Autonomous Underground Water Detection Robot

Rahul Krishnan1*, R Ganesh Babu2, K Lalitha3, S Vanaja1, Keren Naomi Devnesh1

1Department of Electronics and Communication Engineering, Rajalakshmi Institute of Technology, Chennai, India
2Department of Electronics and Communication Engineering, SRM TRP Engineering College, Tiruchirappalli, TN, India
3Department of Electronics and Communication Engineering, SRM Institute of science and technology, Chennai, India
*rahulkrish1990@gmail.com

Abstract. The fast development of sensing element and wireless communication technologies has exaggerated the use of wireless sensors in environmental observance. The water consumption is rising day by day, as the water supplies for various social units and for industrial purposes is rising. And that is why surface water isn't really capable of meeting water needs. This subterranean need for water has been misunderstood. This work is based on meeting the challenge of easily sorting the underground water with the aid of a robot. This robot based on Arduino Mega will examine the surface in relation to Wenner methodology to look for the existence of water body beneath the earth's surface. It will define the location of underground water with respect to a GPS module connected to the Arduino. The location data obtained from the GPS module is used to record at that particular depth the exact location and volume of water present. This knowledge can help to map underground water in that geographical area.

Keywords-underground water; Wenner method; Arduino; GPS

1. Introduction

Water is one of the furthermost significant assets on our planet. Every single living being must intake water to endure. In any case, our current generation suffers from one of the principle issues that is Water scarcity [1]. In India the majority of the lakes, streams and lakes are profoundly contaminated which are viewed as perilous by present day standards. In excess of 163 Million Indian people groups are languishing over clean drinking water. The information gathered by National Institute for Transforming India (NITI) from 24 out of 29 Indian states and has cautioned that the most noticeably awful ever surface water deficiency in the nation is probably going to have unfavorable ramifications for many individuals. This issue can be overwhelmed by expending underground water effectively.

Groundwater, which aquifers below the Earth's surface, is one of the most significant natural resources of the country. India receives about 650mm of annual rainfall in which about 25% is used for ground recharge [7]. Also, India is the world's largest groundwater user with an annual usage of some 251 km3/year [6]. Knowledge of ground-water scenario and factors influencing the groundwater
augmentation are crucial elements in many hydrological investigations, including agricultural water management. Ground-water can be used be either for agricultural (for irrigation or domestic farm water supply) or non-agricultural (for municipal or industrial water supply or recreation). The main advantage is that Ground water generally does not get polluted, if it is away from the unsanitary workplaces. When comparing with the other existing methods like ground penetrating radar (GPR), satellite remote sensing (RS) technology, test drilling method, seismic-refraction method are very complex systems in terms of implementation and analysis. But the proposed method is based on electrical resistivity method which is a simple engineering principle and the system is low cost. This project proposes the detection of underground water by using a robot which searches in and around water logging areas [2]. This robot drills a hole for the detection of underground water by comparing the earth resistance with the help of Wenner method. The proposed work is a prototype and that can be converted to a practical machine for underground water detection and the prototype model can be used for extraterrestrial application as well. Based on the result and cost, conducting automatic electrical resistivity imaging surveys instead of the standardized ASTM G57 surveys would definitely be better with today's technology.

2. Methodology

This work is based on the Wenner method of detecting any source of underground water [4]. Four metallic probes A, B, M and N, with standard orientation, are pushed into the ground in Wenner method [10]. The distance (a) between all four electrodes should be same [7]. The electrodes A and B supplies current at extreme ends. The electrodes M and N are placed between A and B which measures the voltage across the soil [9]. The measurements are per voltmeter linked with electrodes M and N [11]. By ohms law this reading is translated into a form of resistance. This resistance is not the normal field resistance. Soil has heterogeneous layers so it is to be measured for the apparent resistivity [3].

The formula for apparent resistivity is given equation (1)

$$\rho E = \frac{4\times\Pi\times a\times R_w}{1+\frac{2\times a}{\sqrt{a^2+4b^2}} - \frac{a}{\sqrt{a^2+b^2}}}$$  

(1)

$$\rho E = \text{measured apparent soil resistivity (}\Omega\text{m})$$

$$a = \text{electrode spacing (m)}$$

$$b = \text{electrodes depth (m)}$$

$$R_w = \text{Wenner resistance measured as "V/I" (}\Omega\).$$

If b is small compared to a, as in the case of probes penetrating the ground only for a short distance, the equation (1) can be reduced to equation (2).

$$\rho E = 2\times\Pi\times a\times R_w$$  

(2)

The Robot has two L293D motor driver IC powered 300 rpm dc motors at the rear end of it. Two motors attach to driver IC input pins. This driver IC is supplied from 9V battery with external dc supply. This system connects with Arduino. At the front end one servo motor is set which is designed for rotation of 90 degrees. In this manner, the 0° rod mounted to the servo motor stays in the air and injects electrodes into the soil after a 90° rotation rod is attached to the servo motor [11]. The Servo engine has three outputs. The output is connected to the input port of the Arduino board and two other outputs are connected to the ground and Vcc. The electrodes attached to the servomotor are set at the same “a” distance between them, and must be collinear. The electrodes A and B are provided with an
external supply of current through battery. Electrode M is connected to the ground of Arduino and the electrode N is connected to the analogue input of Arduino to provide voltage reading. The Arduino board is connected to a GPS module which has an internal antenna. Its receiver and transmission output are connected, respectively, to Arduino board transmission and receiver pin [12]. The GPS Supply will be provided from the Arduino board [13,14] and the positions monitored by the GPS will be shown in the LCD, which is also interfaced with the Arduino, shown in figure 1.

