A

Major Project On

## WIRELESS SENSOR NETWORK DEPENDABLE MONITORING FOR URBAN AIR QUALITY

(Submitted in partial fulfillment of the requirements for the award of Degree) BACHELOR OF TECHNOLOGY

In

COMPUTER SCIENCE AND ENGINEERING

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Under the Guidance of

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(Assistant Professor)



## DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING CMR TECHNICAL CAMPUS

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**2019-2023**

**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**



**CERTIFICATE**

This is to certify that the project entitled **“ WIRELESS SENSOR NETWORK DEPENDABLE MONITORING FOR URBAN AIR QUALITY ”** being submitted by **M.VEDANGANA (197R1A05N3), G.ALEKHYA (197R1A05L3)** and **K.PRABHATH**

**(197R1A05L9)** in partial fulfillment of the requirements for the award of the degree of B.Tech in Computer Science and Engineering to the Jawaharlal Nehru Technological University Hyderabad, is a record of bonafide work carried out by them under our guidance and supervision during the year 2022-23.

The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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**Submitted for viva voice Examination held on**

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**ABSTRACT**

This project presents an Internet of Things enabled low-cost wireless sensor network with newly-developed dependable schemes to improve reliability for monitoring air quality in suburban areas. The system features sensing units for router communications with energy savings from dynamic conservation. Based on the reliability function and mean time to failure, a continuous time Markov chain model is used to analyze the monitoring performance. The proposed dependable monitoring network is shown to achieve high availability with regards to energy consumption and data assurance with the survival probability of over 80% during a minimum period of 72-hour operation for monitoring air quality in a suburb. Distributions of fine particle concentrations studied over a 6-month period demonstrate feasibility of the developed system in its high correlations to benchmark monitoring stations with the Pearson’s coefficients obtained at 0.903 and 0.817 respectively for PM2.5 and PM10. Statistical analysis is conducted for performance evaluation in association with two extreme events, one with bushfires and the other with pandemic lockdown. The results obtained indicate enhancements in reliability and accuracy of the collocated dependable low-cost sensors network proposed for wireless monitoring of air quality in urban conditions.

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# INTRODUCTION

## INTRODUCTION

### PROJECT SCOPE

This project is titled " Wireless Sensor Network Dependable Monitoring for Urban Air Quality". This project presents an Internet of Things-enabled low-cost wireless sensor network with newly-developed dependable schemes to improve reliability for monitoring air quality in suburban areas. The system features sensing units for router communications with energy savings from dynamic conservation.

### PROJECT PURPOSE

This project has been developed towards environmental sustainability and social resilience in metropolitan areas, it is essential for residents to have clean air. In this regard, technical measures are needed for monitoring and improving air quality, whereby IoT-enabled wireless sensors networks are promising among available monitoring systems for healthy built environment and air quality management.

### PROJECT FEATURES

The main feature of this project is, the proposed dependable monitoring network is shown to achieve high availability with regards to energy consumption and data assurance with the survival probability of over 80% during a minimum period of 72-hour operation for monitoring air quality in a suburb. Distributions of fine particle concentrations studied over a 6-month period demonstrate feasibility of the developed system in its high correlations to benchmark monitoring stations.

# LITERATURE SURVEY

## 2.LITERATURE SURVEY

### A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies.

**ABSTRACT:** In the subject of smart sustainable cities, the underlying theories are a foundation for practice. Moreover, scholarly research in the field of smart sustainable cities operates out of the understanding that advances in the underlying knowledge necessitate pursuing multifaceted questions that can only be resolved from the vantage point of interdisciplinarity or transdisciplinarity. Indeed, research problems in this field are inherently too complex to be addressed by single disciplines. The PhD study addressing the topic of smart sustainable city development falls within the broad research field of sustainability transition and sustainability science where ICT is seen as a salient factor given its transformational, disruptive, and synergetic effects as an enabling, integrative, and constitutive technology. In light of this, the approach to the PhD study is of an applied theoretical kind, and its aim is to investigate and analyze how to advance and sustain the contribution of sustainable urban forms to the goals of sustainable development with support of ICT of pervasive computing. This is to primarily create a framework for strategic smart sustainable city development based on scientific principles, theories, and academic disciplines and discourses used to guide urban actors in their practice towards sustainability and analyze its impact. This involves the application of a set of integrative foundational elements drawn from urban planning, urban design, sustainability, sustainable development, sustainability science, data science, computer science, complexity science, systems theory, systems thinking, and ICT. Accordingly, it is deemed of high significance to devise a multidimensional framework consisting of relevant theories and academic disciplines and discourses that underpin the development of smart sustainable cities as a set of future practices. This framework in turn emphasizes the interdisciplinary and transdisciplinary nature and orientation of the topic of smart sustainable cities and thus the relevance of pursuing an interdisciplinary and transdisciplinary approach into studying this topic. Therefore, this paper endeavors to systematize the very complex and dense scientific area of smart sustainable cities in terms of identifying, distilling, and structuring the core dimensions of a foundational framework for smart sustainable city development as a set of future practices.

