IT4010 – Research Project - 2024

Topic Assessment Form

Project ID: 24-25J-224

1. Topic (12 words max)

Intelligent EcoUrban Monitoring System (IEMS)

2. Research group the project belongs to

Centre of Excellence for AI (CEAI)

3. Research area the project belongs to

Smart Systems (SS)

4. If a continuation of a previous project:

Project ID	-
Year	-

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Urbanization has significantly transformed the environmental landscape of cities, presenting complex challenges that threaten public health and urban sustainability. Key issues include deteriorating air quality, declining green spaces, escalating noise pollution, and increasing vehicle emissions.

Air Quality Concerns

Urban air pollution, driven primarily by emissions from transportation, industry, and residential sources, poses severe health risks to urban residents. Particulate matter (PM2.5), nitrogen dioxide (NO2), and ozone (O3) are among the pollutants that contribute to respiratory and cardiovascular diseases, impacting vulnerable populations such as children and the elderly (WHO, 2018).

Green Space Degradation

The reduction and fragmentation of urban green spaces diminish their capacity to provide essential ecosystem services. Green spaces play critical roles in mitigating urban heat island effects, improving air quality through carbon sequestration, and supporting biodiversity. However, many cities face challenges in maintaining adequate green coverage relative to population density and air quality standards (Gómez-Baggethun et al., 2013).

Noise Pollution Impact

Noise pollution from transportation, construction, and industrial activities has adverse effects on human health and well-being. Chronic exposure to high noise levels can lead to stress, sleep disturbances, and cognitive impairment, affecting quality of life in urban environments (Basner et al., 2014).

Vehicle Emissions Management

The growth in urban populations has led to an increase in vehicular traffic, contributing significantly to air pollution and greenhouse gas emissions. Managing vehicle emissions through effective transportation policies, promoting sustainable modes of travel, and optimizing traffic flow are essential for reducing environmental impacts and improving urban air quality (Ebenstein et al., 2017).

Addressing these environmental challenges requires innovative approaches that integrate advanced technologies and data-driven strategies. Leveraging Internet of Things (IoT), Artificial Intelligence (AI), and satellite imagery analysis can enhance real-time monitoring of air quality, optimize green space distribution, manage noise pollution, and predict and mitigate vehicle emissions. By adopting comprehensive, integrated solutions, cities can promote sustainable urban development, improve environmental health, and enhance the overall well-being of urban residents.

References for EcoSensor AI

1. H. Gupta, V. A. Tikkiwal, D. Bhardwaj, A. Kumar, and H. Agrawal, "An IoT based air pollution monitoring system for smart cities," in *Proc. IEEE Int. Conf. Sustain. Energy Technol. (ICSETS)*, Trichy, India, 2019, pp. 173-177. doi: 10.1109/ICSETS.2019.8744949. [Online]. link
2. **ResearchGate,** "An IoT based air pollution monitoring system for smart cities," *ResearchGate*, 2019. [Online]. Available: link
3. **IEEE Xplore,** "Smart city: A review of IoT based air pollution monitoring system," *IEEE Xplore*, 2018. [Online]. Available: link

References for GreenVision AI

1. **ResearchGate,** "Urban green spaces analysis for development planning in Colombo, Sri Lanka utilizing THEOS satellite imagery - A remote sensing and GIS approach," *ResearchGate*, 2013. [Online]. Available: link
2. **ResearchGate,** "Application of satellite images and GIS in evaluation of green space destruction in urban area: Case study Boukan City," *ResearchGate*, 2012. [Online]. Available: link
3. **National Center for Biotechnology Information (NCBI),** "Green spaces and cognitive development in primary school children," *NCBI*, 2022. [Online]. Available: link
4. **IOPscience,** "Urban green spaces, heat island effects and sustainable development: A review," *IOPscience*, 2021. [Online]. Available: link
5. **Francis Press,** "Urban green spaces and their potential to improve air quality in cities," *Francis Press*, 2022. [Online]. Available: link

References for NoiseGuard AI

1. **IEEE Xplore,** "A smart noise monitoring system with IoT sensors and AI algorithms," *IEEE Xplore*, 2020. [Online]. Available: link
2. **IEEE Xplore,** "AI-based real-time noise monitoring and analysis for urban environments," *IEEE Xplore*, 2021. [Online]. Available: link
3. **IEEE Xplore,** "Smart noise monitoring system using deep learning techniques," *IEEE Xplore*, 2019. [Online]. Available: link

