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Detailed Survey on Motion Sensing

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Abstract: **Motion sensing is the technique in which a system detects a change in position of an object with respect to its surroundings. This paper gives an overview of motion sensors and its applications, and a brief survey on the problems associated with them.**

1. INTRODUCTION

Motion sensing is the process of detecting a change in position of an object with respect to its surroundings, or, change in the surroundings with respect to the object.

Motion can be sensed in several ways:

i. Infrared sensing using passive or active sensors
ii. Vibration sensing using seismic sensors
iii. Sound sensing using acoustic sensors and microphones
iv. Optics sensing using video camera systems
v. Sensing with the help of flow of current
vi. Ultrasonic Sensing using ultrasonic transmitters and receivers.

Motion sensing is classified into following types:

i. Local motion sensing: An infrared motion detector detects motion in a given area
ii. Ultrasonic motion sensing: It uses sound waves to detect motion
iii. Microwave motion sensing: Such systems send out microwaves that bounce off an object and return to the sensors.
iv. Video motion sensing: Such systems use frames from video feed to detect change in motion by comparing multiple concurrent frames.

2. HISTORY

[1]Though the study of what would become radar began in the late-19th century, it was World War II that refined it to a useful detection technology. The use of radar made it possible to detect aircraft, and eventually undersea aggressors, before they could become dangerous to targets. This early use of radar was strictly confined to military applications.

As the war wound down, Samuel Bagno used his knowledge of radar to develop the first motion sensors in the mid-1940s. He called his invention an ultrasonic alarm. The device sent ultrasonic waves throughout a room. When something disrupted the waves, a return echo triggered the alarm. This first success of a non-military application of radar created a commercial demand for more ways to harness radar technology.

The 1970s saw motion sensors integrated into alarm systems. These alarm systems continued to use the principles of Bagno's ultrasonic technology. A sensor emitted an ultrasonic signal and detected changes in the echo. If a change was detected, the sensor notified the alarm system's control panel. The problem was that false alarms were common. The simplest things like a phone ringing or clock chiming could change the ultrasonic wave's echo enough that the alarm sounded.

Infrared motion sensor began replacing radar sensor in the 1980s. Initially, the devices were expensive, but as their uses expanded, the prices became more attractive; in turn, the use of infrared sensors compounded.

3. MOTION SENSORS

Any system used to detect motion related to a person or object is termed as motion sensor. The trigger is an electronic signal that is also a response generated by the sensor. Every sensor has a normal state, and the motion sensor is triggered when it is disturbed. Some sensors report not only the disturbance but also when the sensor returns to its normal state.

How motion is sensed can be depicted below:

i.[2]Generation of a stimuli and sensing of its reflection.

In this method the sensor sends some kind of stimuli (rays) and works on the principle of reflection. When these rays strike the object to be detected they are reflected back and this enable the motion sensor to detect the presence or motion of the object.

Or

ii.[2] Sensing of the signals generated by the object

In this method the motion sensor senses the signal generated by the object to be detected that is when an object comes in range of the motion sensor that signals from the body of the object triggers the motion sensor. These signals are nothing but the body heat of the object. The motion sensors detect this heat or temperature as it differs from that of the surrounding hence triggering the sensor.

Sensors have the following specifications:

a) Accuracy: error between result of a measurement and its true value

b) Resolution: smallest increment of a measure that a device can make

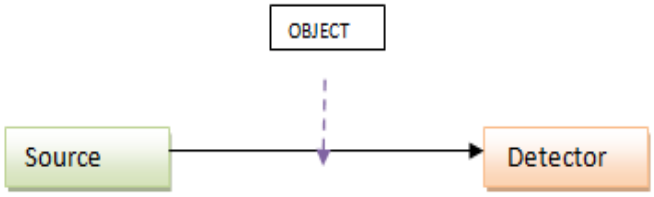
c) Sensitivity: ratio between the changes in the output signal to a small change in physical input signal

d) Repeatability/Precision: ability of the sensor to output the same value for the same input as many times as provided

4. TYPES OF MOTION SENSING

4.1 Local Sensing

It means that the sensing area is defined, that is, the motion sensor is active only for some designated area.



[5]Fig 1: Fig. showing detection of object due to obstruction of light

Some of the motion sensors commonly used for this purpose are

4.1.1 Visible/infrared light beam based motion detectors

It follows Break Beam principle, that is, a light source transmits a beam towards a distant receiver creating an "electronic fence". When an object gets in the way of this beam fence or obstructs this beam, the circuit breaks, the detector is unable to receive the beam transmitted from the source hence the detector triggers the electronic circuit or alarm connected to it.

