**Australian Journal of Basic and Applied Sciences**, 9(10) Special 2015, Pages: 306-312

ISSN:1991-8178

**Australian Journal of Basic and Applied Sciences**

Journal home page: www.ajbasweb.com

# Intelligence Surveillance and Target Acquisition System Using Ultrasonic Sensor

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**ARTICLE INFO**

***Article history:***
*Received 28 January 2015*
*Accepted 25 February 2015*
*Available online 6 March 2015*

***Keywords:***
*Surveillance system, Ultrasonic sensor, Arduino, Processing 2.*

**ABSTRACT**

This paper presents an "Intelligence Surveillance and Target Acquisition system using Ultrasonic Sensor" which works in unknown and unstructured environment on being connected to a Personal Computer. The system collects the data from ultrasonic sensor to build a multileveled description of the environment around it. To manage the accuracy, sensor collects the range information from multiple points of view which are then integrated into a two-dimensional map using simple and robust method. This helps the system to flawlessly detect any unwanted intrusion in its surrounding and inform instantly. Based on the auto generated information, the user is free to mark at any suspicious object using the two laser pointers mounted over the servo motors. In a nutshell, this system will surely establish itself as a must have indispensible assets in boosting security.



**To Cite This Article:** Debashis Chatterjee, Soumen Mondal, Durgapada Chakraborty, Subashis Biswas., Intelligence Surveillance and Target Acquisition System Using Ultrasonic Sensor. ***Aust. J. Basic & Appl. Sci.,*** *9(10): 306-312, 2015*

## INTRODUCTION

This system employs a novel computer-equipped surveillance system which aims to fulfill several drawbacks of traditional surveillance systems emerging in the field of home security, office security, industrial security and border security (Jun Hou, et al., 2008; Xiangjun Zhu, et al., 2008; Lo Presti, L., M. La Cascia, 2008; Ying-Wen Bai et al., 2013) etc. The system acquires meaningful information from its surroundings and manipulates a two dimensional map of its environment of operation. It offers a 360 degree of coverage which ensures greater scope of detection and motion estimation in untrusted environments. The system is developed with high level of autonomy and also designed in such a way that it can be enhanced with more upgraded features according to the functional requirements. The project involves the complex task of extracting range information from the real world by each ultrasonic sensor distance reading which provides information concerning empty and occupied area in front of the sensor. The collected information is then interpreted using computer software, which explicitly represent a rasterized map of unknown, occupied and empty areas (Alberto Elfes, 1987).

### *II. System Architecture:*

Figure 1 shows the overall concept of the proposed system. The core component of the main controlling unit (MCU) is an Arduino Uno, an open-source physical computing platform based on ATmega328 microcontroller. In this project it is managing the cycle time of the sensor, pre-processing sensor readings, conditioning data from the sensor and communicating with processing2 software in order to provide sensible feedback to the user.

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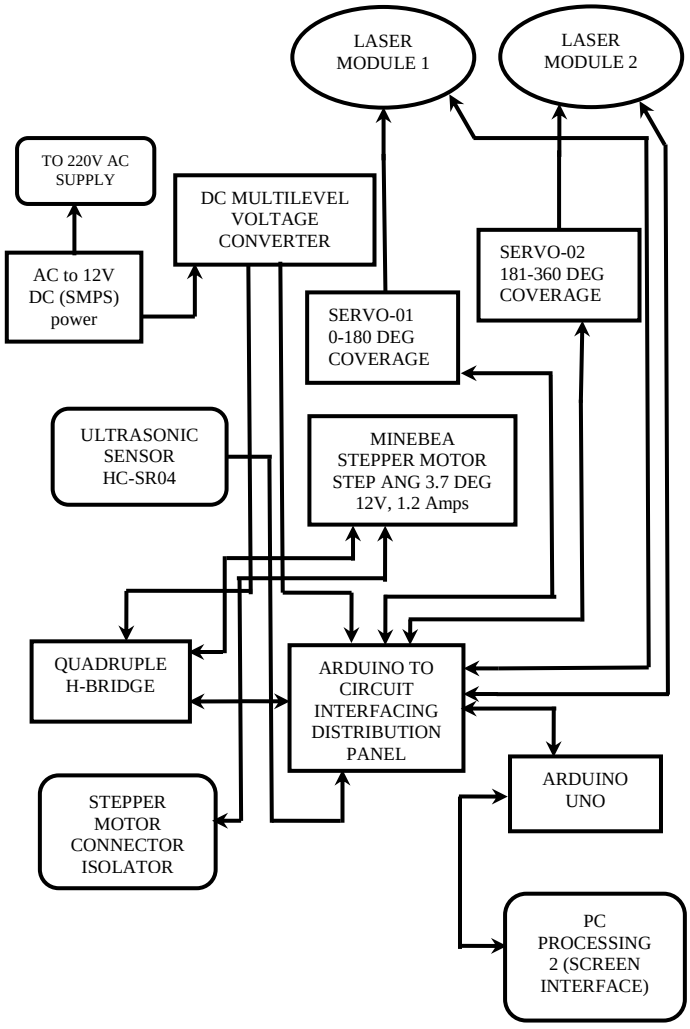


