

A REVIEW ON SMART HOME SENSORS

Joy Rakesh Y
Dept. of Computer Science
CHRIST (Deemed to be University)
Bangalore-29
Karnataka, India
joy.rakesh@mca.christuniversity.in

R Kavitha
Dept. of Computer Science
CHRIST (Deemed to be University)
Bangalore-29
Karnataka, India
kavitha.r@christuniversity.in

Abstract— The usage of smart devices using sensors made modern day life more easy and convenient. In a smart home, heating, ventilation and air condition are maintained with respect to ambiance inside the home. A smart home is a residence where sensors control all the electronic appliances, monitors the environment, generates data, analyze the data and acts accordingly by the operation installed by the owner. In this research paper, the important sensors which are used to build a smart home are discussed. The usage and functionality of commonly used ten sensors namely PIR, RFID, Light sensor, Temperature sensor, Water sensor, Motion sensor, Gas sensor, Gyroscope and Accelerometer, Pressure sensor and current sensor are discussed in this paper. The main aim in discussing the above-mentioned sensors is to describe which sensors played a major part in developing the smart homes.

Keywords— Smart home, Internet of things, PIR, RFID, Light Sensor, Temperature Sensor, Water Sensor, Motion Sensor, Gas Sensor, Gyroscope and Accelerometer, Pressure Sensor, Current Sensor.

I. INTRODUCTION

A smart home is a home that consists of smart appliances and electronic devices which are controlled remotely with the help of sensors. The reason for smart home become popular is, the sensors are easily available. The sensors can be categorized into two type namely environmental and wearable sensors. In a smart home environmental sensors are used to detect the change that is taking place within the home environment. Example for the environmental sensor is a motion sensor which detects motion of any human objects based on the movement. The wearable sensor can be worn on as an object which helps to locate the owner's location within the home.

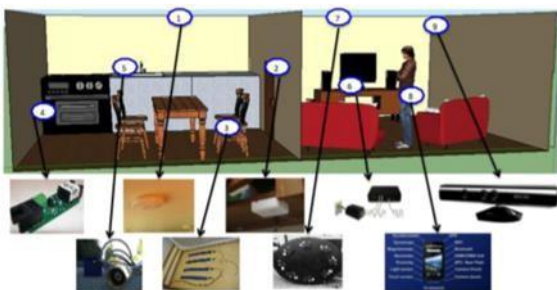


Fig. 1. Smart Home model [16]

An important application of smart homes is automation, that allows the house owners peace of mind by monitoring the environment remotely without any human interaction. It is also helpful for the elderly by monitor and informs continuously to the hospital and nursing homes during critical health conditions. The sensors act as the sensing organism of smart home technology. Each operation is

monitored by the sensors which are installed in the required area inside the smart homes. Fig. 1 shows the smart home model [16]. In this model PIR sensor is used to detect the movement of an object. This sensor uses heat-based movements to detect human. The collected data is sent to server and message is generated when an unusual event occurs. RFID is used to register the object when it is present within the range. The RFID tags can be used to detect a malfunction in the objects. This model is designed to observe human behavior in a home environment using connected sensors.

II. SENSORS USED IN SMART HOMES

There are many different sensors can be used to measure temperature, light, humidity, movements etc. Environmental monitoring services are provided through the use of carbon monoxide sensors. Sensors play a major role in identifying fall detection using images and videos from the data received from various sensors. Blood pressure, electrocardiogram, and saturation of peripheral oxygen can also be monitored using wearable sensors. Various home automation services are achieved using gas sensors, magnetic sensors, movement sensors, and video cameras etc. When it comes to home security services sensors such as camera and infrared sensors are used to monitor and to detect intrusion. The major roles of the sensors are location recognition and smart lighting using a motion sensor to detect movement of an object. Another major application is smart lighting which uses cadmium sulfide (CdS) sensor to measure the amount of brightness present inside the house. Devices such as smart plugs and smart switches use motion sensors, CdS, and touch sensors [16].