In doing so, it focuses on a number of fundamental theories along with academic disciplines and discourses, with the aim of setting a framework that analytically relates city development, sustainability, and ICT, while emphasizing how and to what extent sustainability and ICT have particularly become influential in city development in modern society. In addition, this paper offers an in–depth interdisciplinary and transdisciplinary discussion covering topics of high relevance to the PhD study and at the heart of the very synergic relationship between the theoretical, disciplinary, and discursive dimensions of the foundational framework underpinning smart sustainable city development. These dimensions thus form the basis for the framework for strategic smart sustainable city development that is under investigation and will be developed based on a backcasting approach to strategic planning. This study provides an important lens through which to understand a set of influential theories and established academic disciplines and discourses with high potential for integration, fusion, and practicality in relation to the practice of smart sustainable city development.

### AIR louisville: Addressing asthma with technology, crowdsourcing, cross- sector collaboration, and policy

**ABSTRACT:** Cross-sector partnerships benefit public health by leveraging ideas, resources, and expertise from a wide range of partners. In this study we documented the process and impact of AIR Louisville (a collaboration forged among the Louisville Metro Government, a nonprofit institute, and a technology company) in successfully tackling a complex public health challenge: asthma. We enrolled residents of Louisville, Kentucky, with asthma and used electronic inhaler sensors to monitor where and when they used medication. We found that the use of the digital health platform achieved positive clinical outcomes, including a 78 percent reduction in rescue inhaler use and a 48 percent improvement in symptom-free days. Moreover, the crowdsourced real-world data on inhaler use, combined with environmental data, led to policy recommendations including enhancing tree canopy, tree removal mitigation, zoning for air pollution emission buffers, recommended truck routes, and developing a community asthma notification system. AIR Louisville represents a model that can be replicated to address many public health challenges by simultaneously guiding individual, clinical, and policy decisions.

* + 1. **Sensing data fusion for enhanced indoor air quality monitoring ABSTRACT:** Multisensor fusion of air pollutant data in smart buildings remains an important input to address the well-being and comfort perceived by their inhabitants. An integrated sensing system is part of a smart building where real-time indoor air quality data are monitored round the clock using sensors and operating in the Internet-of- Things (IoT) environment. In this work, we propose an air quality management system merging indoor air quality index (IAQI) and humidex into an enhanced indoor air quality index (EIAQI) by using sensor data on a real-time basis. Here, indoor air pollutant levels are measured by a network of waspmote sensors while IAQI and humidex data are fused together using an extended fractional-order Kalman filter (EFKF). According to the obtained EIAQI, overall air quality alerts are provided in a timely fashion for accurate prediction with enhanced performance against measurement noise and nonlinearity. The estimation scheme is implemented by using the fractional- order modeling and control (FOMCON) toolbox. A case study is analysed to prove the effectiveness and validity of the proposed approach.

### Modeling traffic congestion based on air quality for greener environment:

**An empirical study**

**ABSTRACT:** The primary focus of this paper is to govern traffic congestion on urban road networks based upon a cumulative approach comprising of traffic flow modeling, vehicle emission modeling, and air quality modeling. Based upon the traffic conditions, a simulation model is proposed and further tested for performance metrics, which is relative to three main aspects, namely, the waiting time of the vehicles at the junctions/intersections/signals, the type of pollutant emitted by a vehicle, and the traveling time. The experimental analysis and validation are carried out for different case studies in Malaysia, such as Petaling Jaya, Shah Alam, Mont Kiara, and Jalan Tun Razak. Three different scenarios (morning, afternoon, and evening) are analyzed and tested to explore the traffic usage parameter. The results showed that when traffic is modeled and governed based upon traffic flow, vehicle emission, and air quality index (AQI), nearly 75% of traffic congestion is mitigated, hence making the atmosphere pollution free as well as avoiding Urban Heat Island (UHI) effect due to the heat generated from vehicles. The experimental results are tested, validated, and compared with existing solutions for performance analysis. The proposed model is aimed toward overcoming the major drawbacks of existing approaches, such as single-path suggestions, traffic delay during peak hours/emergencies, non-recurring congestion consideration, congestion avoidance instead of recovering from it, improper reporting of road accidents, and notifications about traffic jam ahead to the users and high vehicle usage rate.