**Fig. 1:** Block diagram of the surveillance system

### *III. Work Methodology*

### *A. Conceptual Working Level:*

The Intelligence Surveillance and Target Acquisition system described in this paper is a wide investigation into issues related to the development of the project. In this section, we briefly outline the conceptual processing levels within which the system performs. The levels include the sensor interpretation, sensor integration real world modelling and control are described below.

*Sensor interpretation*: Data acquisition and its interpretation by sensor module is done on this level, the sensor module used in this project is specialized in extracting specific kind of information from the sensor data which is then sent to the higher levels for processing.

*Sensor integration*: The data and information from the sensor module is aggregated and assertion about the environment is done in this level. For example, the geometric boundaries extracted from an obstacle by the sensor can be used by the software to plot a two dimensional map of the surrounding.

*Real world modelling*: To achieve a substantial degree of autonomy the system should have a proper understanding of its surrounding by creating a rich model of its area of operation. This particular model is based on the information acquired by the ultrasonic sensor, which can be viewed in the computer screen and can be used for several other activities, such as monitoring clockwise and anti-clockwise sweep, target's angel with respect to X axis, target's distance with respect to the center, or grabbing its exact position in X, Y coordinates or Pointing at the desired target with laser pointers.

*Control:* This level is responsible for coordinating all the peripheral devices and data driven activities of the system so that it can work in an integrated manner. This level also handles the user given command on the computer with the hardware of the system.

### *B. Main Controlling Unit With Hardware Peripherals And Software Framework:*

In this section we will briefly outline some of the arduino sketches and relate the present system to its software frame work. To rotate the stepper motor and getting a sensor value, 'runStatus' is set to accept request from the master computer. If run status becomes high then the ultrasonic ranging module HC-SR04 starts scanning. This allows it to detect obstacles in the range of about 3m and at an angle of beam of 360 degrees all around the system when the stepper motor rotates (http://www.elecfreaks.com).

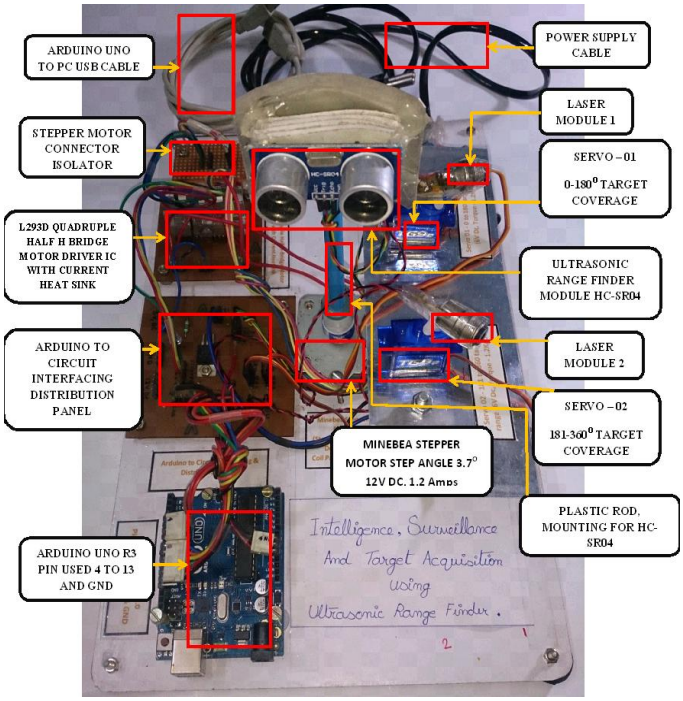


**Fig. 2:** Whole hardware system with Peripherals

The module includes ultrasonic transmitters, receiver and control circuit. It is mounted above the stepper motor at a height of 12 cm by a stiff plastic rod.

```
void loop()
{
  if(Serial.read()== 's')
  {
    runStatus=1;
  }
  while(runStatus==1)
  {
```

The trigger pin of the ultrasonic sensor is made high and a delay of 10 microseconds are used for the signal to return and then the trigger pin is made low and time for the signal to return is calculated and converted to centimeters.

```
digitalWrite(triggerPin, HIGH);
delayMicroseconds(10);
digitalWrite(triggerPin, LOW);
pulseTime = pulseIn(echoPin, HIGH);
distance = (pulseTime/2)/29.1;
```

The stepper motor used in the project is a bipolar ferrite magnet type Minebea 16PU-M202-G1ST whose step angle is $3.75^0$ and operates in 0.6 amps. The shaft or spindle of the stepper motor rotates in clock and counter clock wise direction when electrical command pulses are applied to it in the proper sequence. This is done by L293D quadruple half-H driver IC. To control the stepper motor, both poles of the two coils are used and polarity of the current is reversed which is done by H-bridges which is inbuilt in the IC (http://www.robosoftsystems.co).

