AI-Driven Detection and Mitigation of Urban Heat Island Effects Using Image Analysis and IoT

R25-002

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology Specialized in Software Engineering

Department of Computer Science and Software Engineering

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Declaration

I declare that this is my own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Abstract

The urban heat island (UHI) effect, characterized by elevated temperatures in urban areas compared to their rural surroundings, poses significant challenges to public health, energy consumption, and environmental sustainability. While expert consultants provide valuable mitigation strategies, their services are often costly and difficult to access, limiting widespread implementation. This research aims to bridge this gap by developing an accessible, affordable, and scalable system for UHI detection and mitigation, leveraging advanced technologies to democratize expert knowledge.

Contributing to this system is a novel IoT-based device designed to enhance the precision of temperature data collection. By using high-accuracy sensors and mapping methods like photogrammetry, the gadget synchronizes temperature estimations based on images with actual geographic locations. The system locates certain areas in images that need temperature information by using image segmentation. It then dynamically maps these areas to their physical counterparts and modifies to target those areas for real-time sensing. This procedure fills a significant need in the current UHI detection systems by guaranteeing precise data collection and strong real-world validation.

The broader framework empowers communities, politicians, and urban planners by fusing IoT-driven data collecting with AI-driven analysis and predictive modelling. The method makes it easier to anticipate future urban developments, identify heat hotspots, and assess mitigating techniques. It offers a useful, approachable, and affordable substitute for conventional consulting services by expanding the audience for UHI reduction techniques.

Improved urban sustainability, increased climatic resilience, and better environmental monitoring are among the expected results. By bridging the gap between visual and environmental data, this research promotes improvements in precision environmental sensing for a more sustainable future and makes actionable insights possible.

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List of abbreviations

UHI	Urban Heat Island
HSID	Hotspot Identification
AI	Artificial Intelligence
GNSS	Global Navigation Satellite Systems
LST	Land Surface Temperature

Introduction

Modern cities face serious issues from the metropolitan Heat Island (UHI) effect, an occurrence where temperatures in metropolitan regions are noticeably higher than in their rural surroundings. Urban Heat Island (UHI) is an issue that occurs when temperatures in urban regions are higher than those in their non-urban surroundings [1]. It is thought to be a major contributor to global warming, heat-related deaths, and erratic climate fluctuations. These high temperatures strain environmental sustainability initiatives, raise energy usage, and worsen public health hazards. Although professional consulting provides efficient methods for reducing UHI, their high prices and restricted availability prevent their broad use, leaving many cities without workable answers.

This study aims to address these issues by creating a scalable, reasonably priced, and easily accessible system to identify and lessen the consequences of UHI. The system seeks to democratize expert knowledge and offer useful tools for communities, policymakers, and urban planners by utilizing cutting-edge technology including IoT devices, high-accuracy sensors, photogrammetry, and AI-driven analysis. Processing vast amounts of geographic data is made possible by the better data management and collection made possible by the combination of AI and Big Data [2]. An Internet of Things (IoT)-based gadget that can gather accurate temperature data in real time is a major advance in this system. For precise data collection, the device uses image segmentation to identify areas in photos that need temperature readings and dynamically maps those areas to their corresponding real-world locations.

The detection and management of Urban Heat Island (UHI) impacts has advanced significantly because of this IoT and imaging technology integration. To locate heat hotspots, traditional UHI detection methods frequently rely on remote sensing methods like satellite images or aerial photography. Although these techniques offer useful visual information, they frequently lack the accuracy required to match temperature readings with precise geographic locations in the actual world. This imbalance can hinder the creation of successful mitigation plans and result in inaccurate identification of the most important areas for intervention.

By combining sophisticated imaging methods with high-accuracy IoT sensors, the suggested system closes this gap. The method uses image segmentation to pinpoint specific areas in visual data that need temperature readings. The IoT device can precisely target certain places for real-time temperature data collecting since these segments are mapped to their respective geographic positions using techniques like photogrammetry. The accuracy of heat hotspot identification is greatly increased by this dynamic and iterative procedure, which guarantees that the visual data is not only in line with actual coordinates but also verified by exact measurements. The first and most important element in the motorway safety management process is hotspot identification (HSID) [3].