### Urban air pollution estimation using unscented Kalman filtered inverse modeling with scaled monitoring data

**ABSTRACT:** The increasing rate of urbanization requires effective and reliable techniques for air quality monitoring and control. For this, the Air Pollution Model and Chemical Transport Model (TAPM-CTM) has been developed and used in Australia with emissions inventory data, synoptic data and terrain data used as its input parameters. Since large uncertainties exist in the emissions inventory (EI), further refinements and improvements are required for accurate air quality prediction. This study evaluates the performance of urban air quality forecasting, using TAPM-CTM, and improves accuracy of air pollution estimation by using a two-stage optimization technique to upgrade EI with validation from monitoring data. The first stage is based on statistical analysis for EI correction and the second stage is based on the unscented Kalman filter (UKF) to take into account the spatio-temporal distributions of air pollutant levels utilizing a Matérn covariance function. The predicted nitrogen monoxide (NO) and nitrogen dioxide (NO) concentrations with emissions are first compared with observations at monitoring stations in the New South Wales (NSW). Ozone (O) is also considered since at the ground level it represents a major air pollutant affecting human health and the environment. In the second stage, with the improved EI, TAPM-CTM model errors are reduced further by using the UKF to calibrate EI. Results obtained show effectiveness of the proposed technique, which is promising for air quality inverse modeling, an important aspect of air pollution control in smart cities to achieve environmental sustainability.

# SYSTEM ANALYSIS

## 3. SYSTEM ANALYSIS

### SYSTEM ANALYSIS

System Analysis is the important phase in the system development process. The System is studied to the minute details and analyzed. The system analyst plays an important role of an interrogator and dwells deep into the working of the present system. In analysis, a detailed study of these operations performed by the system and their relationships within and outside the system is done. A key question considered here is, “what must be done to solve the problem?” The system is viewed as a whole and the inputs to the system are identified. Once analysis is completed the analyst has a firm understanding of what is to be done.

### PROBLEM DEFINITION

This project presents an Internet of Things-enabled low-cost wireless sensor network with newly-developed dependable schemes to improve reliability for monitoring air quality in suburban areas. The system features sensing units for router communications with energy savings from dynamic conservation. Based on the reliability function and mean time to failure, a continuous time Markov chain model is used to analyze the monitoring performance. The proposed dependable monitoring network is shown to achieve high availability with regards to energy consumption and data assurance with the survival probability of over 80% during a minimum period of 72-hour operation for monitoring air quality in a suburb.

### EXISTING SYSTEM

In Australia, along with recent big projects for infrastructure development to meet the urbanization needs, the problem of air quality modelling and control is also of top priority. A network of KOALA (Knowing Our Ambient Local Air Quality) low-cost sensors has been implemented for high spatial resolution air quality monitoring to successfully observe the emissions of fine particles and carbon monoxide during six months before and after a big sports event. These initiatives show benefits and feasibility of a low-cost solution using wireless sensor networks for monitoring air pollution and improving air quality in cities. While global smart city development can offer various dimensions and services covering all aspects of municipal activities, it should be people- centric, addressing directly citizens’ well-being and quality of life. Therefore, the needs and preferences of citizens should be considered in public-involved programs to implement of LWSN for environment monitoring.

#### DISADVANTAGES OF EXISTING SYSTEM

Following are the disadvantages of existing system:

This would raise concerns on sustainable development and require the need for

effective measures for environmental monitoring in urban areas. Less monitoring quality in terms of availability, reliability.

### PROPOSED SYSTEM

This project aims to develop a framework of dependable low-cost wireless sensor network (DLWSN) for air quality monitoring, which addresses the affordable deployment of a collocated monitoring system for reliable data aggregation and accurate assessment of urban air quality using the IoT-enabled system with enhanced availability. Here, the reliability analysis for the proposed system is conducted via the mean time to failure (MTTF) derived from the reliability function of the monitoring system, whereby the survival and failing probabilities of its sensor modules are calculated by a Markov chain model (MCM). From the reliability analysis, a suitable configuration is selected for sensor motes supplied with a dynamic energy conservation scheme to increase the system’s runtime and incorporated with a novel wireless dependable algorithm to improve the accurate, reliable and fail-safe operations of the overall system in monitoring outdoor air quality. The availability, reliability and resilience of the proposed DLWSN against environmental volatility are verified in extreme events such as bushfires and pandemic lockdown conditions.

#### ADVANTAGES OF PROPOSED SYSTEM

Following are the advantages of existing system:

The proposed dependable monitoring network is shown to achieve high availability with regards to energy consumption and data assurance with the survival probability.

Enhancements in reliability and accuracy of the collocated dependable low-cost sensors network proposed for wireless monitoring of air quality in urban conditions.

