Design and development of IoT enabled gas sensing system for remote monitoring of air quality in borewell rescue operations

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Abstract. The children demise inside the borewell is expanded in nowadays, with uncovered borewell they fallen without knowing and lost their lives due to asphyxiant inside, likewise without oxygen, food and so forth. The harmful gases like carbon monoxide, Methane, LPG, hydrogen sulphide inside the bore-well it will influence the children breathing and furthermore this may prompt unconsciousness, and without oxygen it might influence the brain functioning of child and child may die and furthermore explicit distance of the child at what distance child stuck isn’t know. To overcome these, we need to detect the various gases with different multiple gas sensors additionally to get the temperature and humidity condition. Alongside this ultrasonic sensor is utilized to get the distance of child at what distance child got stuck. We have utilized two Arduino Uno microcontrollers which is at the transmitter side and other at Receiver side also utilized two ZigBee’s as the communication devices. With the help of IoT involved in the proposed system. Every one of these information are sent to the cloud and we can monitor the data in the thing speak dashboard through PC or from our smart phone through Android App Usage and also, through LCD at Receiver end. We can utilize this proposed framework inside the borewell for up to 80-meter depth. Thus, we came up with this Design and Development of IoT enabled Gas sensing system for remote monitoring of Air quality in borewell Rescue operations. Based on proposed system results of real time data the Rescue specialists can make a further move by providing of oxygen, food, and so forth. Save their lives.

1. Introduction

India is a land of agriculture most them depends on the agriculture as their occupation. Water is most essential thing in every one’s life. Agriculture is mainly depending on the water. Water shortages are increasing day by day and so farmers are therefore drilling more borewells, due to Ground Water deprivation. Borewell becomes more and more water depleted over time. Disasters have increased at Bore Well nowadays, and most of the dried bore-well is not closed due to irresponsible it may take some one’s life and most of the cases children falling into borewell. The serious issue confronted while safeguarding the child stuck in a borewell is that the specific distance of the child isn't known. Absence of representation absence of data about the natural conditions like the risky and harmful gases present, humidity and temperature. Generally, in borewell there will be some hazardous gases such as carbon monoxide, Methane, LPG, butane, nitrogen dioxide etc. will be present and these gases will make asphyxiant. Due to asphyxiant child may go to unconscious, if they are breathing those.
gases for long period, it will affect their children brain functioning due to lack of oxygen and they may die. Rescue authorities will take some time to get out of child who stuck in borewell To protect a child fallen into Borewell Rescue authorities drill the land from other side. Meanwhile inside the bore-well our proposed model will get hazardous gases concentration of carbon monoxide, Methane, Lpg also, temperature and humidity condition and distance of child from the proposed model at what depth child got stuck.

2. Existing System

2.1 Implementation of a Child Rescue System from Borewell using Zigbee for Long Range Applications.
In this work they thought of utilization of sensors and microcontrollers for rescue improves the proficiency of their system. Utilizing observation camera, they are utilizing hand gripper for kid rescue by with security. This aide in the rescue of kid from bore well and furthermore gives continuous information of sensors and camera on mobile and a LCD module of the system through communication with ZigBee. The real time temperature sensed data are missing, also lpg gas sensed data are missing [1].

2.2 Development of In-Pipe Robot for Assisting Borewell Rescue Operations
This work outlines an imaginative strategy to survey the state of the casualty by dissecting different subtleties like the profundity at which the kid is trapped, location of destructive gases present, temperature, mugginess conditions and live feed of the casualty utilizing an in-pipe robot. sensed gas data having mixture of alcohol, smoke, ammonia, gases results but they do not classify as individual gas how much of alcohol ppm, ammonia ppm, smoke ppm it is showing the result of combination of alcohol, smoke, ammonia gases as single gas data this might get confuse to for rescue operator which gas to diffuse or neutralize. They could have used any particular gas sensor or they could have classified as individual gas in mixture of gases.so that even rescue operator and others can also understand [2].