To rotate the stepper motor clockwise from 0-360 degrees and trace the obstruction going from left to right.

```
for(stepCount = 0; stepCount < 100; stepCount++)
{
  if(Serial.available())
    moveServo();

  myStepper.step(1);
```

To rotate stepper in anticlockwise from 360 to 0 degrees going from right to Left

```
for(stepCount = 199; stepCount > 99; stepCount--)
{
  if(Serial.available())
    moveServo();
```

The system includes a low cost reliable pair of TURNIGY TG9e micro servo which coordinates with the user interface with the help of the MCU, and each servo is designated with particular sweep angle from (0-180$^o$ and 181-360$^o$). When the user provides the target and clicks the destroy button in the user interface, the angle of the target with respect to zero degrees is obtained. This confirms the MCU as to which servo should be provided with the signal and servo mounted with laser pointer in that range comes into action and they accurately point the static or moving subject in its vicinity (https://www.servocity.com).

To activate the first servo (0-180) degree, and to point the laser attached to it on a suspected object in its vicinity

```
void firel80()
{
  for(i=1;i<=30;i++)
  {
    digitalWrite(4, HIGH);
    delay(50);
    digitalWrite(4, LOW);
    delay(50);
  }
}
```

To activate the second servo (181-360)degree, and to point the laser attached to it on a suspected object in its vicinity.

```
void fire360()
{
  for(i=1;i<=30;i++)
  {
    digitalWrite(7, HIGH);
    delay(50);
    digitalWrite(7, LOW);
    delay(50);
  }
}
```

### *C. Three Terminal Positive Voltage Regulator:*

The LM78XX series of monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation in this project. 7805, 7806, 7809 are the three voltage regulators which are used with aluminum heat sink to provide adjustable output voltages and currents to all the components used in this project (www.fairchildsemi.com).

### *D. Processing 2:*

The processing software is free and open source and runs on the Mac, Windows, and GNU/Linux platforms. Processing has also evolved into a development tool for professionals. This is where all the work done to read and interpret the values from the stepper motor and the ultrasonic range finder. To read the data sent by the Arduino, variables, background and serial port libraries are loaded. A function from the serial library called serialEvent() is also included which listens for data being sent and allows to read the data easily. To get the stepper position and sensor value, some easy string work of splitting the serial port lines are done. To build the interface user friendly, sensitive and accurate, trigonometry is applied and everything else is done by loops and a few IF statements. The FOR loop is used a lot because all the elements can be displayed programmatically without having to write each rectangle, circle and line to the screen with their own respective statements (https://processing.org/).

The main looping function that always runs is as follows

```
void draw()
{
  textFont(myFont);
  fill(0);
  noStroke();
  ellipse(radius, radius, 750, 750);
  rectMode(CENTER);
  rect(350,402,800,100);

  if (degree>=0 && degree<100)
    motion = 0;
  if (degree>=100 && degree<200)
    motion = 1;
```

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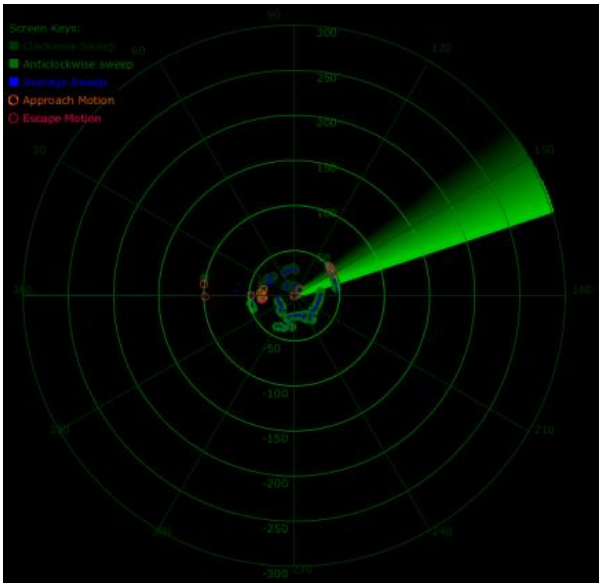