4.1.2. Contact switch based motion detectors

In this type of detectors the object makes contact with the switch that completes the circuit and triggers the alarm. For example, suppose a contact switch is placed under the mat and in this state the circuit is open. When a person steps on it the circuit completes and the alarm gets triggered.

4.1.3 Piezoelectric/Piezoresistive sensors based motion detectors

Piezoelectric sensors generate electrical signals on application of pressure. That is when an object is placed over this sensor or a person steps over it, that application of pressure generates an electrical signal that sets off the alarm.

Piezoresistive sensors change their resistance on application of pressure. This change in resistance is used for measuring the pressure applied that is when a person steps on it or an object is placed over it. This change in pressure generated by measuring the resistance triggers the alarm.

4.2 Motion sensing in an area

[2]This is the kind of motion sensing in which the area to be sensed is not defined that is it is not bounded under a designated area. Sensors commonly used for this purpose are as follows:

4.2.1 Active Infrared (IR) motion detectors

These kinds of sensors work in accordance with the source of the radiation radiating out the IR. Measuring the temperature difference that is created by the presence of the foreign object with respect to the surroundings but only if the foreign object passes through the field of the IR waves generated by the source triggers these motion sensors.

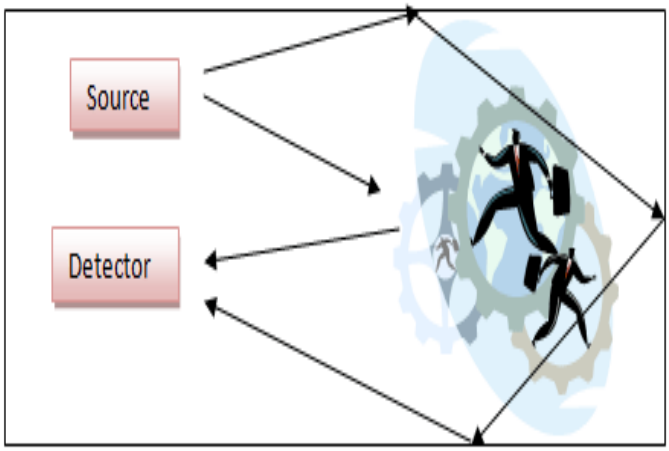
This type of sensor gets restricted to only the specific range where the radiation field exists. Hence it can be used in places such as front yards and doorways.

4.2.2. Passive IR Sensors

This kind of sensors works on the principle same as the Active IR sensors but they have no source of radiation. They have sensors instead, which sense the change in the temperature, that is, IR of the surrounding area. When any foreign object in introduced to this surrounding the heat or the IR from that object disrupts the existing temperature maintained by the surroundings. This sensor thus triggering the alarm senses this change. They are called passive because they sense the heat instead of emitting it.

4.3 Ultrasonic Motion Detectors

[2]The ultrasound transmitter emits ultrasound waves into sensor ambient space continuously. These waves reflect from various objects and are reaching ultrasound receiver. There is a constant interference figure if no moving objects are in the placement.



[6]**Fig 2: Fig. showing basic operation principle of ultrasonic sensors**

4.3.1 Times of Flight Method

In this method of ultra-sonic motion detection there is an electrostatic transducer which acts as both speaker and microphone. This transducer transmits a burst of electronic pulses, and these pulses when hit an object are reflected back. This transducer that also plays the role of the microphone detects this pulse after reflection. The delay in the time or the difference in the crest of the pulse transmitted and the pulse received is measured and accordingly with respect to the speed of sound the distance to the object can be measured.

4.3.2 Doppler Effect Based

Doppler effect states that when the sound or a light wave is reflected back from a moving object the frequency of the wave decreases with respect to the transmitted wave if the object is moving away from the source of the wave and the frequency increases if the object is moving toward the source.

5. APPLICATION AREAS

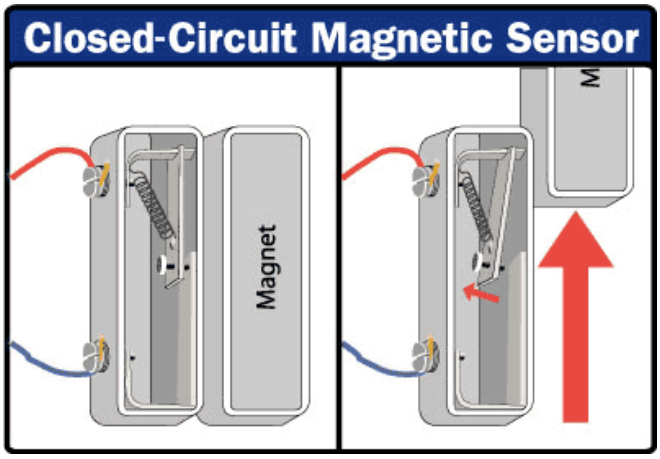
5.1 Automated Lightning System

a. Automated lighting control uses motion sensors to dim or turn off lights when a room is unoccupied.

b. With one touch initiate a "Goodnight" scene to deactivate all interior lights as exterior floodlighting is turned on.

