Smart Cane for the Visually Impaired

Project Report – Group C

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Abstract

The Objective of this project is to utilize engineering tools and technology to build a prototype design of an assistive device by augmenting the conventional walking stick with features, which can help the visually impaired in locomotion. For this purpose, an Arduino based working model was designed and tested. The basic features include, ultrasonic sensors for detecting of objects within 100 cm of distance, water sensor to detect water, mudpools and wet pathways, and a receiver transmitter module to locate stick within a range of 60 feet.

Problem Statement

A cost-effective device needs to be designed to aid people with visual impairment, in walking around and comprehending their surroundings with increased convenience.

Objectives/Required Features

- Detection of objects in proximity
- Detection of objects above a certain height
- Detection of water and mudpools
- Locating device when use is required (or dislocated)
- Switching off unnecessary portions of device when not in use, to reduce battery consumption
- Light weight and easy to carry design (foldable)
- Visibility of device during night time, to indicate blink people
- Change in working boundaries for Indoor and Outdoor scenarios

Hardware Components

The hardware assembly consists of the following parts:

Arduino Nano – ATMega328

At the center of the project, this is the microcontroller used, which controls all functions of the stick.

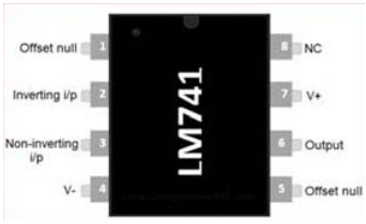
- Operating Voltage(logic level) : 5V
- Input Voltage (recommended) : 7-12 V
- Input Voltage (limits) : 6-20 V
- Digital I/O Pins : 14 (6 for PWM)
- Clock Speed : 16 MHz
- Dimensions : 0.70” x 1.70”

Waterproof Ultrasonic Sensor – JSN-SR04T

The sensor intermittingly sends and receives ultrasonic pulses and calculates the time taken by each pulse to travel the whole cycle. Using this info, it can measure distances from objects.

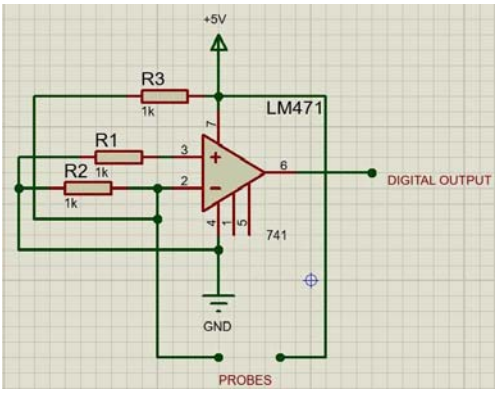
- Operating voltage: DC 5V
- Quiescent current: 5mA
- Total current work: 30mA
- Acoustic emission frequency: 40khz
- Farthest distance: 4.5m
- Blind: 25cm
- Wiring: + 5V (positive power supply)

- Resolution: about 0.5cm
- Module size: 41mm * 28.5mm
- Angle: less than 50 degrees



Comparator (for Water Sensor, Custom Made) – LM741

This is a basic comparator circuit, when there is no medium between probes the resistance between them is in mega ohms, but whenever there is a medium is between two probes the pin2 (pull downed) will get a high signal thus inverting the output of comparator.

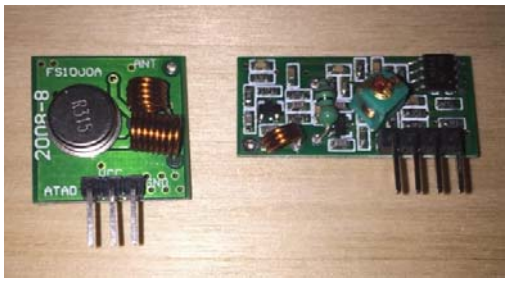


- Input Voltage: 5-9 Volts
- Nominal Current: 3 mA
- Short Circuit current: 5 mA (at 5Volts input)
- Output: Digital

Transmitter and Receiver Module – 433MHz FS1000a
With Encoder and Decoder ICs (HT-12D, HT-12E)

This module is used to locate the stick within a 25 meters periphery. The Receiver module is embedded in the stick, while the transmitter is inside a handheld remote.