III. TYPES OF SENSORS

A. PASSIVE INFRARED SENSOR

The security services in smart homes like burglar alarms, finding the movements of unauthorized objects such as people, animals and other objects inside the house premises are implemented using a passive infrared sensor (PIR sensor). Fig. 2 shows the model of a PIR sensor. PIR sensor is an electronic sensor which identifies the infrared (IR) rays radiating from the object near to its view range. PIR base motion detectors are built using this sensor. This sensor works in such a way that in a real world environment all the objects whose temperature is above absolute zero produces heat energy in the form of radiation. This radiation is usually not visible to humans but can be detected using such sensors. As the name suggests passive, PIR sensor does not emit or radiate rays for detection purpose. PIR sensor is used in motion detection which emits or reflects infrared radiation

from the objects. PIR sensor is best and preferred for home environment since they can work all the time even at night times. These sensors are placed near doors and windows where if an intruder comes into the house without authorization. These sensors can also be used to detect the opening and closing of doors and windows. PIR sensors are not used to measure or detect heat. They are used to in finding movements of an object [2].

In smart homes, all the PIR sensors are connected in one network which will automatically detect the ambient condition of the environment. A smart home model [9] is proposed with the IR sensor to achieve home automation. This changes human life easier by controlling home appliances such as lights, fans etc. The proposed model monitor and informs the owner the amount of energy consumed by all the appliances in the home.



Fig. 2. Passive Infrared sensor [2]

B. RADIO-FREQUENCY IDENTIFICATION (RFID)

Radio-frequency identification (RFID) sensor is used to track an object automatically. Fig. 3 shows the RFID sensor. It identifies an object with the help of tags fixed on the objects. These tags are programmed electronically and data is stored inside the tags for a specific purpose. There are two types of RFID tags. Passive and Active tags. The main difference between these tags is Passive tags collect data from a nearby RFID reader's emitting radio waves. In active tags, a local power source such as a battery is used which is used to operate hundreds of meters from the RFID reader. Here the major difference between active and passive sensors in the range. This tags need not be visible for the reader to detect and collect data rather it can be embedded within to track the objects. The major application of RFID is Automatic Identification of objects and Data Capture. RFID sensors are used in a smart home to monitor the status of movement of objects, collecting required information with respect to the movements and processing that data to the connected network. Today RFID plays an important role in indoor localization based on being able to monitor the subjects and objects present in the indoor environment. RFID is a sensor which is flexible, convenient, and energy efficiency within the local environment [3].

Security plays a vital role in smart home application. The proposed model [10] explains the automation of door locks and lighting system using RFID in smart homes. This model uses a RFID sensor and PIR sensors. In this model components such as keypad 4x4 and RFID tags are used to authenticate the user. If the data/password entered and if the RFID tag is within the range then doors open automatically. Then the

buzzers will detect the doors opening and automatically switch on the light. The light will also turn on automatically if the room is dark. This makes the home environment automated and secure depending on the ambience.

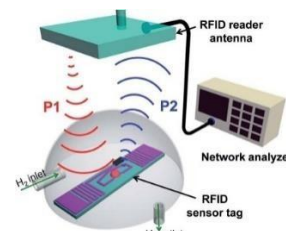


Fig. 3. Radio Frequency Identification Sensors [3]

C. LIGHT SENSOR

The major aim of smart home automation is saving energy. The lighting levels in the room are mainly controlled with the help of lighting available from natural sources. The light sensor plays a major role in building up a smart home. This sensor is majorly used to detect the ambient level of the current environment and also detect an amount of light required. So that it can automatically increase or decrease the brightness of the light in that environment. There are different light sensors available in the market today such as Photoresistors, Photodiodes, and Phototransistors. Fig. 4 shows the usage of a light sensor. Light sensors can save a lot of money and can be applied in home security also. Suppose when the owner accidentally leaves the light and in the room. A light sensor comes into the picture. A light sensor can turn off the lights automatically if there is no movement of objects present. This will save money and avoid wastage of electricity. The frequency of the light sensor is to measure in the form of light spectrum which consists of infrared to visible to ultraviolet light [4].

The main reason for energy consumption in the proposed model in [11] is the light sensor. The light sensor installed inside the smart home is controlled from outside wirelessly with the help of a cloud database. The sensors generate data of the house such as temperature, humidity, luminosity and the wireless sensor which helps to store it in cloud database. The data can be viewed from the web in the form of graphs. This model comes up with wireless control of smart home devices from the outside world.



