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ASMARTAIRPOLLUTANTSMONITORINGSYSTEM USING IOT TECHNOLOGIES

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ABSTRACT

Floods cause significant damage to life and property, necessitating efficient early warning systems. This project presents a Flood Monitoring and Warning System using the NRF (Nordic Radio Frequency) module for wireless communication. The system consists of multiplesensornodesplacednearwaterbodiestomeasureparameterslikewaterlevel,flow rate,andrainfall intensity.Thesesensorscommunicatewirelessly through NRFmodules to a central control unit, which processes real-time data and determines flood risk levels.

In a country like India, air pollution is increasing day by day atthealarmingrate. The main reason for increasing ofpollution level are crop'sremaining burning,emission from themotorvehicle, open defecationof smoke inatmosphere from the industriesand burning of garbage openly. Internet of Things(IOT)basedpollutionsystem isusedto detectthe currentlevelof hazardousgasesinthe atmosphere.Inour daily livesthe qualityofairdeterminesthemostbecause everyhumanbeingneedsfreshairtolive. The IOT based pollution system will help us to fetch the data from anylocationwhere device is installed. On international basis, one in all our century's essential problems is air pollutants

A graphical user interface can be created on the IOT web server side. The graph visualizes the sensor data in a convenient way. By virtue of this IOT based pollution monitoring system project, air and pollution levels can be constantly monitored from a remotelocation.Thisremotelocationcanbeanywhereintheworld.Wecanthentakesteps in order to reduce pollution levels.

INTRODUCTION

A smart air pollutants monitoring system using IoT technologies to provide real-time data on air quality and environmental conditions. By integrating various gas and particulate matter sensors, a display, GSM module for data communication, and a centralized database (BAZAAR), the system monitors and reports key air pollutants and weather conditions to enhance public awareness and safety. The gas sensors include the MQ-131 for ozone, MQ-2 for smoke and flammable gases, MQ-7 for carbon monoxide, MQ-6 for LPG and butane, MQ-4 for methane, MQ-135 for harmful gases like ammonia and benzene, MICS-2714 for high-sensitivity ozone detection, and MICS-5524 for carbon monoxide and volatile organic compounds.[1]

The PMS5003 particulate matter sensor measures PM2.5 and PM10 levels, essential for assessing air quality. A DHT22 sensor collects temperature and humidity data to give context tothepollutantdata.TheAirQuality Index(AQI),calculatedfromsensorreadings,providesa standardized measure of air quality, displayed on the display module for easy access. A GSM module transmits data to remote servers or databases, such as BAZAAR, supporting real-time data logging and monitoring.[5]

BAZAAR stores and processes data for historical access, trend analysis, and integration with other systems. A reliable power supply powers all components to ensure continuous operation.Theproject aimstoprovidereal-timemonitoring, remotedatacommunication, AQI calculation, data analysis, and an intuitive user interface, helping users make informed health decisions and supporting urban planning and environmental policies. This project provides a user-friendly interface and delivers valuable air quality data to aid in public health decisions andsupportsenvironmentalpolicyandurbanplanningbytrackingpollutiontrendsandpatterns. Thesystem calculates an Air Quality Index (AQI), a standardized score that helps users easily interprettheair qualityandunderstandassociated healthrisks.ThisAQIandthepollutantdata aredisplayedonanon-sitemodule,allowinguserstoviewcurrentconditionsinstantly.Through the GSM module, the system sends this data to a remote, centralized database (BAZAAR), enabling continuous data logging, historical data access, and real-time monitoring from any location.