### FEASIBILITY STUDY

The feasibility of the project is analyzed in this phase and a business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. Three key considerations involved in the feasibility analysis:

Economic Feasibility Technical Feasibility Social Feasibility

#### ECONOMIC FEASIBILITY

The developing system must be justified by cost and benefit. Criteria to ensure that effort is concentrated on a project, which will give best, return at the earliest. One of the factors, which affect the development of a new system, is the cost it would require.

The following are some of the important financial questions asked during preliminary investigation:

The costs conduct a full system investigation. The cost of the hardware and software.

The benefits in the form of reduced costs or fewer costly errors.

Since the system is developed as part of project work, there is no manual cost to spend for the proposed system. Also all the resources are already available, it give an indication that the system is economically possible for development.

#### TECHNICAL FEASIBILITY

This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system.

#### BEHAVIORAL FEASIBILITY

This includes the following questions:

Is there sufficient support for the users? Will the proposed system cause harm?

### HARDWARE & SOFTWARE REQUIREMENTS

#### HARDWARE REQUIREMENTS:

Minimum hardware requirements are very dependent on the particular software being developed by a given Enthought Python / Canopy / VS Code user. Applications that need to store large arrays/objects in memory will require more RAM, whereas applications that need to perform numerous calculations or tasks more quickly will require a faster processor.

Operating system: windows, linux Processor : minimum intel i3

Ram : minimum 4 gb

Hard disk : minimum 250gb

#### SOFTWARE REQUIREMENTS:

The functional requirements or the overall description documents include the product perspective and features, operating system and operating environment, graphics requirements, design constraints and user documentation. The appropriation of requirements and implementation constraints gives the general overview of the project in regards to what the areas of strength and deficit are and how to tackle them.

Python idel 3.7 version (or) Anaconda 3.7 ( or)

Jupiter (or) Google colab

### FUNCITONAL REQUIREMENTS

1.Data Collection 2.Data Preprocessing 3.Training And Testing 4.Modiling 5.Predicting

### NON FUNCITONAL REQUIREMENTS

Non functional requirement (NFR) specifies the quality attribute of a software system. They judge the software system based on Responsiveness, Usability, Security, Portability and other non-functional standards that are critical to the success of the software system. Example of nonfunctional requirement, “how fast does the website load?” Failing to meet non-functional requirements can result in systems that fail to satisfy user needs. Non- functional Requirements allows you to impose constraints or restrictions on the design of the system across the various agile backlogs. Example, the site should load in 3 seconds when the number of simultaneous users are > 10000. Description of non-functional requirements is just as critical as a functional requirement.

Usability requirement Serviceability requirement Manageability requirement Recoverability requirement Security requirement

Data Integrity requirement Capacity requirement Availability requirement Scalability requirement Interoperability requirement Reliability requirement Maintainability requirement Regulatory requirement Environmental requirement

# ARCHITECTURE

## ARCHITECTURE

### PROJECT ARCHITECTURE

This project architecture shows the procedure followed for classification, starting from input to final output.

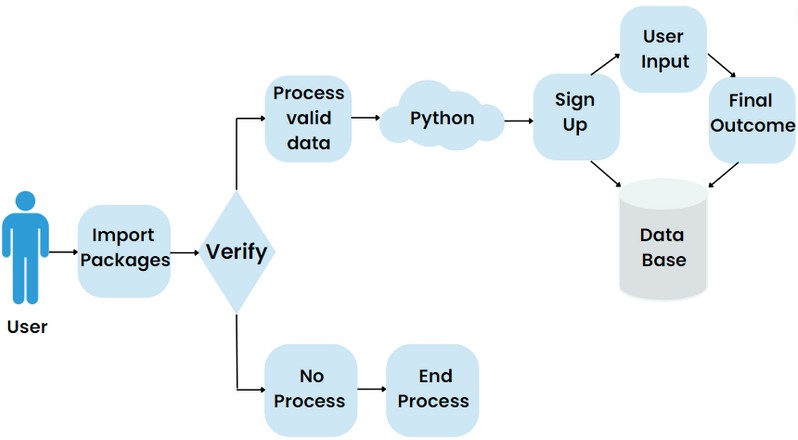


Figure 4.1: Project Architecture of wireless sensor network dependable monitoring for

urban air quality.

### DESCRIPTION

This project presents an internet of things-enabled low-cost wireless sensor network with newly-developed dependable schemes to improve reliability for monitoring air quality in suburban areas. The system features sensing units for router communications with energy savings from dynamic conservation. Based on the reliability function and mean time to failure, a continuous time Markov chain model is used to analyze the monitoring performance.