To optimize its usefulness, the system also makes use of AI-driven analysis and predictive modelling. Using the gathered data, predictive modelling forecasts possible temperature trends and evaluates the long-term effects of urban development choices. Deeper understanding of the variables influencing UHI impacts is possible through AI analysis, which finds patterns, correlations, and anomalies in the data. For instance, the system can examine how traffic density, building materials, and green cover affect local temperature fluctuations.

By integrating these sophisticated features, the framework enables users—communities, policymakers, and urban planners—to assess different UHI mitigation tactics, such rearranging urban layouts, changing building materials, or adding more greenery. Additionally, it facilitates scenario modelling, which lets interested parties forecast the potential long-term effects of measures on urban temperatures. This degree of accuracy and understanding guarantees that decisions are supported by trustworthy data, promoting long-term climate resilience and sustainable urban expansion.

This study increases the audience for mitigation techniques while simultaneously improving the accuracy and scalability of UHI detection. The suggested method enhances environmental monitoring, urban sustainability, and climate resilience by offering a practical and affordable substitute for conventional consulting services.

Background & Literature Survey

A crucial environmental problem made worse by fast urbanization is the Urban Heat Island (UHI) effect. Reduced vegetation, more impermeable surfaces, and the concentration of human activity are some of the variables that contribute to the UHI effect, which is defined by higher temperatures in urban areas relative to their rural surrounds. Its effects include increased air pollution, higher cooling energy demands, and elevated public health concerns, especially for vulnerable groups. Accurate detection and mitigation techniques that are scalable and accessible are necessary to meet these problems.

Nuria Castell, Mike Kobernus, Hai-Ying Liu, Philipp Schneider, William Lahoz, Arne J. Berre, and Josef Noll (2015) investigated how mobile technologies have revolutionized the Citizens' Observatory concept, specifically in the areas of climate change, environmental health, and air quality. The study highlighted how these technologies can improve data coverage by providing high-resolution, near-real-time environmental data in urban settings. Using GNSS (Global Navigation Satellite Systems) data, including GPS, in combination with Citi-Sense-MOB Citizens' Observatory inputs, their work established the Citi-Sense-MOB Citizens' Observatory as a crucial component of an environmental health monitoring system and knowledge base. The primary goal of Citi-Sense-MOB was to promote green growth and sustainable development in Oslo, Norway, by equipping citizens and authorities with critical information on transportation, CO_2 emissions, and air quality. The study highlighted the development of an information value chain, encompassing the sensor platform and system architecture, to create products and services that enable participatory governance, aligning with the principles of the Citizens' Observatory framework [4].

Fachri Ilman Fauzandi, Yulia Retnowati, Josua Dion Tamba, Emir Mauludi Husni, Rahadian Yusuf, and Bernardo Nugroho Yahya investigated the Urban Heat Island (UHI) effect and its substantial influence on human welfare in urban settings in 2021. Higher temperatures in urban regions relative to their rural counterparts are a hallmark of the UHI effect, which can have detrimental effects on the environment and human health. The study identifies two main techniques for identifying UHI: direct measurements using mobile traverses and fixed stations, and indirect measures using remote sensing. Remote sensing is a popular method, especially in places like Indonesia. However, financial limitations frequently impede the development of fixed stations [5].

The paper suggests an affordable Urban Heat Island (UHI) monitoring system that minimizes interference from sun radiation by utilizing inexpensive IoT sensor nodes enclosed in specially designed Stevenson screens. Every minute, these nodes gather temperature and humidity data, which they then send to the cloud via the MQTT protocol every hour. The data is easily available through an API for analysis and retrieval. The results show how well the technology provides real-time UHI data by highlighting notable temperature and humidity disparities between residential and highway regions. Particularly in resource-constrained areas like Indonesia, this research provides a scalable and reasonably priced substitute for fixed station-based systems, allowing for continuous remote monitoring and assisting in the development of well-informed decisions about urban design and climate resilience [5].