OBJECTIVE

Theobjectiveofthisprojectistodesignandimplementasmartairpollutantsmonitoringsystem that provides real-time insights into air quality by detecting various pollutants and environmental conditions. The system aims to collect accurate data on key air pollutants, including ozone, carbon monoxide, methane, volatile organic compounds (VOCs), and particulatematter(PM2.5 and PM10),alongsidetemperatureand humidity. Bycalculating the Air Quality Index (AQI) from these measurements, the system delivers a clear, standardized indicator of air quality. Through the GSM module, data will be transmitted to a centralized database(BAZAAR)forremoteaccess,historicalanalysis,andintegrationwithothersystems. This project intends to support public awareness of air pollution levels, guide informed health and lifestyle decisions, and potentially contribute to environmental policy and urban planning efforts by offering a scalable, cost-effective solution for real-time air quality monitoring and data-driven analysis

This project is to develop an advanced IoT-based air pollutants monitoring system that facilitatesreal-timedetectionandanalysisofvariousairpollutantstosupporthealthandsafety. By using a comprehensive range of sensors—covering gases like ozone, carbon monoxide, methane, LPG, and other volatile organic compounds (VOCs), as well as particulate matter (PM2.5 and PM10)—the system captures a holistic view of environmental air quality. The integration of a DHT22 sensor for temperature and humidity measurement enhances the data accuracy by providing context for air pollutant readings

PROPOSED SYSTEMS

Theproposedsystemaimstoofferamoreadvancedandcomprehensivesolutionforairquality monitoring compared to existing systems by integrating a wider range of sensors, improved datatransmission,andreal-timereporting,allwhileenhancinguser-friendlinessandreliability.

Unliketraditionalairqualitymonitoringsystemsthatoftenrelyonalimitednumberofsensors and static setups, this IoT-based system incorporates multiple sensors, real-time data communication, and cloud-based data storage to create a robust and scalable solution.

Sensor Integration: The system will utilize a broader array of sensors to detect various pollutants, offering more detailed and accurate monitoring than current systems. The sensors integrated into the proposed system include:

- **MQ-2**:Detectssmoke,LPG,andothercombustiblegases,enhancingairqualitydetection for residential, industrial, and urban environments.
- **MQ-7**:Measurescarbonmonoxide(CO)levels,animportantparameterforassessingair pollution and its effects on human health.
- **MQ-6**: Monitors LPG and butane, providing detection forhousehold and industrial gasleaks.
- **MQ-4**:Focusesonmethanedetection,contributingtotheidentificationofspecificair contaminants related to industrial emissions or natural sources.
- **MQ-135**:Measuresharmfulgaseslikeammonia,benzene,andalcohols,furtherimproving the detection of pollutants commonly found in urban environments.
- **DHT22**: Monitors temperature and humidity, offering contextual data that enhances the accuracy of pollutant readings and helps better understand environmental conditions.

  This combination of sensors provides a significantly broader scope of air quality detection thanexistingsystems,whichoftenutilizefewersensorsthatarelimitedtodetectingjustone or two types of pollutants.

Real-TimeDataCommunicationandCloud Integration

- **Display Module**: The system will feature a user-friendly display module that shows real- timedataon air quality, pollutant levels,and the calculated AQI. Thisimmediatefeedback helpsusersmakeinformeddecisionsabouttheirhealthandsafety.
- **GSM Module**: The GSM module is employed to send the collected data to a centralized cloud-based system for remote monitoring and storage. This ensures that the system operates efficiently even in areas without stable internet access, offering real-time data transmission through cellular networks.
- **BAZAAR Database**: Data transmitted via GSM will be uploaded to **BAZAAR**, the centralizedclouddatabase.BAZAARservesasthecentralrepository forallcollecteddata, offeringeasyaccessforlong-termanalysis,historicaltracking,andtrendidentification.This cloud-basedapproachenablesuserstoaccessdatafromanylocationandensurescontinuous data collection and storage.
- This combination of sensors provides a significantly broader scope of air quality detection thanexistingsystems,whichoftenutilizefewersensorsthatarelimitedtodetectingjustone or two types of pollutants.