### MODULES

#### Tensorflow:

TensorFlow is a free and open-source software library for dataflow and differentiable programming across a range of tasks. It is a symbolic math library, and is also used for machine learning applications such as neural networks. It is used for both research and production at Google. TensorFlow was developed by the Google Brain team for internal Google use. It was released under the Apache 2.0 open-source license on November 9, 2015.

#### Numpy:

Numpy is a general-purpose array-processing package. It provides a high- performance multidimensional array object, and tools for working with these arrays.

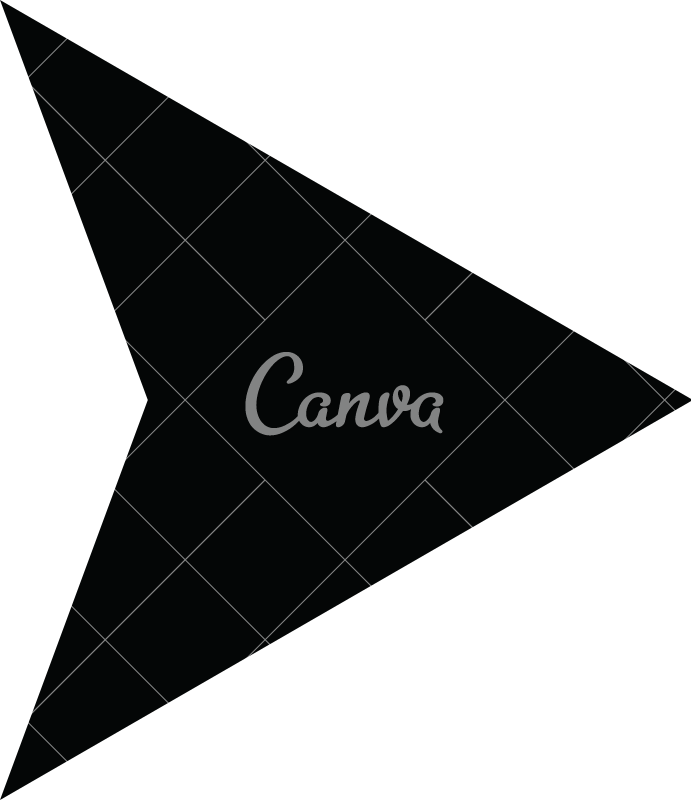
It is the fundamental package for scientific computing with Python. It contains various features including these important ones:

A powerful N-dimensional array object Sophisticated (broadcasting) functions

Tools for integrating C/C++ and Fortran code

Useful linear algebra, Fourier transform, and random number capabilities

Besides its obvious scientific uses, Numpy can also be used as an efficient multi- dimensional container of generic data. Arbitrary data-types can be defined using Numpy which allows Numpy to seamlessly and speedily integrate with a wide variety of databases.

 **Pandas:**

Pandas is an open-source Python Library providing high-performance data manipulation and analysis tool using its powerful data structures. Python was majorly used for data munging and preparation. It had very little contribution towards data analysis. Pandas solved this problem. Using Pandas, we can accomplish five typical steps in the processing and analysis of data, regardless of the origin of data load, prepare, manipulate, model, and analyze. Python with Pandas is used in a wide range of fields including academic and commercial domains including finance, economics, Statistics, analytics, etc.

#### Matplotlib:

Matplotlib is a Python 2D plotting library which produces publication

quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib can be used in Python scripts, the Python and IPython shells, the Jupyter Notebook, web application servers, and four graphical user interface toolkits. Matplotlib tries to make easy things easy and hard things possible. You can generate plots, histograms, power spectra, bar charts, error charts, scatter plots, etc., with just a few lines of code. For examples, see the sample plots and thumbnail gallery.

For simple plotting the pyplot module provides a MATLAB-like interface, particularly when combined with IPython. For the power user, you have full control of line styles, font properties, axes properties, etc, via an object oriented interface or via a set of functions familiar to MATLAB users.

#### Scikit – learn:

Scikit-learn provides a range of supervised and unsupervised learning

algorithms via a consistent interface in Python. It is licensed under a permissive simplified BSD license and is distributed under many Linux distributions, encouraging academic and commercial use.

### USE CASE DIAGRAM

In the use case diagram, we have basically one actor who is the user in the trained model. A use case diagram is a graphical depiction of a user's possible interactions with a system. A use case diagram shows various use cases and different types of users the system has. The use cases are represented by either circles or ellipses. The actors are often shown as stick figures.

