RESEARCH ON DATA ACQUISITION FOR A MOVING POINT

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ABSTRACT: The study presents research on determining the real-time position of a moving object. An HC-SR04 ultrasonic sensor, configured on an Arduino development board, was used to determine its position. In the first application, the sensor was used to count parts or products that pass through a drive belt in a production unit. In the second application, the sensor was used to measure the level of filling in a pool. The sensor was mounted above the pool. The fill percentage was displayed in the Serial Monitor window of the Arduino software. The results of the study aimed to identify a solution for monitoring an object / point in real time at a low cost.

KEYWORDS: movement, sensor, ultrasounds, infrared.

1. Introduction

The term of sensor has become more frequently used with the development of robots, as well as complex measurement / monitoring systems. These are devices that convert a physical quantity into an information signal that can be mechanical, optical or electrical. The next step after conversion is to enter the information into a computer or microprocessor to be processed, analyzed, and, if necessary, displayed or sent as a control signal for other circuits. [1].

Systems using sensors can be divided into [1]:

- measurement systems - where a quantity or property is measured and its value is displayed;
- control systems - information is used to meet certain criteria.

Motion sensors are electrical devices that detect nearby movements. These devices are usually integrated as a component of a system that performs tasks automatically or provides signals to a user in a particular area. They are an important component for security systems, automatic lighting systems, home control, energy efficiency and other useful systems.

Motion sensors have a wide range of uses and the most common are those used in anti-burglary systems. Motion sensors help maintain the quality of life for people with disabilities, being used in applications such as door openers, also motion sensors ensure the security of properties by detecting movement [2].

Two types of sensors are used to control lighting installations. These sensors for intelligent home lighting control are [2]:

- radar motion sensor (high frequency);
- passive infrared motion sensor (PIR);
- microwave sensor;
- ultrasonic sensor;
- tomographic motion sensor;
- photodetectors.

A passive infrared sensor is an electronic device that measures infrared radiation from objects in its field of vision. Motion is detected when a body with a certain temperature passes in front of the infrared source with a different temperature, such as a wall. This means that the sensor detects heat from passing an object through the sensor's field of action, and that object breaks the field that the sensor previously determined to be "normal." Any object, even one of the same temperature as the surrounding objects will activate the PIR sensor if the body moves in the visual field of the sensor [3].

All bodies emit energy in the form of radiation. Infrared radiation is invisible to the human eye, but can be detected by electronic devices designed for this purpose [4].

Ultrasound is a mechanical vibration with frequencies higher than 20,000 Hz. They are usually of low intensity. High intensity ultrasound is obtained by electromechanical processes that are based on the piezoelectric phenomenon and / or the magnetostriction phenomenon [5].

The so-called radar motion sensors, also called ultrasonic sensors or high frequency sensors, work by transmitting high frequency sound waves, which scan the surrounding objects and transmit environmental information to the sensor. The motion detected in the sensor's field of action disturbs the pattern of the reflected waves and activates the sensor. The ultrasonic motion sensor emits high frequency sound waves not perceptible to human hearing [4].

2. The current stage

The biggest advantage of the high frequency motion sensor is also the biggest disadvantage. HF sensors are sensitive to any movement, not just human movements, and can therefore create false alarms. When HF sensors are used for light control, the lights may turn on even if no one is in the field of view of the sensor.

HF sensors have similar coverage to infrared motion (PIR) sensors. HF sensors have a range of 3 meters in height and 8 meters in length [4].

HF sensors can have built-in dual technology, meaning that in addition to the HF sensor, a PIR sensor is included. Dual technology sensors use the PIR sensor which has a moderate sensitivity over long distances and the HF sensor which has a high sensitivity over short distances. Together the HF and PIR sensors improve the overall detection capability [4].

Another advantage / disadvantage of the HF sensor is that it detects motion through solid objects (glass, wall). In areas where there is no direct view, the sensor can detect movement. In this case, the fact that the sensor detects motion through solid objects is an advantage. If the HF sensor detects movement from an adjacent populated area, the sensor will trigger light from the unpopulated area, creating false alarms [4].

The correct choice and installation of the sensor leads to a viable option for light control in both residential and industrial / commercial areas [4].

3. Principles of operation

Ultrasonic transducers and ultrasonic sensors are devices that generate or detect ultrasonic energy. These can be divided into three broad categories: transmitters, receivers, and transceivers. Transmitters convert electrical signals into ultrasound, receivers convert ultrasound into electrical signals, and transceivers can transmit and receive ultrasound at the same time [6].

Ultrasound can be used to measure the speed and direction of the wind (anemometer), the level of liquid in the tank or channel and the speed through air or water. To measure speed or direction, a device uses multiple detectors and calculates the speed from distances relative to particles in the air or water. To measure the level of the liquid in the tank or channel and also the sea level (tide gauge), the sensor measures the distance in the range to the surface of the fluid. Other applications include: humidifiers, sonar, medical ultrasonography, burglar alarms, non-destructive testing, etc. [6].