In 2019, a research collaboration between E2DESIGN and Monash University, led by Nigel Tappe, Sara Lloyd, Jane McArthur, Emir Mauludi Husni, and Kerry Nice, focused on assessing the impact of various policy settings on the biophysical environment, including urban warmth, in a de-identified case study of a suburban landscape in Melbourne. The study, documented in their report, explored how different urban planning and policy strategies influence the Urban Heat Island (UHI) effect, aiming to understand and mitigate its impact. Additionally, the partner report by RCMG, titled "Estimating the Economic Benefits of Urban Heat Island Mitigation – Economic Analysis," quantifies the economic advantages of reducing summertime heat through these policy measures. This research contributes valuable insights into the relationship between urban planning, environmental sustainability, and the economic implications of UHI mitigation strategies, offering a framework for informed decision-making in urban heat management [6].

A 2018 study by Vina Nurul Husna, Nurul Ihsan Fawzi, and Irza Arnita Nur examined how urbanization affected Yogyakarta, Indonesia's Urban Heat Island (UHI) effect. The researchers assessed the UHI strength and distribution using Landsat 8 remote sensing data, and they discovered that the city's UHI intensity was roughly ±2.5°C. To derive land surface temperature, the study used Planck's Law inverted, adding atmospheric adjustment using the radiative transfer equation. The findings identified Malioboro and the adjacent areas as possible hotspots for UHI, indicating the necessity of mitigation measures such putting in green roofs or increasing vegetation coverage to lessen the negative impacts of UHI on locals and visitors alike. his research emphasizes the critical role of remote sensing in monitoring UHI and the importance of integrating green solutions in urban planning to mitigate its impacts [7].

The Urban Heat Island (UHI) phenomena in Palembang, South Sumatra, was investigated in a 2019 study by A.L. Gaol, Y.R. Serhalawan, and A. Kristianto in connection with changes in land use and population density. To analyze surface temperature fluctuations, the study used multi-temporal Landsat images from 1989, 2001, and 2018 that were processed using the Land Surface Temperature (LST) method and guided categorization. Urbanization and rising surface temperatures were found to be directly correlated by the study, with significant determining coefficients (R2) for population growth, built-up land, and open land being 62.6%, 86.3%, and 55.0%, respectively. On the other hand, there was a significant inverse relationship between surface temperature and thick vegetation (R2 = 90.4%). The UHI effect was most pronounced in the city center, affecting approximately 33.5 km^2. The study emphasized the need for effective urban planning and mitigation strategies, such as increasing green spaces to counter the negative effects of urbanization and population growth [8].

Research Gap

Urban Heat Island (UHI) detection and mitigation technologies have advanced significantly, but current methods have serious drawbacks that limit their accuracy, usability, and feasibility. Large-scale coverage is offered by remote sensing technologies like satellite and aerial thermal imaging, but they lack the temporal and spatial resolution needed to identify localized hotspots. Similarly, without a large and expensive sensor network, ground-based temperature sensors cannot provide complete coverage, even while they are accurate at certain locations. Despite their adaptability, mobile sensor networks frequently do not integrate with visual data and are unable to accurately correlate temperature readings with urban features. Although useful for predicting, AI-driven predictive models rely mostly on historical data and are unable to adjust to changes in the environment in real time or validate data using measurements taken in the real world.

These drawbacks point to a serious research need in resolving the discrepancy between visual information and actual temperature readings. Accurate hotspot detection and successful mitigation techniques depend on the ability of current technologies to dynamically and precisely relate image-based temperature estimations with their corresponding geographic locations. Additionally, existing solutions are sometimes costly and complicated, which restricts their use in metropolitan settings with limited resources. To provide policymakers and urban planners with useful information, scalable and affordable systems that combine real-time data collecting, AI-driven predictive modelling, and verified visual data analysis are also required.

An outline of the Urban Heat Island (UHI) phenomenon, which is defined by higher temperatures in urban regions relative to rural ones and has a substantial negative influence on both the environment and human health, is given in research paper "B" [9]. It covers two main techniques for identifying UHI: direct measurement via mobile traverses and fixed stations, and remote sensing, which is popular in Indonesia. The study suggests a low-cost Internet of Things-based monitoring solution to overcome the financial difficulties associated with setting up fixed stations. The temperature and humidity data is collected every minute by this system using sensor nodes with bespoke Stevenson screens. It is then sent hourly over MQTT to Amazon Web Services (AWS), where it is stored and analyzed using an API. The implementation showed distinctions in temperature and humidity between roadway and residential areas, demonstrating its effectiveness. However, the system currently falls short in real-time data collection, integration with IoT and thermal imaging, and continuous data validation, limiting its ability to provide users with actionable insights effectively.

