequency • Requires external power
Infrared sensor	• Operates with low power • Capable of detecting presence or absence of light • Does not require contact with object • Not affected by corrosion or oxidation • Strong noise immunity	• Requires line-of-sight deployment • Gets blocked by common objects • Limited range • Affected by environmental conditions • Transmission data rate is slow
Pressure sensor	• High output signal level • Low cost • Technological robustness	• High hysteresis • Sensitive to vibrations • Movable contacts
Ultrasonic sensor	• Sensing capability to all the materials • Not affected by dust, rain, snow etc • Works in any adverse conditions • Higher sensing distance • Not affected by colour or transparency of objects • Can be used in dark environments	• Sensitive to variation in the temperature • Difficulties in reading reflections from soft, curved, thin and small objects • Cannot work in a vacuum • Sensing accuracy is affected by soft materials

Sensors	Advantages	Disadvantages
Smoke and gas sensor	• Simple and low-cost technology • Measures flammability of gases • Linear output and low power requirements • Wide measurement range • Higher sensitivity, resolution and reliability	• Requires air or oxygen to work • Narrow or limited temperature range
Humidity sensor	• Does not require much maintenance • Flexibility to use • No ageing effects	• Sensitive to dewing and substances • Limited accuracy and measurement range
Color sensor	• Easy to change or modify setups without even re-programing the sensor device • Easy to implement • Common color space, used in a wide range of devices	• Lens subject to contamination • Sensing range affected by colour • And reflectivity of target
Chemical sensor	• Linear output, low power requirements and good resolution • Excellent repeatability and accuracy	• Narrow or limited temperature range • Short or limited life • Cross-sensitivity for other gases
Seismic sensor	• Detects lateral and vertical variations in velocity • Produces detailed images of the subsurface • Used to map stratigraphic units.	• Data processing is time consuming • Equipment is expensive

III. Modern Sensors

The sensor technologies have changed a lot in the last decade in terms of compactness, smartness and sensitivity. The traditional sensors such as photosensors, optical sensors, capacitive sensors and almost all sensors have been replaced by their integrated circuit forms such as MEMS (microel ectromechanical system). The sensors are embedded in all modern computing and navigation devices in compact forms and this is why an ordinary smartphone carries around 22 sensors for various purposes. The technologies of sensors have further advanced and become intelligent as smart sensors and available in wearable forms. This may be seen in smart watches, smart gadgets or a large application such as self-driving cars where hundreds of smart sensors are involved for seamless and smooth driving without assistance of a driver. The same can also be seen in robotics, medical diagnosis, brain–computer interface (BCI) and many more, where AI (artificial intelligence) has empowered the sensors with intelligence and smartness for emerging and modern applications such as industry, healthcare and sophisticated automation.

IV. Methodologies

4.1 Smart Sensors and Ad-Hoc Wireless Networks

CPSs rely on a strong synergy between computational and physical components. A CPS is the integration of abstract computations and physical processes [9] where sensors, actuators, and embedded devices are networked to sense, monitor, and control the physical world. Therefore, smart sensors and wireless sensor networks are major components of CPSs. Wireless sensor networks (WSNs) are composed of tiny devices equipped with sensing, processing, storage, and wireless communication capabilities. Each node of the network can typically have several sensing units, able to perform measurements of physical variables, such as temperature, luminosity, humidity, and vibration, thus being the main components to create a perception of the physical world. WSN nodes operate collaboratively, extracting environmental data, performing same (often) simple processing, and then transmitting them to external systems, via sink nodes, to be analyzed and further processed.

Sensor nodes are severely constrained regarding memory, energy, and processing capabilities. Therefore, several approaches have been proposed to reduce the energy consumption of these nodes in order to extend the overall lifetime of the system. Since radio communication is the dominant factor of energy consumption in most WSN (except for the hungry devices of multimedia sensor networks), an effective approach is the reduction of data transmission between the sink and the sensing nodes. One of the most commonly used technique to reduce radio communication is the dual prediction mechanism and several proposals are reported in the literature [10,11,12]. However, while all existing approaches have been proven to be very effective in reducing the amount of data reported to the sink, their efficiency is countered by an increase in complexity. Moreover, they are very sensitive to data loss which renders the dual prediction mechanism obsolete [13]. In the paper “Fault Tolerant Data Transmission Reduction Technique in Wireless Sensor Networks” [13], the authors present an alternative technique that has as a major benefit to be simple yet robust, and more effective in terms of prediction accuracy and data reduction. Their approach exploits the fact that sensor data changes smoothly over time, therefore they leverage the prediction model proposed in [14] to forecast future readings. They coupled this technique with a data reconstruction algorithm [15] that exploits both temporal smoothness and spatial correlation among different sensed features in order to estimate missing values.