2.3 Pipeline Inspection And Borewell Rescue Robot
This work outlines the state of caught kid is caught with USB Camera and observed on PC. LM-35 Temperature Sensor and 16X2 LCD are interfaced with PIC 16F877A microcontroller to detect the temperature inside the drag well and to show it separately. The microcontroller stores the detected information and showcases it on the LCD. Real time implemented data are missing, it does not have temperature sensed data and also captured images are missing [3].

2.4 Arduino Based Child Rescue System from Borewells
In this work they contributed with Arduino controller to control along with mechanical system & it will go inside the borewell & it moves with help gripper with user commands given.as per environmental conditions concern it does not have any gas sensors to detect the harmful gases. the complexity is might high when it goes deeper inside the borewell might get loss of communication they could have used a proper communication protocol [4].

2.5 Borewell Rescue Robot
In this work the rescue robot consists of Arduino at mega controller for control the temperature sensor, camera for capturing the images & ultrasonic sensor for distance measurement. [5]This paper outcome with only proposed design model, but not implemented it real time. Also, real time data are missing in this work.
2.6 Pipeline Inspection and Borewell Rescue Robot
In this work the rescue robot consists of USB camera for capture images to monitor in laptop, they used atmega16 controller to control the temperature sensor, co2 sensor & LCD. Problem might arise when it goes deeper in to bore well might be loss of communication; they have not used a proper communication protocol.

2.7 Borewell Child Fall Safeguarding Robot
In this work the safe guard robot which consists of Pic controller for controlling the gas sensor, temperature sensor. IR transmitter and receiver for distance measurement. This work does not have implemented result in real time in borewell and this does not have proper communication protocol & problem might arise when it goes inside the borewell very deep. The sensed gas data and temperature data results are missing in the work.

2.8 Arduino controller based borewell child rescue system
In this work they proposed a system with mechanical & electronics system. They used Arduino Uno microcontroller to control the ultrasonic sensor, also control the motors, also to control the switch and button. As environment concern in inside borewell this does not have any particular gas sensor for to detect the harmful gases. Real time implementation of distance and captured images data are missing with this work.

2.9 Design and implementation of LabVIEW based bore well child rescue robot
In this work they designed the rescue robot which consists of the microcontroller which is used to control motor, camera, temperature sensor, altitude sensor to find distance measurement. This proposed system design implemented only in the LabVIEW. This does not have the hardware implementations.

2.10 Smart Bore well Rescuing Robot.
In this work they have used Arduino Uno microcontroller which is utilized to control the Ultrasonic sensor. This Ultrasonic sensor is utilized to quantify the distance at which the casualty is available and shows it on the LCD show in both meter and centimetre. The rescue unit comprises of two DC motors, a Web camera and a LED light. Web camera is associated with the PC to see the situation with the casualty inside the borewell. A motor driver (L293D) is utilized to drive two DC motors. One DC motor is utilized for the flat and vertical development of the rescue unit and another DC motor is utilized for the open and close development of the rescue unit. Meanwhile for rescuing work the as per concern of environmental condition of child is important this does not have any gas sensor for harmful gas detection. This has not implemented in real time borewell field.

3. Proposed System
The main aim of our project is to sense the poisonous gas inside the borewell along with this will also get the distance information of child and temperature & humidity condition.
This section consists of as follows.
- Block diagram
- Transmitter side
- Receiver side
3.1 Block diagram.

![Block diagram of the proposed system](image)

**Figure 1.** Proposed system Block diagram.

3.2 Transmitter side

- To sense the harmful gases inside the bore-well here we are using MQ-4, MQ-6, MQ-7 gas sensors. MQ-4 sensor for detection of methane, MQ-6 sensor for detection of LPG and MQ-7 for detection of carbon monoxide. Along with this HC-SR04 ultrasonic sensor is used to get the distance of obstacle (child) at what depth child got stuck and DHT11 sensor for to sense temperature and humidity. These are the gas sensors is used to sense the different gases present around inside the borewell.