The complex relationship between various roadway designs and the UHI phenomenon—where urban areas are noticeably warmer than rural regions due to anthropogenic heat release and the absorption of heat by urban structures—is summarized in research paper "C" [10]. Problems including higher energy use, worse air quality, and elevated health risks are made worse by UHI. According to the study's hypothesis, UHI behavior in an urban setting can be accurately modelled by examining a representative sample of streets. Using two clustering methodologies—Time Series Clustering K-Means for temperature data and K-Prototypes for socio-economic and morphological categorization—streets were categorized into distinct typologies based on temperature profiles and socio-economic and morphological characteristics. With R-Squared values of 0.85 and 0.80 and MAE values ranging from 0.22 to 0.84 °C for CUHI and SUHI, respectively, the study showed strong model performance while lowering data collection efforts by 50–70%. These results highlight how useful street typologies are for comprehending UHI mechanisms and how crucial it is to take localized and temporal UHI changes into account when developing mitigation plans. The suggested system seeks to overcome the shortcomings of the current system, providing users with cutting-edge tools and insights. These shortcomings include real-time data gathering, the capacity to map data to the physical environment, and integration with IoT and thermal imaging.

By creating a novel Internet of Things-based system that combines photogrammetry, image segmentation, and high-accuracy temperature sensors, the proposed study seeks to close this gap by dynamically targeting and measuring particular metropolitan areas. The method overcomes the drawbacks of current UHI detection systems by providing an easily accessible, accurate, and scalable solution to urban heat mitigation by real-time alignment of visual data with geographic coordinates and combining this with predictive modelling. The following given table 1 depicts the feature of the currently done research and the proposed research.

TABLE 1 : COMPARISON BETWEEN EXISTING SYSTEMS

Research	Real-Time Data Collection	Mapping data with the real world	Integration of IoT and Thermal Imaging	Continuous Data Validation	Empowerment of Users
Research A [5]	✓	X	✓	X	X
Research B [9]	X	✓	X	X	X
Research C [10]	X	X	X	✓	X
Proposed system	✓	✓	✓	✓	✓

Research Problem

A major issue in urban planning and environmental management is the Urban Heat Island (UHI) effect, which is defined by warmer temperatures in urban regions relative to nearby rural areas. Human activity and the transformation of natural landscapes into urban infrastructure—which absorbs and retains heat—are the main causes of this issues. Several environmental and social issues are made worse by the UHI effect, such as higher cooling energy use, elevated air pollution, and serious health risks, particularly for vulnerable groups like children, the elderly, and people with pre-existing medical conditions. Furthermore, high urban temperatures exacerbate the long-term effects of climate change, making effective mitigation measures even more urgent.

The ability of current UHI detection and mitigation technologies to deliver accurate, localized, and actionable data is noticeably limited. For example, satellite-based thermal imaging provides extensive spatial coverage, but it frequently lacks the resolution required to detect minute temperature changes in intricate urban settings. These algorithms are excellent at giving broad insights, but they are not very good at identifying localized hotspots, like neighborhoods or urban elements like parks or highways.

Despite its excellent precision, ground-based temperature sensors need a lot of infrastructure to provide useful coverage in cities. Such systems are frequently too expensive to establish and maintain, particularly for smaller cities and municipalities with limited resources. Additionally, the data collected by these sensors is typically limited to point measurements, which cannot fully represent the intricate thermal patterns of urban landscapes.

A promising development in UHI analysis is represented by mobile and AI-driven systems, which provide flexibility and adaptability in data collection and predictive modelling. Nevertheless, these systems frequently struggle with the inability to integrate exact geographic coordinates with visual data, like thermal imagery. Their capacity to offer validated, real-time insights that correspond with actual urban aspects is hampered by this disconnect. As a result, there is a big disconnect between the information produced by these systems and the useful knowledge needed to make wise decisions.