References for Echo Go: Predict and Reduce CO2 Emissions by Vehicles

1. **ScienceDirect,** "Prediction of vehicle CO2 emission and its application to eco-routing navigation," *ScienceDirect*, 2016. [Online]. Available: link
2. D. F. Plusquellic, "Predicting CO2 emission footprint using AI through machine learning," *MDPI*, 2022. [Online]. Available: link
3. Kaggle, "Dataset-CO2 Emission by Vehicles." Available at: link
4. A. H. AI-Nefaie, "Predicting CO2 emissions from traffic vehicles for sustainable and smart environment using a deep learning model," *MDPI*, 2023. [Online]. Available: link

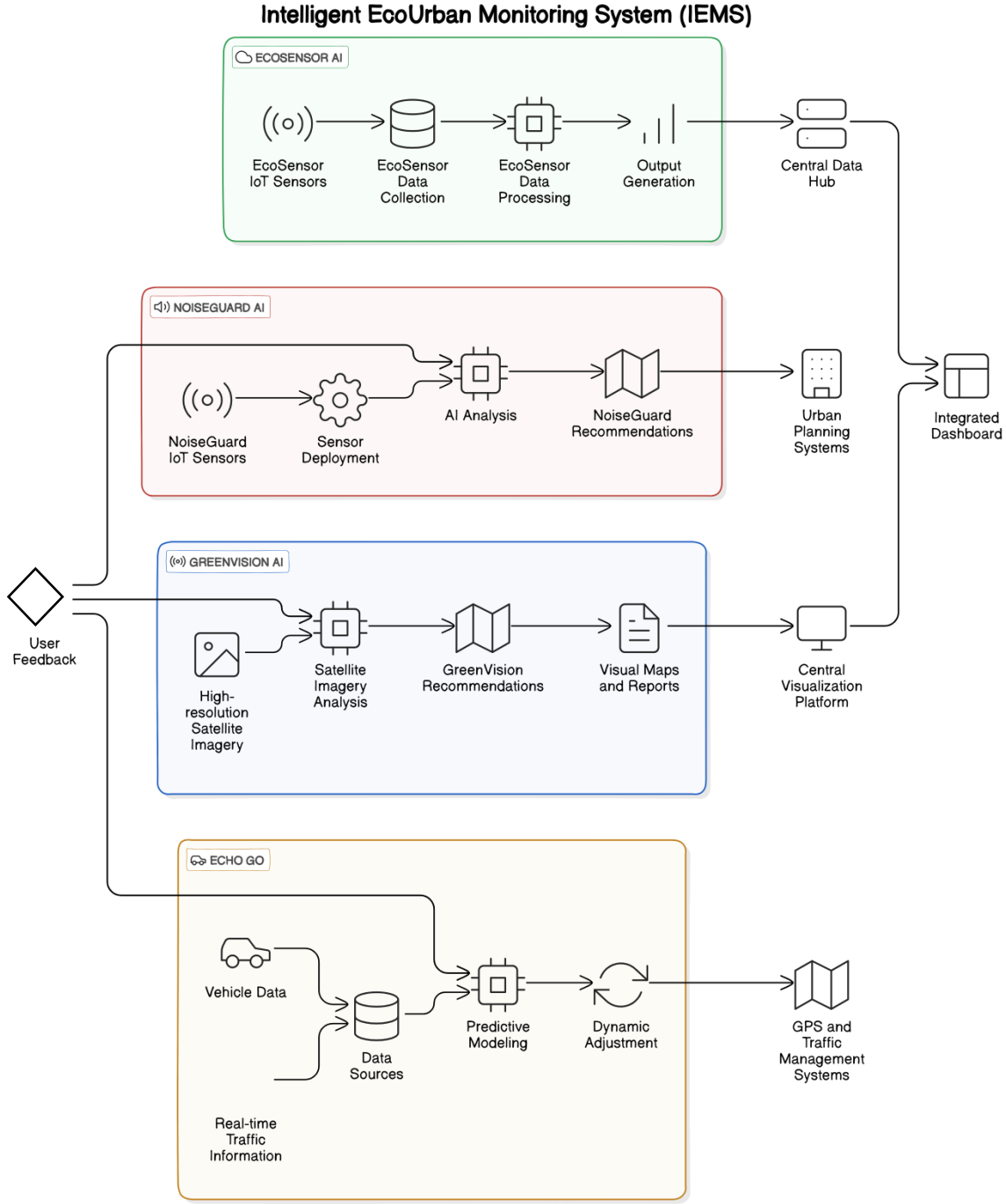
6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

The Integrated Environmental Monitoring System (IEMS) integrates multiple AI-driven components to address key environmental challenges in urban areas: EcoSensor AI, GreenVision AI, NoiseGuard AI, and Echo Go. Together, these technologies form a comprehensive framework for monitoring and managing urban environmental quality.