Once activated, the buzzer has to be manually turned off by switching off the stick



The one in the left side of the picture is the transmitter and the right side module is the receiver. These modules are working in 433 MHz range and operating in single channel mode. However with the use of encoder – decoder ICs HT12E & HT12D signal encryption can be achieved so that the stick will only be corresponding to a single remote. The three pins from left to right in the picture of the transmitter are

1. Data input
2. Vcc
3. Ground

In receiver circuit the pins order as follows

1. Vcc
2. Data output
3. Ground

Piezo Buzzer

This is a small, low voltage sounding device which generates beeps, with frequencies varying with the input voltage provided. Hence it is connected to PWM pin of Arduino.

- Operating Voltages: 5V, 12V

Reflective Sheet:

This reflective sheet is utilized so that during the night, the stick is made prominent and people in the surrounding can identify the visually impaired, and hence they can be a bit more careful.

Vibrator:

This is a small motor, with cams at one end. When rotated, the off-balance cams create vibrations.

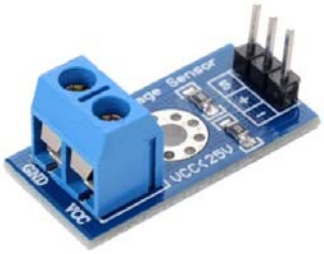
- Rated current: 90 mA Max
- Rated speed: 11,500 +/- 2,000rpm
- Operating voltage: 2.0 ~ 4.0V DC

Metallic collapsing walking stick:

This is a common walking stick, with adjustable length. It is hollow from the inside, therefore wires and small components can be adjusted within.

9V Battery and Battery Voltage Level Sensor

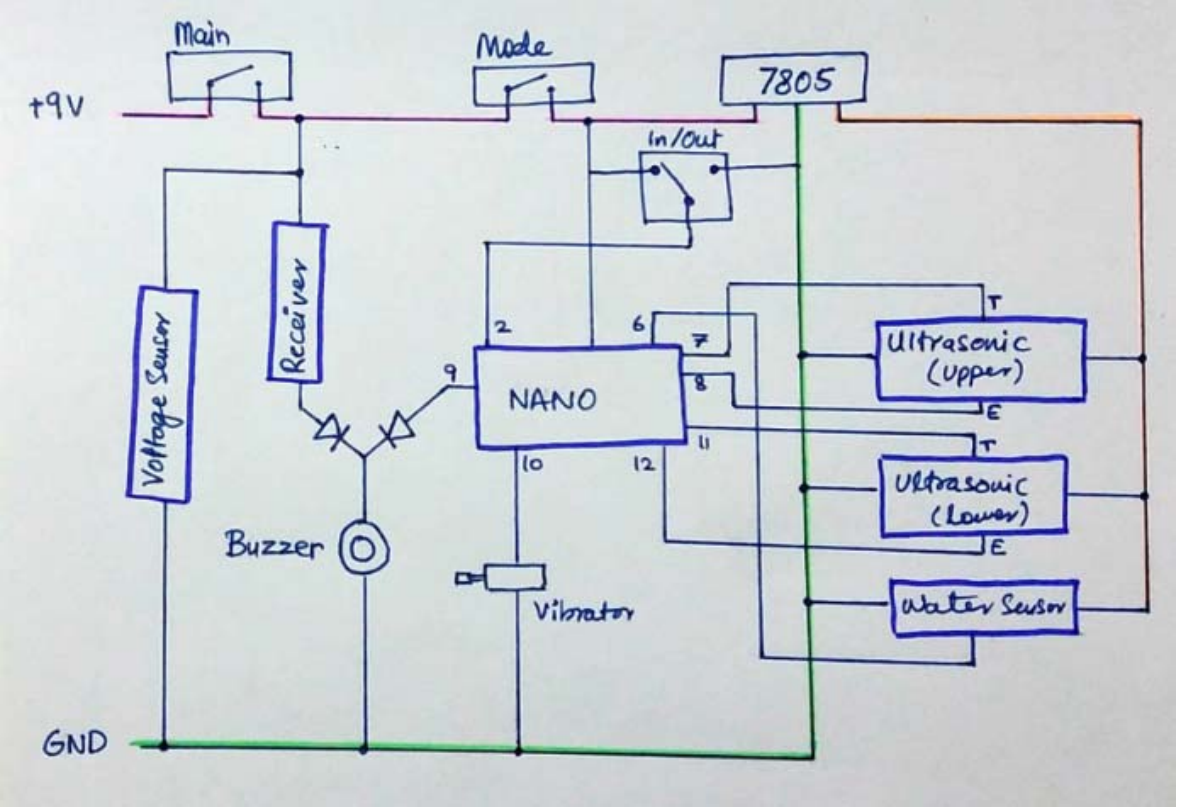
This is a general purpose battery, easily available in the market. The project has been designed so that it can conveniently operate with this power source. To indicate the voltage level of the battery is below a certain threshold, a small voltage level sensor module is used, which is basically a voltage divider circuit.