- These sensors detect the gases and transmits the Analog signal coming from sensor to the Arduino microcontroller. This Arduino Uno microcontroller having 10Bit ADC and convert these Analog signals to the digital signals. This ADC takes sample of Analog signal then converts into Digital signal which corresponding to Analog. For longer range of communication here proceeding with Zigbee Modules.

- To transmit this digital signal for up to 80 meter of range we are using two Zigbee Modules.
  - We need to configure two Zigbee’s as Co-Ordinator Zigbee and Router ZigBee. Then the coordinator Zigbee is interfaced with Arduino Uno micro controller that is connecting TX pin of Zigbee to RX pin of Arduino. RX pin of Zigbee to TX pin of Arduino which is at Transmitter end. And a 5000mah 5V battery power bank for power supply for the circuit present in the Transmitter side. As shown in **Figure 2** transmitter side is enclosed in a box. After powered on all the sensors, microcontroller & ZigBee get powered on. The Co-Ordinator ZigBee send’s the data to the receiver side.
3.3 Receiver side

- Receiver side consists of Arduino Uno with Ethernet shield and 20*4 LCD interfaced also with 3 LEDs for Harmful gas alerts as shown in Figure 3.
- Next interface the Ethernet shield on Arduino Uno microcontroller. After this Zigbee(router) is connected to RX pin of Zigbee with TX pin of Arduino and TX pin of Zigbee with RX pin of Arduino. Along with this a 20*4 LCD interfaced with it. 3-LED’S for harmful gas Alerting when it exceeds the harmful threshold range the LED will Blink.
- Plug in the RJ45 cable from Ethernet shield to Laptop, then plugin the USB cable of Arduino Uno to Laptop. After a few seconds the receiver side gets powered ON.
- The Ethernet shield with Arduino gets IP address after getting connected to specified IP address. Router ZigBee receives the data coming from the other end. Then it sends data to the Thing speak cloud.
- At each interval of 60seconds of time period it sends the data to Thing speak cloud. Then we can monitor the real time Data through Mobile App or through Thing speak dash board from PC also we can monitor the Real time Data through 20*4 LCD.
4. Results And Conclusion

The Design and Development of IoT enabled Gas sensing system for remote monitoring of Air quality in borewell Rescue operations was tested with in the real time borewell. And furthermore, we saw that execution of our proposed system is contentment for rescue activity.

Transmitter side is tied with rope and left into bore-well up to depth 80meter deep. The gas sensors started to sense gases, DHT11 sensor sense temperature and humidity, Ultrasonic sensor detects the obstacle and all these data are processed in Arduino Uno microcontroller these data transmitted to receiver end and at the Receiver side received the data successfully.

Figures 6,7,8,9&10 represents the Results of live monitoring of Methane, LPG, Carbon-monoxide gases concentrations and distance information (Here for this instance it is measuring the distance of side wall of borewell pipe casing, because of ultrasonic sensor measures around 15degree) displaying in LCD and Android App. And Table1 shows the Collection of Real time data which is exported from the Thing speak cloud to excel sheet.
Figure 4. Sending the transmitter side in to borewell up to 80 meter deep

Figure 5. Over view of receiver side

Figure 6. Live monitoring methane, LPG, CO gases concentrations and distance information displaying in LCD
Figure 7. Live GUI of Real time monitoring of methane gas concentration in the cloud through the mobile App.

Figure 8. Live GUI of Real time monitoring of LPG gas concentration in the cloud through the mobile App.

Figure 9. Live GUI of Real time monitoring of carbon monoxide gas concentration in the cloud through the mobile App.