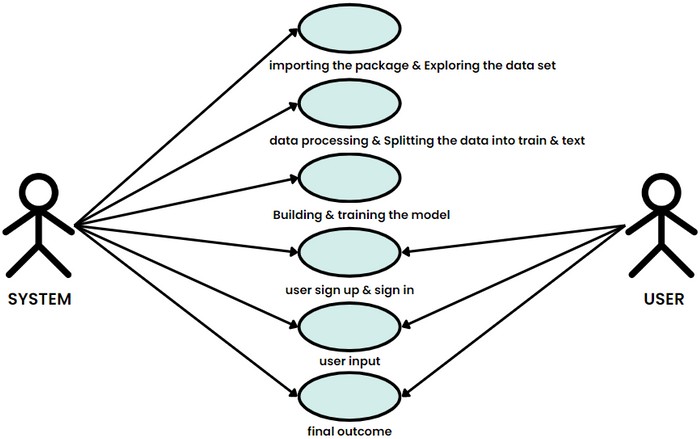


Figure 4.4: Use Case Diagram of wireless sensor network dependable monitoring for urban air quality.

### CLASS DIAGRAM

Class diagram is a type of static structure diagram that describes the structure of a system by showing the system’s classes, their attributes, operations (or methods), and the relationships among objects.

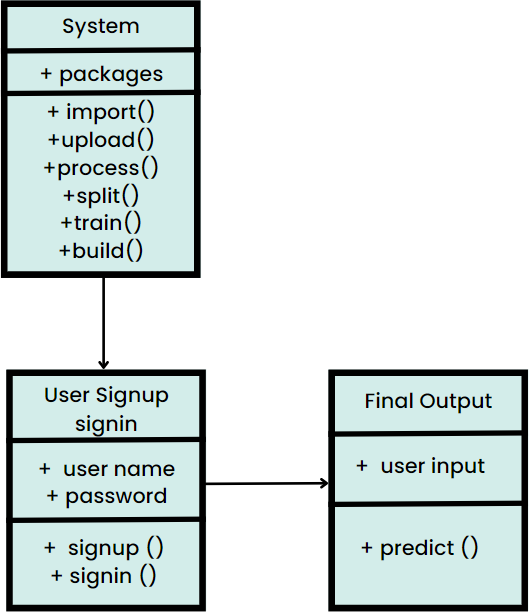


Figure 4.5: Class Diagram of wireless sensor network dependable monitoring for urban air quality.

### SEQUENCE DIAGRAM

A sequence diagram shows object interactions arranged in time sequence. It depicts the objects involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the logical view of the system under development.

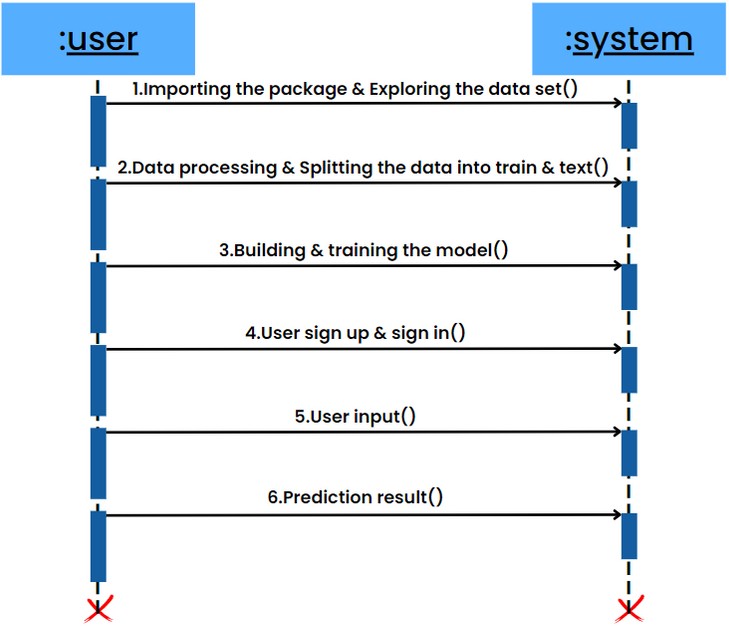


Figure 4.6: Sequence Diagram of wireless sensor network dependable monitoring for urban air quality.

### ACTIVITY DIAGRAM

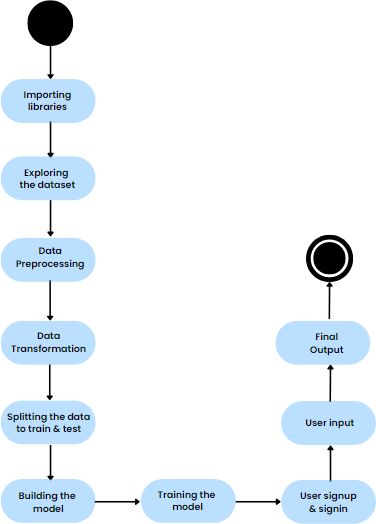
Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. They can also include elements showing the flow of data between activities through one or more data stores.