* For the software part, the programming is done in Embedded C, on the Arduino IDE. Code is attached at the end of document.

Circuit Diagram

Complete Circuit Arrangement:

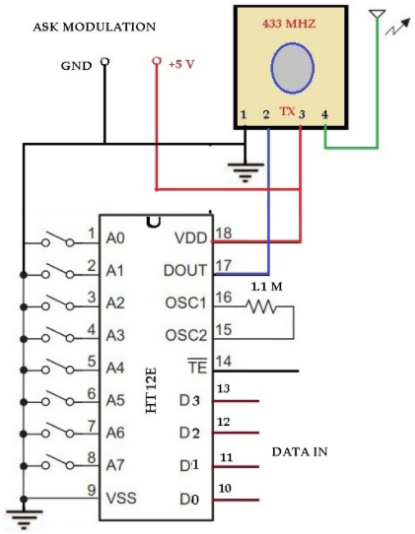


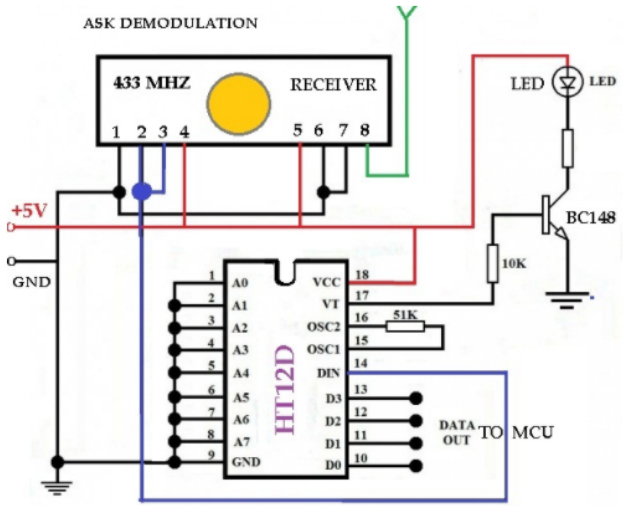
Transmitter/Receiver Module:

(The receiver module used in the diagram here is slightly different from the one used in the project, but the working principle and pins connectivity is almost the same.)

The data in and out of both circuits are connected to the encoder decoder ICs. The encoder IC HT12E could take in a 8 bit address for encryption and 4bit data input and convert that 12 bit data in to a series of pulses which can be transmitted through a single channel. This train of pulses the fed to the transmitter input, which will be transmitted in 433MHz frequency towards the receiver. The receiver receives the pulse train in the same form it was generated by the encoder IC. This data then directed to the decoder IC HT12E to read the information encrypted. First the IC determines whether the address is correct or not. In order to have matching addresses for both ICs, it is very important to give the same address bar configuration to both ICs (pin 1 to 8). If the address is matching then the IC will accept the data encoded in to the signal.