![Block diagram of underground water detection Robot](image)

**Figure 1.** Block diagram of underground water detection Robot

### 3. Materials and Design

#### 3.1. System development

When a 9V DC power supply from the battery is supplied to the IC driver, the motor will be triggered. The motor is recommended to perform for 5 seconds. After this, the servo motor attached to the Arduino is turned on and rotates 90 degrees. Now the electrodes attached to the servo motor are inserted into the soil with equal spacing. The current is transferred to the electrodes at the extreme ends and the robot remains in place until the M and N electrodes test the voltage between them. If the readings are taken, the servo motor returns to its initial position and the robot begins to move again. The GPS will get the location of the location where the reading is taken and it will be shown on the LCD monitor. This activity will continue until the program is finished. The study is rendered on the basis of the reading taken by the robot. The readings are translated into an apparent form of resistivity by the law of the ohms and an apparent form of resistivity to soil resistivity [5]. Resistance values at various locations and in different soil types will vary based on weather conditions, soil type and temperature in that area.

#### 3.2. System specifications

This system consists of an Arduino UNO microcontroller board with ATmega328P Microchip. Arduino UNO is powered at 5 volts. It comprises 14 digital Input / Out pins, out of which 6 pins are PWM pins. It has six analog input pins on it. The L293D driver IC is used to operate two 300 rpm DC motors at the same time. It is used to regulate the speed and direction of the motor. The input pins are connected to the Arduino UNO to control the speed and direction of the motor. The model works with servo motor, LCD monitor, GSM and GPS modules.
4. Analysis and Results
Soil tests performed on different soil types yielded various results. The different resistance was demonstrated by the soils, dry soil and wet soil that were used. All these taken soils are tested using Wenner method [8]. The resistivity of all these variety of soil was found using the resistance in apparent resistivity formula. The table below shows the measurements taken by the robot in two different soil types: dry soil and wet soil of varying depth and spacing between electrodes. Using ohms law and apparent resistivity formula, the resistivity and apparent resistivity of the soil is measured and is tabulated along with the readings taken in table 1.

Table 1. Reading taken in different types of soil.

| Soil | Spacing (a) | Depth (b) | Voltage (v) | Current (I) | Resistivity (ρ) | Apparent Resistivity |
|------|-------------|-----------|-------------|-------------|-----------------|---------------------|
| Dry  | 0.004       | 0.0015    | 0           | 0.13        | 0               | 0                   |
|      | 0.007       | 0.003     | 0.16        | 0.13        | 1.2             | 0.05                |
|      | 0.013       | 0.0065    | 0.7         | 0.13        | 5.3             | 0.42                |
| Wet  | 0.004       | 0.0015    | 0.004       | 0.13        | 5.4             | 0.1                 |
|      | 0.007       | 0.003     | 0.007       | 0.13        | 5.8             | 0.2                 |
|      | 0.013       | 0.0065    | 0.013       | 0.13        | 3.8             | 0.3                 |

Figure 2. Spacing between electrodes vs. resistivity graph
The distance between the electrodes vs the resistivity graph obtained is shown in figure 2. From this it is found that when the spacing between the electrodes is increased the resistivity of dry soil increases. But resistivity in wet soil diminishes as the spacing between electrodes increases. In figure 3, the depth vs. the resistance graph that obtained is shown. From this, it is found that as the depth is increased, the resistivity of dry soil increases and in wet soil, as the depth is increased, the resistivity decreases. While equating the resistance between dry soil and wet soil, wet soil resistance is lower compared to dry soil since the moisture content is much more in wet soil. Variation in resistance is seen in both soils when calculated by the Wenner method. Since water is a good conductor of electricity, the conductivity of wet soil is increased and thus the resistance is reduced. As a consequence, it is clear that water is present at that specific spot. Voltage values and coordinates of the GPS position where the soil was analyzed were shown on the LCD.

5. Conclusion

This proposed method is useful to detect the existence of underground water in the soil using a robot. Because of an old generic test, defined in ASTM G57, written for electrical soil testing, the Wenner electrode array is used for profiling or mapping in soil testing. Profiling is defined by this norm and is achieved with the Wenner array. With today’s technologies, conducting automated electrical resistivity imaging surveys instead of the standardized ASTM G57 surveys will probably be safer, based on the outcome and cost. Also, this robot is resistive to moderate climatic condition. This project can be further implemented where this small robot can be turned into a large one and also, it can be utilized for the application of IOT in which the data can be stored and accessed from anywhere.

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