Fig. 4. Light sensor [4]

D. TEMPERATURE SENSOR

Temperature is most often measured under environmental condition. Temperature can be sensed either

through direct contact with the heating source. There are various types of temperature sensors such as Thermocouples, Thermistors, Resistance Temperature Detectors (RTDs), Semiconductor Sensors are available in the market. The thermistor is a temperature sensing device whose resistance changes with temperature. A temperature sensor can be used for many applications based on accuracy, reliability and timely update. This sensor plays an important role in monitoring the temperature of the environment where it is placed in. If the temperature exceeds the threshold value then preventive action should be taken by the system to lower the temperature. In a smart home this is very useful in fire alarm notification if any fire casualties occur [5].

In a smart home, the data collected from sensors like temperature is useful for automation. In the proposed model in [12], the data such as temperature, humidity, and light are sent to the main home controller device. This model comes up with the advantage of collecting and monitoring data in real-time environment. As mentioned in [9] the data collected from the temperature sensor are used to make the model more intelligent by controlling the device and environment.



Fig. 5. Temperature sensor [5]

E. WATER SENSOR

Water sensor is also known as level sensing sensor. It measures a level of flow substance such as liquids, granular material, and slurries. However, the sensor is the sensing device can detect a level of flow of liquid within a specific range defined. Water sensors are of many types such as pressure transducers, bubblers, float sensors, ultrasonic sensors. Fig. 6 shows an image of a water sensor. In smart homes, water sensors can be placed in water tanks so that overflow of water can be stopped. Water sensor can be placed in a washing machine, dishwasher, and water supply lines. For frequent checking before a major issue occurs the water sensor can be placed in such potential areas of the smart home [8].

Water is so essential for all human beings to survive. Unfortunately, people forget to turn off the water tap, so there is a wastage of water. Sometimes this problem can cause serious flooding issues inside the house. In this proposed model [13] when the tube is full of water, a signal is sent to the smart home controller and it automatically stops the overflow. In this model ultrasonic sensor is used to check the water tube is full or not.



Fig. 6. Water sensor [8]

F. MOTION SENSOR

Motion sensors play an important role in smart home technology with numerous applications. It works on the fundamental principle of radar in ultrasonic waves. Samuel Bango is the inventor of a motion detector. Even today motion detector's works on the same principle. Motion sensors are placed in banks, offices, and home for intruder detection. The image of the motion sensor is shown in Fig 7. These motion detectors can stop major accidents by sensing the persons who are in close proximity to the device. Motion sensors are used to open doors automatically in homes and shopping malls, by detecting an object coming close to the sensor. Motion detector devices are built with multiple other sensors such as an ultrasonic sensor, microwave sensor, PIR sensor. A certain spectrum is fixed with respect to an ultrasonic sensor when this spectrum is disrupted a no connection sound wave is created. This is majorly used in home security purposes. [7]

In a recent development in smart home implementation, the focus is on to energy management. The proposed model in [14] which predict is the energy consumed pattern based on the location and with the help of LED smart switch. A sensor is embedded within a switch to monitor active and passive movement. The smart switches locate the user with the help of internetwork switch connection.



Fig. 7. Motion sensor [7]

G. GAS SENSOR

A Gas sensor used in smart home devices to detect the leakage of gases within an environment, for safety reasons. The detectors are built with sensors to detects a leak in gases, it is interfaced with the home system so that it automatically shutdowns the system without causing any casualties. Gas detectors can also be applied as an alarm so that if there's a leak of gases it notify the people in that area to leave the premises. [6]The image of the gas sensor is shown in Fig. 8.

A smart home model [9] continuously checks the amount of gas in the gas cylinder. It is lesser than the threshold value it automatically books the cylinder and the reference number is sent to the owner.

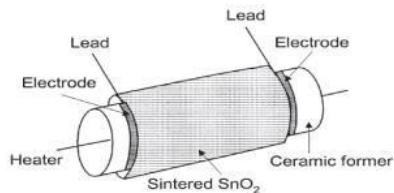


Fig. 8. Gas sensor [6]

H. GYROSCOPE AND ACCELEROMETER

The gyroscope is a sensor which is used for measurement of angular velocity and navigation. Gyroscopes can also measure values from X, Y, Z direction. The also 3 axis gyroscope is often implemented with the accelerometer to provide full six degrees of freedom of motion tracking system.