Existing UHI detection and mitigation systems have constraints that limit their price and accessibility in addition to impairing the accuracy and usefulness of the data they collect. Because of the high price and infrastructural requirements of advanced systems, many metropolitan areas—especially those in low-income regions—cannot embrace them. This discrepancy highlights the pressing need for creative, affordable, and scalable technologies that can offer localized, validated, and real-time temperature data to enable policymakers and urban planners to combat the UHI effect. The proposed system should cater to the below needs which highlights the need for a system that provides accurate, validated, and affordable UHI data collection and empowers decision-makers to implement sustainable urban heat mitigation strategies effectively.

- Most existing solutions lack mechanisms for dynamic, real-time temperature sensing and fail to validate data against visual and geographic inputs
- Current systems often collect data over broad and non-targeted areas, resulting in resource inefficiency and less actionable insights for urban planners.
- The cost of deploying and maintaining traditional UHI detection systems restricts their use to resource-rich urban areas, leaving smaller cities and low-resource settings underserved.

Objectives

Main Objective

The main goal of this research is to offer a comprehensive and creative solution to address the serious issues raised by the UHI effect. The suggested system makes use of IoT capabilities to facilitate real-time temperature sensing, guaranteeing precise and current data collection. The technology goes beyond traditional approaches to match temperature data with geographic locations by incorporating cutting-edge imaging techniques like photogrammetry and image segmentation. Localized UHI hotspots can be identified thanks to this accurate mapping, which older methods frequently miss.

Because of its scalable and cost-effective design, the system can be used in a variety of metropolitan areas, including those with limited resources that cannot afford pricey infrastructure or consulting services. The technology makes it possible to dynamically focus temperature measurements by fusing IoT devices with image technologies, guaranteeing that data collection is effective and pertinent to urban planning requirements.

By comparing temperature readings with visual and geographic inputs, the technology also highlights data accuracy and validation. Urban planners and policymakers may assess mitigation solutions, estimate the effects of urban projects, and make well-informed decisions for sustainable growth with the help of this validated data, which provides a solid basis for predictive modelling and AI-driven analysis. The ultimate objective is to offer a useful, accessible tool that democratizes access to cutting-edge UHI detection and mitigation technologies, fostering urban sustainability and climate resilience.

Specific Objectives

1. Precise Mapping of Temperature Data.
    - To develop a method that accurately maps real-time temperature data from the IoT device to geographic locations, achieving at least 90% mapping accuracy within urban environments.

2. Real-Time Data Collection and Validation
    - To collect and validate temperature data in real-time every 5 minutes with a 95% success rate, ensuring continuous and accurate monitoring of urban temperature variations.

3. Integration of IoT and Advanced Imaging
    - To fully integrate IoT temperature sensors with photogrammetry and image segmentation, ensuring accurate mapping of temperature data to urban imagery, with integration completeds.