ImprovedSystemCapabilities

Theproposedsystem offersseveraladvantagesoverexistingsystems:

- **Comprehensive PollutantDetection**: With moresensorsdeployed,thesystem provides a much broader range of pollutant detection (including gases, particulates, temperature, and humidity), significantly improving the accuracy and reliability of the air quality data.
- This combination of sensors provides a significantly broader scope of air quality detection thanexistingsystems,whichoftenutilizefewersensorsthatarelimitedtodetectingjustone or two types of pollutants.
- **Real-TimeMonitoring**:Thesystem'sintegration ofGSMcommunication allowsforreal- time reporting of air quality conditions to remote servers, unlike traditional systems that may offer delayed data or only monitor a fixed set of locations.
- **Remote Accessibility**: By using the BAZAAR cloud-based storage solution, the system allows for easy access to historical data, real-time monitoring, and trend analysis, giving users better insight into air quality patterns and pollution hotspots.
- **Scalability**: The system is designed to be scalable, allowing additional sensors or componentstobeeasilyintegratedforfurtherexpansion,makingitsuitablefordeployment in both urban and rural areas.

DESIGN APPROACHES ARCHITECTURE

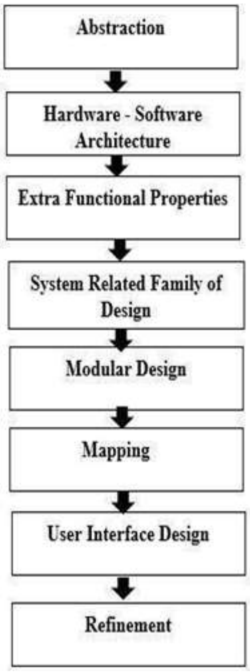
A system designed with the embedding of hardware and software together for a specific function with a larger area is embedded system design. In embedded system design, a microcontroller plays a vital role. Micro-controller is based on Harvard architecture, it is an important component of an embedded system. External processor, internal memory and i/o components are interfaced with the microcontroller. It occupies less area, less power consumption. The application of microcontrollers is MP3, washing machines.

potentiallycatastrophicand,therefore,hardconstraintsareimposedonthem.Nottoworry,youcanswitch it off just by clicking a button on your cell phone using this technology. In the last yearstheamount of software accommodated within CES has considerably changed.

For example, in smart cars the amount of software has grown about 100 times comparedtoprevious years. This change means that software design for these systems is also bounded tohard constraints (e.g., high security and performance). Along the evolution of CES, theapproaches for designing them are also changing rapidly, so as to fit the specialized needs ofCES. Thus, a broad understanding of such approaches is missing.

The different teps in the embedded system design flow/flow diagram include the following:

StepsintheEmbeddedSystemDesignProcess



Hardware–SoftwareArchitecture

Properknowledgeofhardwareand softwareto be knownbeforestarting anydesign process.

ExtraFunctionalProperties

Extrafunctionstobeimplementedaretobeunderstoodcompletelyfromthemain design.

SystemRelatedFamilyofDesign

Whendesigningasystem, oneshould referto apreviioussystem-related familyofdesign.

ModularDesign

Separatemoduledesignsmustbemadesothat theycan beusedlater onwhen required.

Mapping

Basedonsoftwaremappingisdone.Forexample,dataflowandprogramflowaremapped into one.

UserInterfaceDesign

In userinterfacedesign it dependson userrequirements, environment analysis and function of the system. For example, on a mobile phone if we want to reduce the power consumption ofmobile phones, we take care of other parameters, so that power consumption can be reduced.

Refinement

Everycomponentandmodulemustberefinedappropriatelysothatthesoftwareteamcan understand.
Architecturaldescriptionlanguageisusedtodescribethesoftwaredesign.

- Control Hierarchy
- Partitionofstructure
- Datastructureand hierarchy
- SoftwareProcedure.

WORKING

TheSmartAirPollutantsMonitoringSystemisacomprehensivesolutiondesignedtoprovide real-timeairqualitymonitoringusingadvanced IoTtechnologies.Thesystemincorporates a variety ofsensors to detect multiple types ofair pollutants, such as the MQ-2, MQ-7, MQ-6, MQ-4, MQ-135, MICS-2714, and MICS-5524, which measure gases like smoke, carbon monoxide, methane, LPG, volatile organic compounds (VOCs), and ozone.