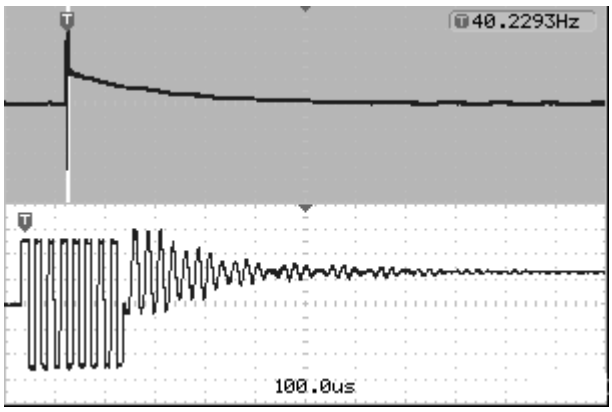

**Fig. 3:** The graphical interface of the system with screen keys

***IV. Data Collection And Processing:***

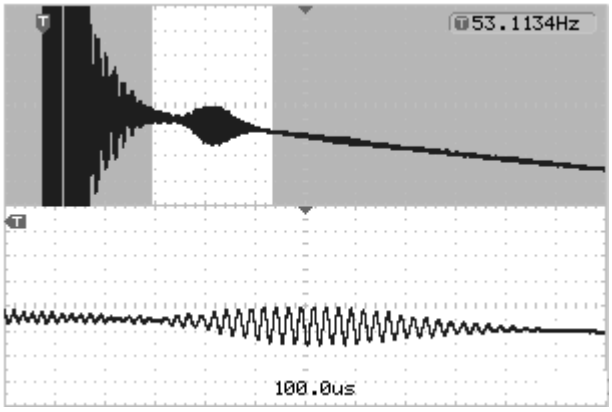
The hardware system consists of an inexpensive Ultrasonic ranging module, (series HC SR-04) and a Arduino Uno board that can operate under the Windows operating system with a 'processing 2' software as a user interface. For all results reported here, the ultrasonic module was placed on a table top, at approximately the same height as the stand upon which each object was placed. The front surface of the stand was covered with sound absorbent material to minimize spurious echoes, though we have found from our previous experiments that detection is quite robust even if other objects are ensonified by the ultrasonic range finder. The distance of each object was measured manually and later confirmed directly from the sonar echoes (http://www.elecfreaks.com; Ihsan Ecemis, M. and Paolo Gaudiano).

***A. Ultrasonic range finder test result:***

A metallic plate sends a sound signal (ping) at 40 KHz and waits for it to return 8 cycles of square signal is displayed in the oscilloscope. The following sinusoidal is the "ringing" of the transducer (the metallic plate keeps resonating after the signal is sent). This is why we cannot measure any incoming signal while this happens, and thus, it limits the range in which we can measure (with this sensor, the min distance is 15cm).After sometime, the signal arrives (pong), being attenuated and with a lot of noise. In the following image, the target was at 20 cm, and was a metal plate which is an example of an ideal target (http://138.100.100.129).




(a)




(b)

**Fig. 4:** (a) before the ranging of an object, (b) After the ranging of an object

***B. Communicating with Arduino through processing:***

Arduino comes with some basic examples for communicating with Processing. These are useful when you want to write both Arduino and processing programs which facilitate communication between themselves. This works best for communicating simple information like extracting data from Ultrasonic module in my case (https://processing.org/; http://www.instructables.com).

The Arduino sketch reads the incoming values on the declared ports and then uses Serial Communication functions to output the values. The processing separates the value by comma characters (denoted by quotation marks). TheSerial.begin() functions the baud rate, number of "signaling events per second" which in my case is 9600.To enable Serial Communication processing sketch is started and the only function that may need modification is the initialization of a new Serial object,

```
//Setup the serial port and buffer
myPort = new Serial(this, Serial.list()[3], 9600);
myPort.bufferUntil('\n');
```

Which creates a new object. The second argument of the Serial.list() function is the incoming port being used by Arduino in my case. The third argument is the baud rate which is same as the baud rate used in the Serial.begin() function of the Arduino sketch. The program can be started by clicking the Play button.

***Conclusion:***

The surveillance system proposed here functions with near flawlessness and ensures a high level of security. It gives a $360^0$ of surveillance which ensures greater level of detection and motion estimation in unknown environments. But still, there are areas where this system can be enhanced and advanced in the future. In order to increase its effective time to sweep $360^0$ more ultrasonic sensors can be added to the system, which will also enhance the target acquisition as well as object detection. As ultrasonic module used in the project can give accurate result upto 250 cm approximately, a better quality of ultrasonic range finder can be expected in the future. Ultrasonic is not good with absorbent objects, so different passive infrared sensors and cameras can be installed to increase the reliability of the current system. The Stepper Motor at the bottom is able to move by $3.75^0$ to encompass $360^0$ and while doing this small detection areas are missed. In future, this Stepper Motor can be replaced by a more accurate servo motor which will cover the areas more precisely. Nevertheless the system can easily work in real time, making it possible to digitize, process and recognize each echo several times per second the project has shown that ultrasonic sensors are useful in smoky environments and that using only ultrasonic sensor is possible under certain circumstances.

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