Methodology

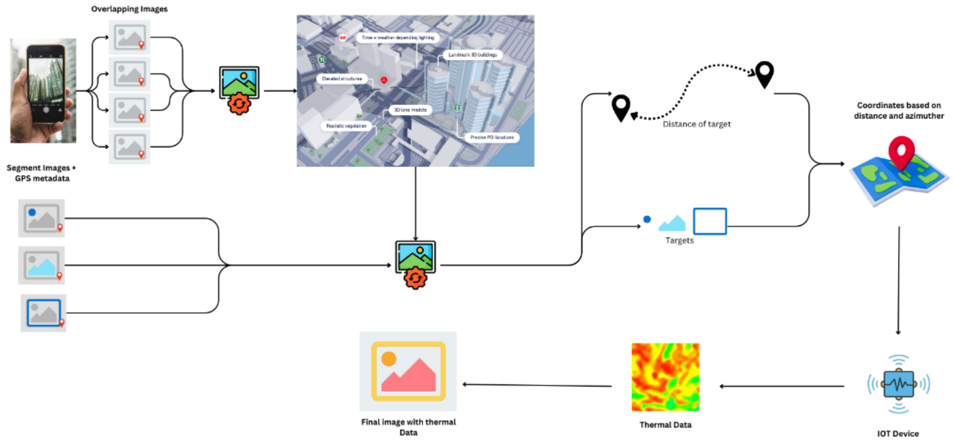


FIGURE 1 : HIGH LEVEL ARCHITECTURE DIAGRAM

As depicted in the Figure 1, the proposed system is designed to provide a suitable method to capture real-time temperature data for urban surfaces. Making an advanced Internet of Things gadget that can record temperature data in real time is the first step in the procedure. To enhance the real-time temperature mapping process, the device will be equipped with localization capabilities, such as GPS for outdoor environments or Indoor Positioning Systems, and orientation tracking using an Inertial Measurement Unit (IMU). Because of its 360-degree rotational design, this gadget can precisely measure temperature and scan urban surfaces. The device's high-quality temperature sensors guarantee that the data it collects is precise, dependable, and indicative of the environment. Its automated nature makes it possible to collect data over vast urban areas with ease and guarantees that no important thermal information is overlooked. The core of the thermal data collection process will be this Internet of Things device, which will lay the groundwork for further mapping and analysis.

The next task is to map the temperature data to the appropriate areas of the photos of the urban environment after the IoT device has collected it. Photogrammetry can be employed to generate accurate 3D models of the urban area, which will serve as a spatial reference for mapping temperature data. By reconstructing the urban environment in 3D, photogrammetry provides precise spatial coordinates for each segment, enhancing the accuracy of temperature mapping. This involves using techniques such as camera calibration to determine the camera’s intrinsic and extrinsic parameters, homography to map the image plane to real-world coordinates, georeferencing to align the data with geographic locations, and photogrammetry to create detailed 3D models for improved mapping precision. To guarantee that the temperature readings precisely match the image components, this procedure needs to be automated. Accurate representation of each segment's thermal characteristics can be achieved by smoothly integrating the recorded data with image segments using sophisticated image segmentation techniques. Tools such as OpenCV can be utilized for image segmentation and integration, ensuring precise alignment of temperature data with the corresponding image segments. In this step, automation is crucial because it reduces the possibility of error and does away with the need for manual intervention, allowing for the effective handling of big datasets.

The last stage is to create an extensive thermal map of the urban area after the temperature data has been successfully mapped to the image segments. The inclusion of photogrammetry in the mapping process allows the thermal map to be overlaid on realistic 3D models, providing a more comprehensive and visually intuitive representation of temperature variations. This thermal map will be visualized using GIS platforms to provide geospatial context and analyzed with heatmap generation techniques to highlight temperature variations across the region effectively. The segmentation data and temperature readings are combined to provide a comprehensive thermal profile of the region in this thermal map. By highlighting temperature changes, the resulting map makes it possible to identify hotspots—regions with abnormally high temperatures—which may be a sign of problems like inadequate heat dissipation or areas that require action. Urban planners and decision-makers can identify problem regions by examining this thermal map, which could help direct the installation of sustainable measures like cooling systems or green infrastructure to lessen the effects of heat in cities. The analysis will be presented through interactive dashboards and simulation tools, enabling planners to visualize temperature patterns and evaluate the potential impact of proposed interventions effectively.

Summary of technologies, techniques, and algorithms used for the classification of is shown in the table (Table 2) below.

TABLE 2 : TECHNOLOGIES, TECHNIQUES, ARCHITECTURES, AND ALGORITHMS USED.

Technologies	OpenCV, Geographic Information Systems (GIS), Thermal temperature sensor, Wi-Fi / LoRa, Azure / AWS, ESP32, python
Techniques	Data mapping, Automation, Visualization
Algorithms	Time series Analysis, Edge detection, Thermal map generation, K-Means

Software Solutions

Development Process

The Agile technique, which prioritizes adaptability, teamwork, and iterative development, is the most effective way to oversee the proposed system's development process. Agile enables frequent stakeholder feedback and continuous delivery of functional components by segmenting the project into smaller, more manageable sprints. The project's initial focus will be on obtaining specific requirements through interactions with technical teams, environmental specialists, and urban planners. This stage guarantees that the goals—such as creating thermal maps, creating picture segmentation algorithms, and building the IoT device—are understood. The iterative development process will be guided by a prioritized backlog of work and a high-level strategy.