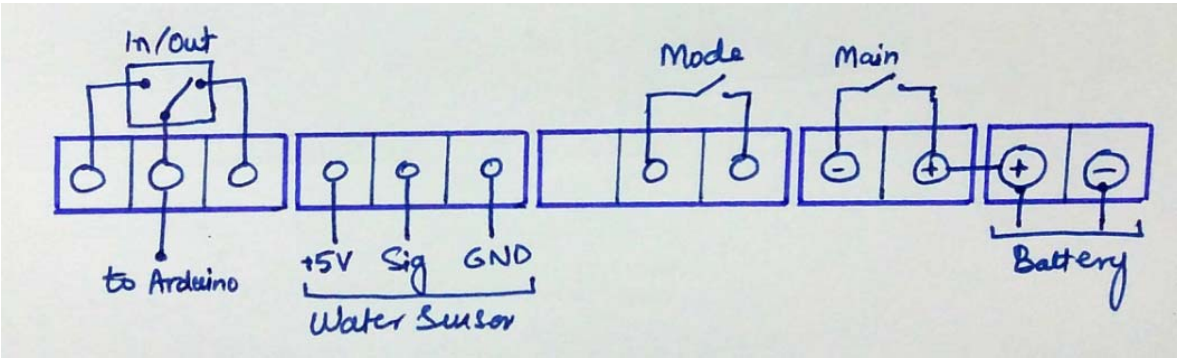
The TE pin is for enabling the transmission and is connected to ground as the IC is active low.





Terminal Block connection on board:

Shown are the connections on the circuit, with components outside the veroboard, like switches and battery. This comes in handy while assembling/disassembling the circuit.



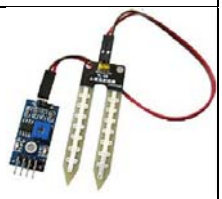
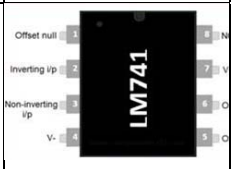
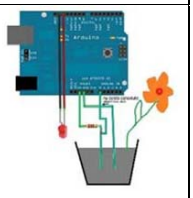
Included Features

- Object Height Detection using Ultrasonic Sensor: 116 cm (outdoor), 100 cm (indoor)
  - Buzzer to sound differently for near and far objects within range
- Obstacle Avoidance in pathway using Ultrasonic Sensor: 100 cm (outdoor), 50 cm (indoor)
  - Dedicated vibrator to vibrate differently for near and far objects within range
- Stick Location through RF Module: 25 meters periphery
  - Buzzer to indicate stick location

- Water/Wet mud Sensor using comparator (also used with Buzzer)
- Low Battery Alarm: for below 4V (also used with Buzzer)
- Reflector paper for prominence during night time
- Small power requirements, works completely on a single 9V battery
- Compact size and low weight, for ease of use
- Wirings done internally, circuity packed inside a package which can be made waterproof.
- Waterproof ultrasonic sensors.
- Except for the ultrasonic sensors, cost effective components are used, especially the custom-made water sensor.

Case study – Water Sensor

For the water sensor, the following alternatives were possible:

	Sensor	Price	Current Rating	Pros	Cons	Figure
1	Water/ Rain Drop Sensor Module	Rs. 50	20mA	Cheap, easily available	Analog Output, Inappropriate due adhesion	
2	Soil Moisture Sensor/ Soil Hygrometer	Rs. 160	100mA	Digital Output, easily available	Costly	
3	Capacitive Water Sensors	Rs. 200	100mA	Precise, Long life	Costly, not easily available	
4	Self-built using Comparator	Rs. 50	5mA	Cheap, Digital, Power efficient	Not ready Available.	
5	Using analog read and two wires with Arduino	Rs. 10	300mA	Most Cost effective	Poor practice, High current, No short circuit protection	