Figure 10. Live GUI of Real time monitoring of humidity and temperature condition in the cloud through the mobile App.
Table 1 Collection of Real time data which is exported from the Thing speak cloud to excel sheet.

| SL | Methane Gas in ppm | LPG Gas in ppm | Carbon-monoxide in ppm | Humidity in % | Temperature in degree C | Distance in cm |
|----|--------------------|----------------|------------------------|---------------|-------------------------|----------------|
| 1  | 770                | 635            | 212                    | 85            | 29                      | 1              |
| 2  | 768                | 629            | 208                    | 87            | 29                      | 1              |
| 3  | 764                | 623            | 203                    | 88            | 29                      | 1              |
| 4  | 763                | 623            | 199                    | 88            | 28                      | 1              |
| 5  | 761                | 622            | 195                    | 89            | 28                      | 1              |
| 6  | 758                | 614            | 192                    | 89            | 29                      | 1              |
| 7  | 756                | 617            | 189                    | 89            | 29                      | 2              |
| 8  | 754                | 610            | 187                    | 89            | 29                      | 2              |
| 9  | 751                | 610            | 184                    | 89            | 29                      | 1              |
| 10 | 749                | 609            | 182                    | 89            | 28                      | 1              |
| 11 | 748                | 606            | 180                    | 90            | 28                      | 1              |
| 12 | 746                | 599            | 178                    | 90            | 28                      | 2              |
| 13 | 744                | 606            | 176                    | 90            | 28                      | 2              |
| 14 | 743                | 602            | 175                    | 90            | 28                      | 2              |
| 15 | 741                | 597            | 174                    | 91            | 28                      | 2              |
| 16 | 740                | 600            | 172                    | 91            | 28                      | 1              |
| 17 | 706                | 581            | 172                    | 91            | 28                      | 1              |
| 18 | 706                | 581            | 172                    | 91            | 28                      | 1              |
| 19 | 707                | 581            | 169                    | 91            | 28                      | 2              |
| 20 | 706                | 581            | 168                    | 91            | 28                      | 2              |
| 21 | 706                | 582            | 167                    | 91            | 28                      | 2              |
| 22 | 705                | 580            | 166                    | 91            | 28                      | 2              |
| 23 | 705                | 570            | 166                    | 91            | 28                      | 2              |
| 24 | 705                | 581            | 165                    | 92            | 28                      | 2              |
| 25 | 704                | 579            | 165                    | 92            | 28                      | 2              |
| 26 | 704                | 580            | 163                    | 92            | 28                      | 1              |
| 27 | 703                | 571            | 162                    | 92            | 28                      | 1              |
| 28 | 702                | 575            | 162                    | 92            | 28                      | 2              |
| 29 | 702                | 566            | 161                    | 92            | 28                      | 2              |
| 30 | 770                | 635            | 212                    | 85            | 29                      | 1              |

5. Summary and Future Scope

The proposed system will help rescue operators for consistent checking of framework by observing three gases Methane, LPG, Carbon-monoxide concentration with focus additionally, temperature & humidity conditions and alongside the Distance information of obstacle (child).
• Due to minimum in size, it is portable. Due to its compactness, it can be used in any identified borewell spot.
• To develop this proposed system the cost is very much reduced.
• Subsequently the proposed system is effectively executed in borewell and came with Positive outcomes. Have tried up to 80meters depth inside borewell.
• Getting all these valuable real time data and sending these data to the Cloud.
• Monitoring of the real time data in the thing speak dashboard from mobile App or can monitor data in the thing speak dashboard through PC also.
• Suppose if there was internet issue in identified spot means can monitor all the real time data such as Methane, LPG, Carbon monoxide gases concentration and Distance of obstacle information through LCD at Receiver side.
• Additionally, can integrate camera for future for rescue operations in borewell as well in mining areas and in pipeline operations.
• For the proposed system can add some more sensors and also need to be upgraded with microcontroller having more analog and digital pins if it requires.
• If it requires even long range of communication in kilometres means it can be upgraded with long range of communication module like Lora. Etc.

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