Vehicular ad hoc networks (VANETs) are a subclass of mobile ad hoc networks (MANETs), and a promising approach for future intelligent transportation systems (ITS). A VANET typically supports two communication models, namely Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I). Currently, most VANET applications rely on V2V communications since they do not require costly infrastructure. However, as VANET is a very dynamic network, information must be exchanged between mobile vehicles in an efficient way by avoiding as far as possible the broadcast storm problem, that occur whenever a huge number of vehicles broadcast messages at the same time thus leading to a network saturation, packet delay and collision issues. In this context, data aggregation is an appealing approach allowing to integrate several data about similar events to generate a summary (aka aggregate) and as a consequence potentially reducing the network traffic. There are several proposals for data aggregation in VANETs already reported in the literature. However, the highly complex urban and highway networks produce an overwhelming traffic information data that requires efficient selection criteria and smart filtering before the aggregation process. The design of an efficient data aggregation approach that combines correlated traffic information or Floating Car Data (FCD) is still a challenging issue. The authors of the paper “Towards a Smarter Directional Data Aggregation in VANETs” [16] introduce a new data aggregation protocol, called Smart Directional Data Aggregation (SDDA), with the goal of selecting the most appropriate FCD messages that have to be aggregated.

Based on the aforementioned research works, it is clear that the future CPSs and intelligent applications heavily rely on the presence and widespread of physical sensors and WSNs. To ensure the functionality of an application, such as intruder detection, it is of critical importance to guarantee the coverage and availability of wireless sensors during deployment. As such, barrier coverage is a critical issue for wireless sensor deployment for many industrial and military applications, where each wireless sensor can sense within its range and a collection of wireless sensors can be deployed to cover the entire range of a barrier. Over the last decade, different barrier coverage algorithms had been established for different types of sensors such as seismic [17] and acoustic [18] sensors, while in recent years, more research efforts are dedicated to radar sensor systems [19, 20]. In “Optimal Placement of Barrier Coverage in Heterogeneous Bistatic Radar Sensor Networks” [21], authors investigate the barrier coverage problem for bistatic radar sensor systems. Different to the traditional passive sensing model, the Cassini oval sensing model is investigated and an optimal placement strategy for heterogeneous transmitters and receivers has been proposed to achieve maximum barrier length coverage. The proposed algorithm has been validated through theoretical simulations to demonstrate the optimal coverage.

Cyber-social networks have significantly improved social relationships among mobile users across device-to-device communications. In the paper “A Detailed Review of D2D Cache in Helper Selection” [22], the authors present a survey work which focuses on D2D helper selection techniques according to three basic categories, including the network frame, computing method, and social-aware attribute. Differing from other surveys which mainly consider the energy consumption and latency minimization in D2D networks, they discuss the selection of D2D helper based on different network architectures, such as content distribution networks, peer-to-peer networks, named data networks, cellular networks, and vehicular ad-hoc networks. In particular, a variety of computing paradigms are taken into account to classify D2D helper selection techniques, such as mobile cloud computing, fog computing, and mobile edge computing.

V. CONCLUSION

This chapter presented an overview of sensors with basics, characteristics and different types of sensors. A sensor is a device that receives a signal and converts it into an electrical signal. These sensors are classified on the basis of their applications, cost, accuracy and range. Sensors are classified also into different categories like thermal, electrical, magnetic optical, mechanical and chemical sensors. The sensor technologies have become advanced now and cognitive and smart sensors are being used in all modern applications.

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The paper consist of the information related to smart computing. It focuses on the following elements and values such as introduction, methodologies, privacy, security, behavior and influence analytics in social computing, results and discussion followed by conclusion and references. I hereby declare that all the information provided in the respected paper is authenticated, authorized and hence reliable. I would like to thanks all the viewers and readers of this paper for their precious time.

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