Out of these, solution 4 has been implemented, due to its cost effectiveness and low power requirement. The total cost for this approach is summed up:

COMPONENTS	PRICE (Rs)
Vero Board (Small piece)	20
Resistances (1k)	5
Lm147 IC	10
Wires + Probes	10
IC bed	5
Total	**50**

Flaws and Shortcomings

1. *Slow Response Time and garbage* of Ultrasonic Sensors, hinders the working of cane.
2. Ultrasonic sensors are prone to damage since they are *attached outside* the frame.
3. Not completely *waterproof*, yet
4. *Adhesion* on Water Sensor terminals will latch the electrodes and the water sensor will keep buzzing until properly cleaned.
5. Water sensor activates for *any conductive surface.*
6. *Comprise on collapsibility* of Stick due to the internal wires bundling up
7. *Reflective paper* is not as responsive to night light as is required.

Suggestions

The following improvements can be made to the project:

1. *Rechargeable batteries* can be implemented, especially the modern ones with USB-C Type charging ports.
2. The *multiple ultrasonic sensors* can be attached, to sense objects on left and right hand sides too. For this, additional vibrators can be attached ergonomically, to indicate direction too.
3. The wires, set up internally can be attached to an *elastic mechanism* which will avoid them from bundling up inside the cane as it is collapsed and retracted.
4. The *water sensor electrodes* can be formed into thin plates so that they can put on surfaces easily
5. Better *reflective paper* can be used so that shine is prominent during night time.
6. Design Adjustments can be made to *embed the ultrasonic sensors* within the frame of stick.

Project Budget

No.	ITEM	PRICE (Rs)	Descrption	Vendor
1	Acrylic + Box	80.00	For packaging	Azeemi Electric
2	Wires	50.00	Wires of various sizes	hallroad.org
3	Arduino Nano	350.00	Arduino Nano	hallroad.org
4	Samad Bond	50.00	Sealing/Adhesive	Local
5	433 Mhz RF TX and RX	300.00	2 x Radio Frequency Module	hallroad.org
6	Vibrator motors	360.00	3 Vibrators, 120 each	hallroad.org
7	JSN SR-04t	2,400.00	2 Ultrasonic Sensors, 1200 each	hallroad.org
8	Switches	80.00	Rocker and Toggle switches	hallroad.org
9	LM741	50.00	Comparator for Water Sensor	hallroad.org
10	piezo buzzer	30.00	Buzzer	hallroad.org
11	9V battery connector	30.00		hallroad.org
12	Arduino Wires	100.00	Arduino wires	hallroad.org
13	9V batteries	400.00	x5	hallroad.org
14	Vero board	40.00		hallroad.org
15	Connectors	150.00	terminal blocks and connectors	hallroad
16	Reflector paper	200.00	Red, 1 sqft	Neela ghumbat
17	Stick	450.00		Neela ghumbat
18	Encoder And decorder	600.00	2 Transmitter reciever addressing	hallroad.org
19	IC base + female headers	30.00	mounting Nano and other sensors	IC shop
20	Antenna	60.00	for Transmitter	hallroad
21	Voltage Sensor	150.00	Battery Level Indication	IC shop
22	Resistances	30.00	RF Circuit	hallroad
23	12V cell	50.00	for Transmitter	hallroad
	Total	6,040.00		
	Total From group Members	5,500.00		
	Balance (Deficit)	540.00		