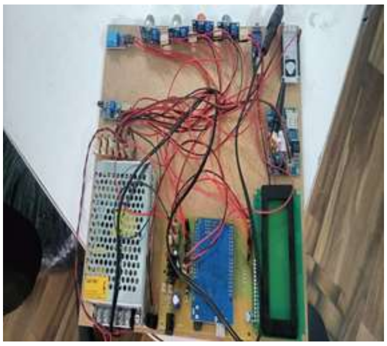
Additionally,thePMS5003sensormeasuresparticulatematter(PM2.5and PM10),which is crucial for assessing the fine dust in the air. The DHT22 sensor provides real-time data on temperature and humidity, offering a more complete understanding of environmental conditions that influence air quality.

Themicrocontroller(e.g.,ArduinoorESP32)processesthesensordataandcalculatestheAir Quality Index (AQI**)** based on predefined thresholds and algorithms. This AQI is then

Circuit connections

displayed on a local screen, such as an LCD or OLED display, allowing users to view the current air quality in real time.

1. **Sensors**: The system uses multiple sensors (e.g., MQ series, DHT22) to detect pollutants likegases(e.g.,carbonmonoxide,methane,ozone)andparticulatematter(PM2.5,PM10),

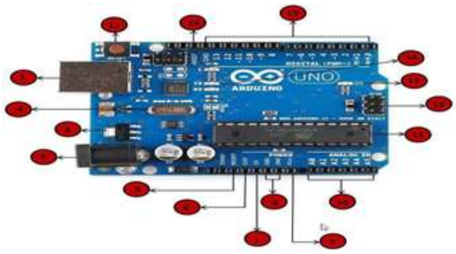


2.Microcontroller & AQI Calculation**: A microcontroller processes the data from these sensors and calculates the** Air Quality Index (AQI)**, which is a standardized way of reporting air quality.**

Local Display: The AQI and sensor data are displayed on a screen for immediate access, providinguserswithreal-timeinformationonairquality

ARDUINOUNOBOARD:

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/outputpins(ofwhich6canbeusedasPWMoutputs),6analoginputs,a16MHzceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everythingneeded tosupportthemicrocontroller; simply connect it toacomputerwithaUSB cable or power it with a AC-to-DC adapter or battery to get started.



Arduinounoboard

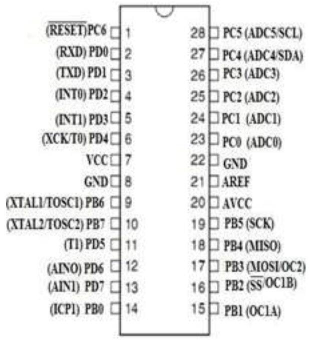
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed asaUSB-to-serialconverters.6analoginputs,a16MHzceramicresonator,aUSBconnection, a power jack, an ICSP header, and a reset button. It contains everything needed to supportthe microcontroller.

Main microcontroller:

Each Arduino board has its own microcontroller (11). You can assume it as the brain of your board.ThemainIC(integratedcircuit)ontheArdsuinoisslightlydifferentfromboardtoboard.

ThemicrocontrollersareusuallyoftheATMELCompany.YoumustknowwhatICyourboard has before loading up a new program from the Arduino IDE. This information is available on thetopoftheIC.FormoredetailsabouttheICconstructionandfunctions,youcanrefertothe data sheet.

Pin diagram



PinDescription:
VCC: Digitalsupplyvoltage.
GND: Ground.
PortB(PB[7:0])XTAL1/XTAL2/TOSC1/TOSC2:
Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). ThePortBoutputbuffershavesymmetricaldrivecharacteristicswithbothhighsinkandsource capability. As inputs, Port B pins that are externally pulled low will source current if the pull-upresistorsareactivated.ThePortBpinsaretri-statedwhenaresetconditionbecomesactive, even if the clock is not running.
Abuzzerisanelectroniccomponentusedtoproducesoundinresponsetoanelectrical signal,makingitanessentialdeviceforalerts,alarms,andnotificationsinvariousapplications**.**

BUZZERSENSOR

Buzzers can be either active or passive, where active buzzers generate a sound when powered, while passive buzzers require an external oscillating signal, such as a PWM (Pulse Width Modulation) signal, to produce sound of varying frequencies. Due to their small size, lowpowerconsumption, and easeofuse, buzzers are widely employed indeviceslike alarms, timers, security systems, household appliances, and embedded systems.