1. **EcoSensor** AI deploys IoT sensors across urban areas to collect real-time data on air pollutants like CO2 and PM2.5. These sensors are strategically placed to ensure comprehensive coverage and accuracy. AI algorithms analyze this data to predict air quality trends, detect anomalies, and issue timely alerts to authorities and residents. We need to maintain a good CO2 level in the environment because CO2 is necessary for photosynthesis. This system will provide recommendations to maintain optimal CO2 levels and predict future scenarios if we effectively manage CO2 and air pollution levels.
2. **GreenVision AI** utilizes deep learning models to analyze satellite imagery, assessing the distribution and health of green spaces in urban environments. By leveraging vegetation indices and object detection algorithms, it identifies areas needing enhanced green coverage relative to population density and air quality standards. This informs decisions on establishing new green spaces to improve biodiversity, mitigate heat islands, and enhance environmental quality.
3. **NoiseGuard AI** implements a smart noise monitoring system with IoT sensors and AI algorithms to measure real-time noise levels in urban areas. It analyzes data to pinpoint noise sources, assess their impact on resident health, and suggest noise reduction strategies. Integration with city planning and transportation systems optimizes noise management policies, improving acoustic comfort and quality of life.
4. **Echo Go** utilizes machine learning models to predict CO2 emissions from vehicles by analyzing various vehicle attributes. The system includes a personalized recommendation engine that offers customized CO2 reduction strategies. It continuously collects and analyzes real-time user feedback to improve these recommendations. An automated model retraining pipeline, enhanced with reinforcement learning techniques, ensures that the recommendations stay relevant and effective by dynamically adapting to user interactions and changing driving conditions.

The Integrated Environmental Monitoring System enhances urban sustainability by leveraging advanced AI technologies to monitor air quality, green spaces, noise pollution, and vehicle emissions. It empowers cities with actionable insights for informed decision-making, aiming to improve environmental health, urban livability, and overall quality of life for residents.

conceptual diagram



7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

Specialized Domain Expertise

- Environmental Science and Air Quality Monitoring
  - Expertise in understanding urban air quality dynamics, including pollutant sources, dispersion patterns, and health impacts. This knowledge supports the interpretation of data from IoT sensors to develop predictive models for air quality trends.
- Remote Sensing and Satellite Imagery Analysis
  - Proficiency in remote sensing techniques is essential for analyzing high-resolution satellite imagery used to assess green space distribution and health. Advanced algorithms for image processing, vegetation indices, and object detection are employed to extract actionable insights.
- Artificial Intelligence and Machine Learning
  - Strong capabilities in AI and machine learning enable the development of algorithms for processing large datasets from IoT sensors and satellite imagery. This includes deep learning, predictive modeling, anomaly detection, and optimization algorithms to enhance accuracy in environmental monitoring and management.
- Geographic Information Systems (GIS)
  - Proficiency in GIS tools facilitates the integration and visualization of diverse environmental datasets. Spatial analysis techniques enable the creation of interactive maps and geospatial analyses crucial for informed decision-making in urban planning.

Knowledge Requirements

- Factors Influencing Environmental Quality: Comprehensive understanding of factors such as traffic emissions, industrial activities, meteorological conditions, and noise pollution. This knowledge informs the design of monitoring strategies and the interpretation of environmental data.
- Ecological Principles and Urban Management: Sound understanding of ecological principles related to green space management, biodiversity conservation, and ecosystem services. This knowledge guides decisions on enhancing urban biodiversity, mitigating heat islands, and improving overall environmental quality.
- Technological Advancements: Keeping abreast of advancements in IoT, AI, remote sensing, and GIS technologies is essential. This ensures the application of cutting-edge tools for sustainable urban development and effective environmental monitoring.