Arduino Code

```
// Smart Cane for the Visually Impaired - Arduino Code
const int moist = 6; //  Moisture Sensor Pin
bool moisture = LOW; bool moistState = LOW;
const int buz = 9; // Buzzer Pin (PWM)
const int vib = 10; // Vibrator Pin (PWM)
// Ultrasonic Sensor Pins
const int trigPinU = 7;
const int echoPinU = 8;
const int trigPinD = 11;
const int echoPinD = 12;
int dul = 0;  // delay variable
float duration; float distanceD; float distanceU;
int volts = 5; float vout = 0.0; float vin = 0.0;
float R1 = 30000.0; float R2 = 7500.0;
const int inOut = 2; // Interrupt Pin for Indoor, Outdoor Switch
float uLim = 116;
float dLim = 100;

void setup() {
  pinMode(trigPinU,OUTPUT);
  pinMode(echoPinU,INPUT);
  pinMode(trigPinD,OUTPUT);
  pinMode(echoPinD,INPUT);
  pinMode(buz,OUTPUT);
  pinMode(vib,OUTPUT);
  pinMode(moist,INPUT);
  pinMode(inOut,INPUT);
  if (digitalRead(inOut) == HIGH){
    uLim = 100;
    dLim = 50;
  }
  else{
    uLim = 152;
    dLim = 100;
  }
  // InDoor, OutDoor Modes connected to Interrupts
  attachInterrupt(digitalPinToInterrupt(inOut),inOutFunc,CHANGE);
  Serial.begin(9600);
}

void loop() {
  // put your main code here, to run repeatedly:
  // Utrasonic Sensor Operation
  // 1. Upper ---------------------------------------------
  digitalWrite(trigPinU, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPinU, LOW);

  duration = pulseIn(echoPinU, HIGH);
  distanceU = duration*0.034/2;
  // 2. Lower ---------------------------------------------
  digitalWrite(trigPinD, HIGH);
```

```
  delayMicroseconds(10);
  digitalWrite(trigPinD, LOW);

  duration = pulseIn(echoPinD, HIGH);
  distanceD = duration*0.034/2;
  volts = analogRead(A0);
  vout = (volts * 5.0)/1024.0; // see text
  vin = vout/(R2/(R1+R2));

  // Loop for Battery Check ------------------------------
  // Rest of the cane won't work if battery level is insufficient
  if (vin < 4){
    while (vin < 4){
      digitalWrite(buz,HIGH);
      delay(1000);
      digitalWrite(buz,LOW);
      delay(1000);
      volts = analogRead(A0);
      vout = (volts * 5.0)/1024.0; // see text
      vin = vout/(R2/(R1+R2));
    }
  }

  // Condition for Ultrasonic Sensor (Lower) ------------
  if (distanceD < dLim){
    if (distanceD > dLim/2){
      dul = 200;
    }
    else{
      dul = 100;
    }
    analogWrite(buz,255);
    delay(dul);
    analogWrite(buz,0);
    delay(dul);
    analogWrite(buz,255);
    delay(dul);
    analogWrite(buz,0);
    delay(dul);
  }
  else
  {
    digitalWrite(buz,LOW);
  }

  // Condition for Ultrasonic Sensor (Upper) ------------
  if (distanceU < uLim){
    if (distanceU > uLim/2){
      dul = 200;
    }
    else{
      dul = 100;
    }
```

```
    analogWrite(vib,123);
    delay(dul);
    analogWrite(vib,0);
    delay(dul);
    analogWrite(vib,123);
    delay(dul);
    analogWrite(vib,0);
    delay(dul);
  }
  else
  {
    analogWrite(vib,0);
  }

  // Condition for Water Sensor ------------------------
  moisture = digitalRead(moist);
  while (moisture == HIGH){
    analogWrite(buz,50);
    delay(50);
    analogWrite(buz,100);
    delay(50);
    analogWrite(buz,150);
    delay(50);
    analogWrite(buz,200);
    delay(50);
    analogWrite(buz,250);
    delay(50);
    moisture = digitalRead(moist);
    }
}

// Interrupt Function for InDoor OutDoor modes -------
void inOutFunc(){
  if (digitalRead(inOut) == HIGH){
    uLim = 100;
    dLim = 50;
  }
  else{
    uLim = 152;
    dLim = 100;
  }
}
```