Figure 4.7: Activity Diagram of wireless sensor network dependable monitoring for urban air quality.

# IMPLEMENTATION

### 5.1 SAMPLE CODE

from flask import Flask, render\_template, request import joblib

import numpy as np import pickle import sqlite3

app = Flask( name )

lr = joblib.load("Models/model.pkl") @app.route('/')

def home():

return render\_template('home.html')

@app.route('/logon') def logon():

return render\_template('signup.html')

@app.route('/login') def login():

return render\_template('signin.html')

@app.route("/signup") def signup():

username = request.args.get('user','') name = request.args.get('name','') email = request.args.get('email','') number = request.args.get('mobile','')

password = request.args.get('password','') con = sqlite3.connect('signup.db')

cur = con.cursor()

cur.execute("insert into `info` (`user`,`email`, `password`,`mobile`,`name`) VALUES (?,

?, ?, ?, ?)",(username,email,password,number,name)) con.commit()

con.close()

return render\_template("signin.html")

@app.route("/signin") def signin():

mail1 = request.args.get('user','') password1 = request.args.get('password','') con = sqlite3.connect('signup.db')

cur = con.cursor()

cur.execute("select `user`, `password` from info where `user` = ? AND `password` = ?", (mail1,password1,))

data = cur.fetchone()

if data == None:

return render\_template("signin.html")

elif mail1 == 'admin' and password1 == 'admin':

return render\_template("index.html")

elif mail1 == str(data[0]) and password1 == str(data[1]):

return render\_template("index.html") else:

return render\_template("index.html")

@app.route("/index") def index():

return render\_template('index.html')

@app.route('/predict', methods = ['POST']) def predict():

if request.method == 'POST':

T, TM, Tm, SLP, H, VV, V, VM = float(request.form['T']), float(request.form['TM']),

float(request.form['Tm']), float(request.form['SLP']), float(request.form['H']),

float(request.form['VV']), float(request.form['V']), float(request.form['VM']) lr\_pm = lr.predict([[T, TM, Tm, SLP, H, VV, V, VM]])

# print(lr\_pm)

return render\_template("result.html", lr\_pm = np.round(lr\_pm,3))

@app.route('/notebook') def notebook():

return render\_template('NOtebook.html')

@app.route('/about') def about():

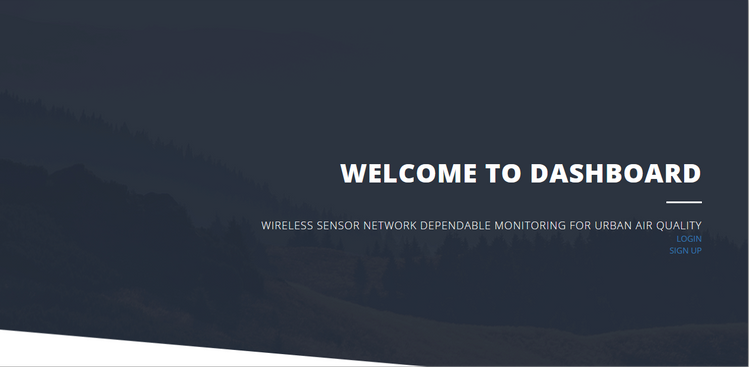
return render\_template('about.html')

if name == " main ": app.run(debug = True)

# RESULTS

### Home Screen

This is the home screen of wireless sensor network dependable monitoring for urban air quality. This is an login page where the user needs to login if he/she already has an account or else need to create an account using sign up option.



Screenshot 6.1: Home screen

### Result page

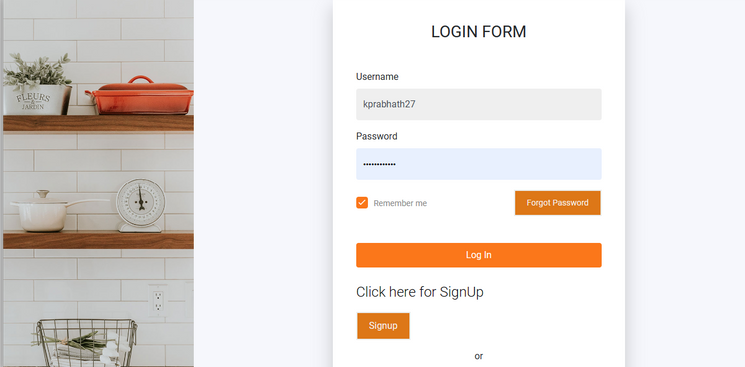
This is the result page of wireless sensor network dependable monitoring for urban air quality. These are the results for the input given by the user.