RESULT

The implementation of the Smart Air Pollutants Monitoring System using IoT has yielded promising results in detecting and monitoring various environmental parameters. The system successfully collected and transmitted real-time data on gas concentrations, temperature, humidity, light intensity, and fire hazards. The MQ-series gas sensors effectively detected pollutants such as CO, CO2, LPG, and NH3, providing accurate readings under controlled conditions. The DHT11 and DHT22 sensors offered reliable temperature and humidity data, ensuring a comprehensive environmental assessment. The GSM module efficiently sent alerts andnotificationswheneverpollutionlevels exceededpredefinedthresholds, demonstratingthe practicality of remote monitoring

Thedata collected from thesystemprovidedinsightsintopollutiontrends, allowingfortimely interventionandnecessaryactionstobetaken.Overall,thesystemprovedtobeaviablesolution for air quality monitoring, highlighting its potential for large-scale deployment in urban and industrial environments. Although some sensor fluctuations and calibration challenges were observed, the results affirm the effectiveness of the system in contributing to a healthier and saferenvironment.Tofurthervalidatethesystem'sefficiency,testswereconductedindifferent environments, including residential areas, industrial zones, and urban locations.

Overall,theprojecthasdemonstratedthefeasibilityoflow-costIoT-basedairpollution monitoring, paving the way for future developments in smart environmental solutions. The results suggest that with proper enhancements, this system can become a crucial tool for policymakers, industries, and individualsaimingto reduce pollution exposureand improveair quality management.

APPLICATIONS

The Air Monitoring and Warning System has a wide range of applications across various sectors. It plays a crucial role in disaster management, urban planning, agriculture, and infrastructure protection. Below are the key applications:

1. **IndoorAirQuality Mointoring**

The Helps maintain air quality in homes, offices, and hospitals. Can trigger air purifiers when pollution exceeds a threshold.

2. **IndustrialSafety&Pollution Control**

Usedinfactories to detect harmful gasleaks and firerisks.Helps prevent workplaceaccidents and ensures compliance with pollution norms.

3. **SmartCities&UrbanPollutionControl**

Helps municipalities monitor city-wide air quality. Can be used for data-driven pollution control policies.

4. **Agriculture&GreenhouseMonitoring**

Monitors gases like CO2 and ammonia in poultry farms and greenhouses. Helps regulate ventilation for better crop and livestock health

5. **Schools,Hospitals,andPublic Spaces**

Ensuresasafeandhealthyenvironmentforchildren,elderly,andpatients. Alertsauthoritiesin case of high pollution levels.

Throughcontinuousdatacollectionandanalysis,thisprojectdemonstratesthepotential of IoT in providing real-time solutions for air quality management. The results of this project highlighttheeffectivenessofusinglow-costsensorstomonitorpollutionandthefeasibilityof deployingsuchasysteminhomes,industries,andpublicspaces.Firesensorandgassensorsact asan early warning system forfireandgas leak hazards.

Alerts in case of gas leaks, high CO levels, or fire hazards. Can be integrated with an automatic ventilation system or alarms. The system utilizes error correction algorithms to maintainstableandaccuratedatatransmission,eveninchallengingenvironments.Poweredby solar energy, it operates continuously, even during power outages, providing uninterrupted floodmonitoring.Overall,theprojecthasdemonstratedthefeasibilityoflow-costIoT-basedair pollutionmonitoring,pavingthewayforfuturedevelopmentsinsmartenvironmentalsolutions. The results suggest that with proper enhancements, this system can become a crucial tool for policymakers,industries,and individualsaimingtoreducepollutionexposureandimproveair quality managem

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