5.2 Security Systems

[4] In a closed-circuit system, the electric circuit is closed when the door is shut. This means that as long as the door is closed, electricity can flow from one end of the circuit to the other. But if somebody opens the door, the circuit is opened, and electricity can't flow. This triggers an alarm.



[7]**Fig 3: Fig. showing closed circuit magnetic sensor's working**

In an open-circuit system, opening the door closes the circuit, so electricity begins to flow. In this system, the alarm is triggered when the circuit is completed.

5.3 Cell Phones

An accelerometer is used in cell phones which is a complex motion sensor. It translates motion into action on screen. It is typically used so that images on tablets and cell phone screens are displayed in an upright manner. It is also used in video games to detect tilt and appropriately, control the motion of the player.

5.4 Video Games

The primary innovation in sensitive motion gaming is in areas that enable advanced posture, gesture, facial and voice recognition

6. PROBLEMS FACED

Motion sensing, though a breakthrough technology, faces several challenges as of now; which can be stated as follows:

6.1 Sensor Obstruction

If the sensor is blocked, it cannot detect any motion within its range. This blockage could be as trivial as an insect resting on the motion sensor.

6.2 Dirty Sensor

Sensors exposed to external environment are highly prone to becoming dirty, which has the same effect as a blockage.

6.3 False Motion

Any type of motion could trigger an alarm. So if a curtain blows or a window shuts close due to a windy day, the sensors detect that and can raise an unwanted alarm.

6.4 False Heat Signature

Instead of being triggered by natural motion, some sensors are triggered by change in temperature of the surroundings. In such a system, if there is a fireplace, the alarm could trigger unnecessarily.

6.5 Battery Life

Life of a motion sensor is entirely dependent on the batteries, in case they are powered by them.

6.6 False Daylight

On several security lights, sensors save on battery life by switching off when the light in a given area approximates daylight. So if sometimes, at night, a security light fails to get switched on, it could be because of another source of life triggering the shutdown.

7. FUTURE OF MOTION SENSING

7.1 Acceleration, vibration, shock, tilt, and rotation

[3]All except rotation are actually different modes of acceleration over different periods of time. Considering each mode separately helps in envisioning more possibilities.

a. Acceleration measures the change in velocity per unit time.
b. Vibration is the acceleration and deceleration that happens quickly in a periodic manner.
c. Shock is an acceleration that occurs instantaneously or a non-periodic vibration.
d. Tilting can be considered as the movement of an object or changing the axis of the object with respect to the earth and the force acting upon it is gravity hence it is also a case of acceleration.
e. Rotation is the measure of angular rate motion. And this might take place without any change in velocity hence without acceleration or deceleration.

7.2 Acceleration in Usability and Power Management

a. Sense the movement and generate interrupt in radio for military and public safety personnel.

b. To keep communication secure. Various combinations of functions can be kept active or put into the lowest power state possible according to their usage sensed by the accelerometer.

c. Automation of external defibrillators is done by measuring the distance between the chest and the pads of ED. The acceleration between the pad and the chest during cardiac arrest can be measured and accordingly the pressure can be applied.

7.3 Vibration for Monitoring and Energy Saving

[3]Very Small accelerometers with very wide bandwidth are ideal for measuring vibration in motors, fans, and compressors.

Measuring changes in equipment's vibration patterns can be used to detect energy efficiency.

7.4 Shock, Gesture Recognition, and More

[3]Shocks in the form of taps, double-taps, or shakes, allows users to activate different features adjust the mode of operation of the device.

Disk Drive protection is found in many Notebook PC's that protects the drive from external shocks.

The accelerometers can fit into small medical aid devices such as hearing aid thus making the user interaction hassle free.

7.5 Tilt Sensing for precision Operation

[3]Used in construction or industrial inspection equipment.

Used in compensating the position of a device. For example, compass in GPS or mobile handset.

7.6 Rotation: Gyroscope and IMUs in Action

[3]Inertial measurement units have been introduced which increases the accuracy. Refinement in medical imaging equipment, surgical instrumentation, advanced prosthetics, and automated guidance for industrial vehicles.

8. CONCLUSION

Motion sensing is a recent technology that has shown massive development over the decades. With the advent of technology, it has been tested and applied in several domain areas such as security, gaming, cell phones, and cars. There are certain issues faced when using motion sensors. Motion sensing has further scope in areas that focus on acceleration, vibration, shock, tilt etc.

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