Screenshot 6.2: Result page

### Login page

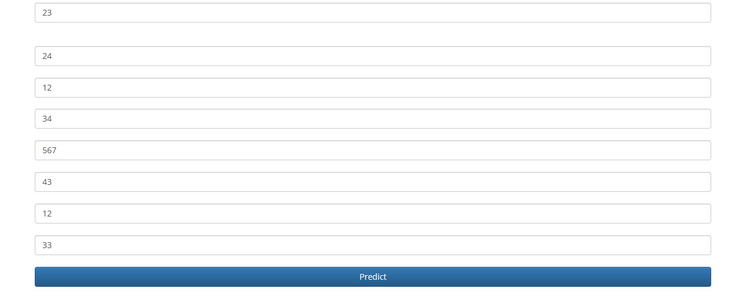
This is the login page of wireless sensor network dependable monitoring for urban air quality. The login page is redirected from home screen. Here the user has to fill the details like user name, password and login to the page respectively.



Screenshot 6.3: Login page

### User input page

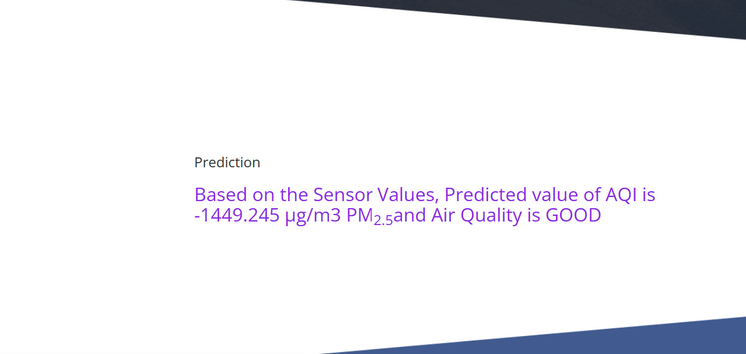
This is the user input page of wireless sensor network dependable monitoring for urban air quality. Here the user has to give different temperatures as an input from the given database. Hence the given inputs is used to predict the air quality.



Screenshot 6.4: User input page

### Prediction

This is the prediction of wireless sensor network dependable monitoring for urban air quality. Based on the user's input the air quality is predicted.



Screenshot 6.5: Prediction

# TESTING

## TESTING

### INTRODUCTION TO TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, subassemblies, assemblies and/or a finished product. It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of tests. Each test type addresses a specific testing requirement.

### TYPES OF TESTING

#### UNIT TESTING

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .It is done after the completion of an individual unit before integration. This is a structural testing that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

#### INTEGRATION TESTING

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

#### FUNCTIONAL TESTING

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted. Invalid : identified classes of invalid input must Input be rejected. Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised. Systems/Procedures : Interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases.

### TEST CASES

#### CLASSIFICATION

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test case ID | Test case name | Purpose | If available | If not available |
| 1 | User signup | To purpose of user sign up is to get registered. | User gets registered into the application | There is no process. |
| 2 | User signin | The purpose of user signin is to login into application. | User get login into the application. | There is no process. |
| 3 Enter input for prediction | | The purpose of giving input is to predict the result and to display on the screen. | Prediction result displayed. | There is no process. |

# CONCLUSION

### CONCLUSION & FUTURE SCOPE

### PROJECT CONCLUSION

This project has presented a new development for a reliable environmental monitoring system built on the combination of physical and communication redundancies. By colocation of similar sensor motes to monitor the same parameters, increasing the time to failure for each module via energy management, and incorporating an effective IoT-enabled dependable control algorithm, the proposed low-cost wireless sensor network can significantly improve the monitoring quality in terms of availability, reliability with high correlations (0.903 for PM2.5, 0.817 for PM10) and fault tolerance with a high survival probability above 80%. The continuous-time Markov model and statistical tools are utilized in the design and performance verification. The system architecture is described along with hardware implementation. The developed system has been successfully tested in laboratory conditions as well as applied to real-world monitoring of air quality profiles of a construction site in a suburb, considering the impact of construction activities as well as different weather events such as bushfires, COVID-19 lockdown and heavy rain. The obtained results show feasibility and advantageous merits for the proposed low-cost wireless sensor network for environmental monitoring, particularly for air pollution assessment. They also indicate a promising application in microclimate analysis for cities.

### FUTURE SCOPE

The potential idea behind the idea of the project is, statistical analysis is conducted for performance evaluation in association with two extreme events, one with bushfires and the other with pandemic lockdown. The results obtained indicate enhancements in reliability and accuracy of the collocated dependable low-cost sensors network proposed for wireless monitoring of air quality in urban conditions.

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### GITHUB LINK

https://github.com/kph27/major-project.git

# PAPER PUBLICATION