The distance to the target is calculated by measuring the duration using equation [9]:

$$d = c * t / 2 \tag{1}$$

where d = distance [m];
c = sound speed [m / s];
t = duration [s].

The systems usually use a transducer that generates sound waves in the ultrasonic field, over 18 kHz, converting the electrical energy into sound, then, upon receiving the echo, transforms the sound waves into electrical energy that can be measured and displayed. Infrared motion sensor (PIR) technology illuminates when a person passes through the sensor's field of view, and the sensor will not turn on the light if a person remains motionless within the sensor's range [3].

Infrared motion sensors are more sensitive on cool days than on hot days. This is due to the fact that the temperature difference between the ambient air and the human body is larger on cold days, the sensor easily noticing the temperature difference. This has its disadvantages, if the sensor is too sensitive, the sensor will also detect the movement of small animals creating false alarms, unnecessary lighting. The optimum operating temperature of the motion sensor for luminaires is between 15°-20° C. At temperatures above 30° C, the sensitivity of the sensor will decrease and infrared emissions will be more difficult to detect [3].

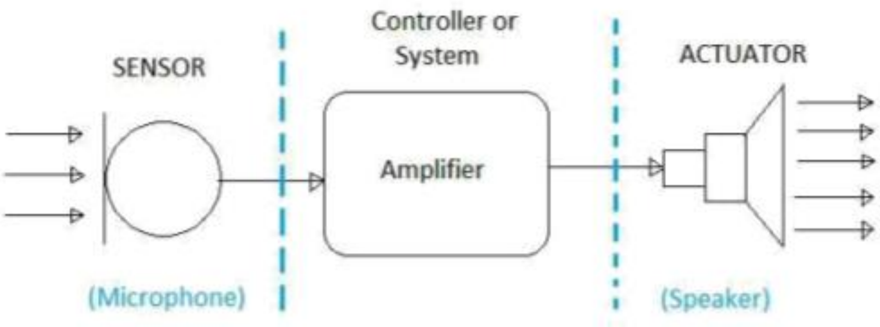

Fig. 1. Principle of operation of a sensor system [7]

4. Using the ultrasonic sensor to measure batches of parts

The sensor systems assist the production of cars with innovative technology and high quality standards. Temperature, pressure, fill level and flow sensors reliably monitor process environments. Optical barriers, optical safety curtains and inductive safety sensors guarantee the safety of machines and people, for example in the presses, robot cells and mounting stations. The positions of the machine components are accurately detected by inductive, capacitive, optoelectronic and cylinder sensors. Vibration monitoring systems are available for state-of-the-art machine tool maintenance [9].

The ultrasonic sensor will count the parts that will pass on a conveyor belt. For this application we used an ultrasonic sensor HC-SR04. Table 1 shows the sensor’s specifications.

Tabel 1. Specifications of HC-SR04 ultrasonic [8]

Supply voltage [V]	Electricity consumed [mA]	Operating distance [cm]	Operating frequency [KHz]	Measurement angle	Error [mm]	Input signal duration [μs]	Dimensions [mm]
5	15	2-400	40	15˚	±3mm	10μs	45x20x15

Fig. 2. HC-SR04 ultrasonic distance [8]

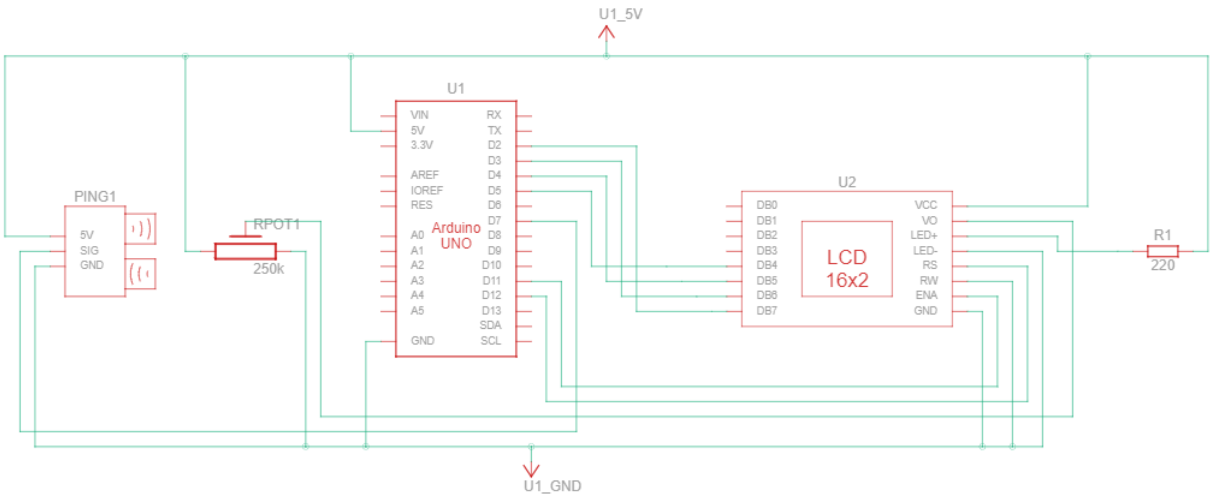

Fig. 3. Wiring diagram of the application

This system can be used for production lines where the drive belt through which the parts or products pass has a width of up to 3.5m. The sensor will be positioned sideways facing the drive belt and will be able to transmit a signal for each part that passes in front of it regardless of shape, color or material. This number can be displayed either on an LCD screen connected to the Arduino board or in its Serial Monitor window.