Data Requirements

- Real-time and Historical Environmental Data: Continuous collection of data on air quality parameters (e.g., CO2, PM2.5), noise levels, and other environmental metrics from IoT sensors deployed across urban areas.
- High-resolution Satellite Imagery: Access to satellite imagery for detailed analysis of green space distribution, land-use classifications, and urban infrastructure maps essential for spatial analysis and planning.
- Meteorological Data: Continuous monitoring of weather patterns to understand their impact on air quality, green spaces, and overall environmental conditions.

This integrated expertise, knowledge base, and data framework enable our team to effectively monitor, analyze, and manage urban environmental quality, fostering sustainable development and enhancing quality of life for urban residents.

8. Objectives and Novelty

Main Objective The objective of this comprehensive AI-driven system is to enhance urban sustainability through effective monitoring, prediction, and mitigation of environmental challenges while optimizing green spaces and improving air quality. By deploying IoT sensors for real-time air and noise pollution monitoring, analyzing satellite imagery to assess green space distribution, recommending optimal locations for green infrastructure, and developing Echo Go for optimizing transportation emissions, the system aims to equip cities with advanced tools for sustainable urban development and proactive environmental management.			
Member Name	Sub Objective	Tasks	Novelty
Arandara.S.D	Deploy IoT sensors and give recommendations and prediction about the CO2 level	• Install IoT sensors • Establish data transmission protocols • Get real time data from IOT. • Train Prediction model • Train Recommendation model. • Train Multilayered model by combining two models • Interface integration • Adaptive sensor calibration using AI for dynamic accuracy adjustments	Real-time IoT data collection, Give prediction about the Air quality and give recommendations to maintain the Good Air quality and Co2 levels.

Thuduwage I.M.H.G	Analyze satellite imagery for enhance the analysis and management of urban green spaces by utilizing deep learning models to assess the distribution and health of vegetation. This system aims to identify areas requiring increased green coverage relative to population density and air quality standards, thereby informing decisions on establishing new green spaces to improve biodiversity, mitigate heat islands, and enhance environmental quality.	• Integrate satellite data APIs • Train deep learning models • Quantify green coverage • Visualization and User Interface • High-resolution image analysis for detailed green coverage assessment • Enhanced vegetation classification • Object detection and segmentation • Temporal analysis and prediction	Detailed vegetation health assessment by combining multiple indices (NDVI, EVI, SAVI) and uses advanced deep learning models (CNNs, Mask R-CNN, U-Net) for precise classification and segmentation. It incorporates LSTM and TCN models for accurate prediction of green space changes and provides dynamic, interactive maps and dashboards for enhanced data visualization. Real-time data integration via APIs ensures up-to-date analysis, supporting informed urban green space management decisions
Karunarathne R.Y.D.	Implement a smart noise monitoring system with IoT sensors and AI algorithms.	• Install IoT sensors • Measure and map noise pollution in real-time. • Classify different types of noise (e.g., traffic, industrial, residential). • Predict future noise levels based on historical data.	Implementing real-time classification of noise sources, distinguishing between traffic, industrial, and residential noises.

		• Implement adaptive sensor calibration using AI • Implement alert mechanisms for exceeding noise thresholds.	
Kodithuwakku C.K.	Develop a personalized CO2 emissions prediction and reduction engine for vehicles, evolving with user feedback and reinforcement learning adaptation.	• Preprocess data. • Train machine learning models (using Ridge Regression, OLS Regression, LASSO Regression). • Evaluate model performance using metrics like RMSE, and R^2. • Develop personalized recommendation algorithms. • Implement user feedback collection system. • Aggregate and store user feedback. • Retrain models periodically using new data.	A personalized recommendation engine that predicts CO2 emissions using machine learning, provides dynamic reduction strategies, and continuously improves through real-time user feedback and reinforcement learning.

		• Monitor and evaluate the performance of updated models.	

9. Supervisor checklist

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	✓	No	

b) Does the proposed topic exhibit novelty?

Yes	✓	No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes	✓	No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	✓	No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

10. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Dr.	Samantha	Rajapaksha	
Co-Supervisor	Ms.	Kaushika	Kahatapitiya	
External Supervisor				
Summary of external supervisor's (if any) experience and expertise				

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Topic Assessment Form

<u>This part is to be filled by the Topic Screening Panel members.</u>

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

The Review Panel Details

Member's Name	Signature

*__Important__:

1. According to the comments given by the panel, make the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and follow the same procedure until the topic is approved by the assessment panel.