Gyroscope has evolved from mechanical inertial spinning devices consisting of rotors, axles. Each sensor exploits some physical property in the system allowing it to detect rotational velocity about some axis. There are many events related to trigger a present event based on a set of motions by the user. For example, unlocking the phone by shaking it. Fig. 9 shows the image of Gyroscope.

Few applications of the gyroscope are camera app used to capture pictures and videos are used to remove vibrations. Mobile games with angular motions which is used to apply 3d motion for smooth rotation and execution of various commands, Auto rotation of the phone is one of the main applications of a gyroscope [18].

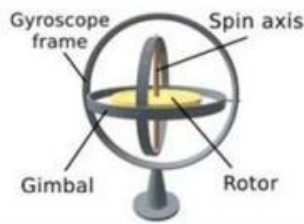


Fig. 9. Gyroscope [18]

Smart homes are not only built for automation but the companies and researcher mainly concentrate on health care. In this proposed model [15] taking care of the elderly is been applied with the help of accelerometer. The model [15] proposes a system that recognizes real-time activities of the resident and errors of the resident. Here the outcome is based on the data which is been generated by this model which is further compared with clinical data gathered from previous experiments.

I. PRESSURE SENSOR

The Pressure sensor is mainly used to measure gases and fluids. Pressure can be defined as the force required to stop fluid from expanding. It is also stated as force per unit area. Fig. 10 shows the usage of a pressure sensor. The main application of the pressure sensor is to generate a signal when the pressure is imposed on it. A pressure sensor is used to measure the flow, speed, altitude, and level of fluid and gases. It is mainly used in the fields such as automobiles, aircraft and weather instrumentation. Altitude

sensing used in rockets and satellites and weather balloons [19].



Fig. 10. Pressure sensor [19]

Smart homes are installed with many electronic devices which consumes power such as air conditioning system. The proposed model [16] discusses a solution that includes a micro electro mechanical system using a pressure sensor with an analog to digital converter. This model proposes a way to reduce energy consumption.

J. CURRENT SENSOR

Current sensor is used in smart homes to detect electric flow of current. A signal is generated proportional to current. The voltage generated by this sensor can be analog or digital output. Ammeter is used to display current from the generated signal. The sensed current can be altering current input, analog output or digital output which changes when sensed current exceeds a threshold value [20].



Fig 10. Current sensor [20]

This model proposed in [17] is designed to measure current in closed conductors. The model consists of magnetic field sensor, a simple communication scheme and algorithms to compute the conductor current based on magnetic field measured. The model [17] is built to measure current in residential homes. They created an alternative platform to save home energy usage.

IV. APPLICATIONS OF SENSORS IN SMART HOME

Smart homes are built using various sensors that are available in the market. In a smart home all sensors are connected as one network which detects the ambient condition of the environment automatically. A smart home model with multiple sensors changes human life easier by controlling home appliances. Table 1 shows the different smart home applications, usage and sensors used in that corresponding application.

TABLE I. DIFFERENT SMART HOME APPLICATIONS, USAGE AND SENSORS USED.

<i>Smart Home Application</i>	<i>Usage</i>	<i>Sensors</i>
Energy Management [17]	To save power.	PIR, Light, Temperature, Humidity.
Home Security System [16]	Secure the premises from unauthorized entry.	Camera, IR sensor.
Health Care [15]	Identify fall detection	Camera, Accelerometer, Gyroscope.
Smart Lighting System [14]	On/Off light automatic adjustment of the brightness.	Light sensor (CDS), Motion sensor.
Environment Monitoring System [1]	Sense light, temperature, motion and gas present and adjust accordingly.	Temperature, Light, Motion, Gas sensor.
Location recognition [15]	Locate the presence of an object	PIR

V. CONCLUSION

The advanced technologies in smart home models have developed importance of understanding the working principles of various sensors. This paper discusses the different sensors used in smart home and their applications. Selection of the correct sensor plays an important role in the smart home model. It increases the performance of a smart home. The selection of the sensor varies from one application to another. This paper explained the working of ten different sensors which are used commonly in smart home implementation. As a future work, an efficient smart home will be designed using the best sensors which will serve the purpose.

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