sketch_may10a §

```
// C++ code
//
int inches = 0;
int cm = 0;
int currentState = 0;
int previousState = 0;
int counter = 0;
long readUltrasonicDistance(int triggerPin, int echoPin)
{
  pinMode(triggerPin, OUTPUT);  // eliberam transmitatorul
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(triggerPin, LOW);
  pinMode(echoPin, INPUT);
  return pulseIn(echoPin, HIGH);
}
void setup()
{
  Serial.begin(9600);
}
```

```
void loop()
{
  // transformam timpul de reactie in centimetri
  cm = 0.01723 * readUltrasonicDistance(2, 3);

  if (cm <= 20) {
    currentState=1;
  }
  else {
    currentState=0;
  }
  if(currentState != previousState) {
    if(currentState == 1){
  counter = counter + 1;
  Serial.println(counter);
}
  delay(1000);
}

}
```

Done uploading.

Fig. 4. Code sequence used

5. Non-contact and continuous measurement of filling level

Important applications of ultrasonic sensors include measuring the level of filling in tanks or silos. Whether it is a vessel containing liquids or bulk products, these measurements are always reliable and accurate. Particularly aggressive agents and vapors encountered in certain applications can be a major challenge for many sensors [9].

The ultrasonic signaling device is non-contact and wireless, so it can be used even in aggressive and explosive environments. After the initial configuration, such a sensor does not require any specialized maintenance, and the absence of moving parts significantly prolongs the life [10].

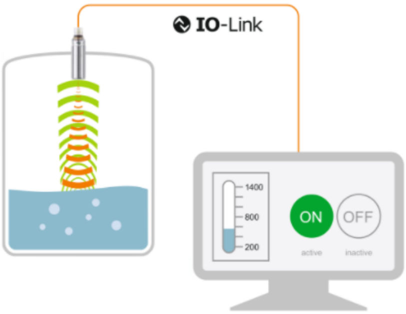

Fig. 5. Filling level measurement system [9]

The same sensor was used for this application as in the previous application. The ultrasonic sensor will be positioned at the top of the container and the waves will be reflected from its contents. To avoid errors, different adapters can be attached to the sensor depending on the shape and size of the container.

sketch_may10a §

```
// C++ code
//
int inches = 0;
int cm = 0;
long readUltrasonicDistance(int triggerPin, int echoPin)
{
  pinMode(triggerPin, OUTPUT);  // eliberam transmitator
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(triggerPin, LOW);
  pinMode(echoPin, INPUT);
  return pulseIn(echoPin, HIGH);
}
void setup()
{
  Serial.begin(9600);
}
```

```
void loop()
{
  // transformam timpul de reactie in centimetri
  cm = 0.01723 * readUltrasonicDistance(2, 3);

  if (cm<16){
    Serial.println("100%");
  }
  else if(cm<17){
    Serial.println("75%");
  }
  else if(cm<18){
    Serial.println("50%");
  }
  else if(cm<19){
    Serial.println("25%");
  }
  else {
    Serial.println("0%");
  }

  delay(100); // Wait for 100 millisecond(s)
}
```

Fig. 6. Code sequence used

6. Conclusions

Ultrasonic sensors can detect the movement of targets and can measure the distance to them in many automated factories and processing plants, which makes the choice of these types of sensors feasible for various industrial applications.

Although some ultrasonic sensors are widely used in the automotive industry as parking sensors, they are being tested for a number of other uses in the automotive field and beyond.

Because ultrasonic sensors use sound rather than light for detection, they work in applications where photoelectric sensors cannot operate. Ultrasound is an excellent solution for detecting clear objects and measuring liquid levels, applications that photoelectricians struggle with due to the transparency of the target. Also, the target color or reflectivity does not affect the ultrasonic sensors, which can operate reliably in high brightness environments [11]. These features give an advantage to these types of sensors for use in detecting a moving object. Passive ultrasonic sensors can also be used to detect high pressure gas or liquid leaks or other hazardous conditions that generate ultrasonic sounds.

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8. Notations

The following symbols are used in the paper:
HF = High frequency;
PIR = Passive infrared;
LCD = Liquid Crystal Display;
Hz = Hertz;
UAV = Unmaned aerial vehicle.