Iterative design, prototyping, and integration are the next steps in the development process after requirements collecting. A 360-degree rotating IoT device prototype with temperature sensors will be created during the first sprints to get accurate data. To precisely match temperature data with metropolitan surface segments, subsequent sprints will concentrate on developing and improving image segmentation algorithms. Thorough testing will be conducted after these parts are integrated into a single system to guarantee smooth operation and dependability. Feedback from stakeholders will drive changes and enhancements, guaranteeing that the system provides accurate thermal profiling of urban environments, which can successfully direct interventions and decision-making.

Feasibility Study

1. Technical Feasibility
   The suggested solution makes use of widely accessible, well-established technology including temperature sensors, IoT devices, and image processing techniques. It is possible to create a 360-degree rotating Internet of Things device with temperature sensors by combining high-precision thermal sensors with pre-existing hardware platforms such as ESP32 or Raspberry Pi.

2. Operational Feasibility
   The solution offers decision-makers actionable thermal insights and is made to blend in smoothly with urban planning operations. Because of its automated data gathering and mapping features, less manual involvement is required, guaranteeing user-friendliness and operational effectiveness. Its intuitive interface, which shows heat maps and identifies hotspots, will be useful to local authorities, environmental researchers, and urban planners.

3. Economic Feasibility
   The system's long-term advantages exceed the cost of its development. Purchasing hardware components for the Internet of Things device, software development resources, and cloud storage for data management are the main costs. But over time, the ability to pinpoint urban heat hotspots and direct efficient interventions—like cooling systems or green infrastructure—offers substantial financial and health benefits. Its economic viability is further improved by funding opportunities from environmental and governmental organizations.

Testing

1. Unit Testing
   Individual system components, including the IoT device, temperature data collection, picture segmentation algorithms, and thermal map production, will undergo unit testing. This guarantees that every module operates as intended when used alone and appropriately manages edge circumstances. For instance, testing will determine whether the IoT gadget collects data efficiently and whether temperature sensors provide reliable readings in a range of scenarios.

2. Integration Testing
   The goal of integration testing is to make sure that the system's many modules function as a cohesive whole. This will entail testing how the IoT device and the backend system that handles the temperature data interact, as well as how picture segmentation algorithms are integrated with the temperature data that has been gathered. Verifying that data moves between the system's components correctly and that interactions do not interfere with overall functionality is the aim.

3. System Testing
   System testing will make sure that the system functions, satisfies all functional criteria, and produces the desired results. To guarantee that the system functions effectively when managing sizable datasets and functioning in metropolitan settings, this phase will replicate real-world circumstances. The system's capacity to gather temperature data in real time, accurately map it to image segments, and produce thermal maps without experiencing performance deterioration will all be tested.

4. User Acceptance Testing
   To ensure that the system satisfies the requirements and expectations of end users, including urban planners, environmental agencies, and city decision-makers, user acceptance testing will be carried out. To evaluate the software's usability, interface, and general user experience, feedback will be solicited. This stage guarantees that the system is user-friendly, accessible, and offers users actionable insights in a format that is simple to comprehend and utilize when making decisions.

5. Security Testing
   To guarantee the availability, confidentiality, and integrity of the system and its data, security testing will be carried out. Verifying that sensitive temperature data is safely transferred, stored, and processed is essential since the system processes real-time data from Internet of Things sensors. Testing will entail evaluating possible weaknesses, such as data leaks, illegal access, and device connection security. To ensure data confidentiality and compliance with data privacy rules, encryption technologies and secure communication channels will be examined.

Project Requirements

Functional Requirements

- The system must collect temperature data in real-time using the IoT device and store it in a database
- Automate the mapping of collected temperature data to corresponding urban image segments.
- Combine segmented data with temperature readings to create a detailed thermal profile of urban areas.
- Provide users with an intuitive interface to view thermal maps, temperature trends, and identified hotspots.
- Allow users to export thermal data and generate customized reports for analysis and decision-making.

Non – functional Requirements

- The system should handle large-scale data collection and processing for diverse urban environments
- Ensure uninterrupted data collection and processing, with minimal downtime
- The system should process temperature data and generate thermal maps within seconds for timely analysis.
- The system should be compatible with different hardware platforms and operating systems
- The interface should be user-friendly and accessible for non-technical users.

User Requirements

- Users require an intuitive interface for uploading, viewing, and analyzing data
- Users should be able to customize the thermal map view, such as filtering specific areas or timeframes
- Alerts for identified hotspots or unusual temperature trends.
- Access to the platform from mobile devices for convenience.
- Users require guidance and resources for using the system effectively.

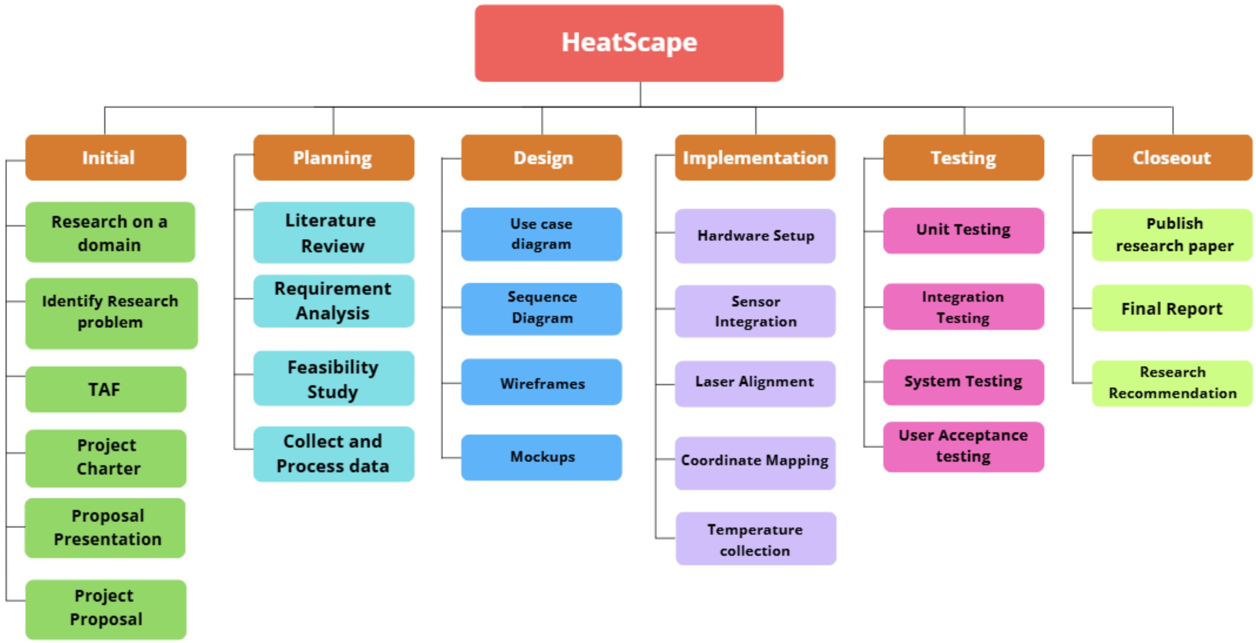
System Requirements

- Temperature sensors
- Server for data storage
- JavaScript libraries
- Node JS
- PostgreSQL / SQL / Firebase

Gantt chart


Task
2024
2025
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Planning Stage
Feasibility Study
Requirement Analysis
Literature review
Topic Assessment Form
Project proposal
Software Design Stage
UML diagrams
Design Wireframes
Design Mockups
Implementation Stage 1
Implementation functions
Integration and testing level 1
Progress presentation 1
Implementation Stage 2
Research paper
Implementation functions
Integration and testing level 2
Progress presentation 2
Final Stage
Final Report
Project Status Document
Final Presentation and Viva

Work Breakdown Structure



Description of personal

Facilitators

1. Mr. Vishan Jayasinghearachchi - Supervisor
2. Ms. Kaushalya Rajapakse – Co Supervisor
3. Dr. Rajitha De Silva – External Supervisor

Budget

TABLE 3 : BUDGET PLAN

Requirement	Price (Rs.)
Cloud Computing Service	10,000.00
Cost for hardware products	30,000.00
Domain Registration	4,000.00
Transportation costs	5,000.00
Internet and Wi-Fi charges	6,000.00
Other Charges	5,000.00
Total estimated cost	60,000.00

Commerlization

Target Audience and Market Space

Target audience

- Urban Planners and City Officials
- Environmental Agencies and NGOs
- Researches
- innovators

Market space

- IoT and sensor technologies
- Green infrastructure
- Construction technologies
- Disaster management

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