Machine Learning Based Automated Construction Planning System for Sri Lanka

Project ID: 24-25J-201

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology Specializing in Information Technology

Department of Information Technology

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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 our knowledge and belief it does not contain any material previously publish or written by another person expect where the acknowledgement is made in the text.

Name	Student ID	Signature
Sathurjan.K	IT21188718	K.Sathurjan.

The supervisor/s should certify the proposal report with the following declaration.
The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Ravi
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Signature of the Supervisor
(Mr. N.H.P. Ravi Supunya Swarnakantha)

23/08/2024
……. …………..
Date

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Signature of the Co-Supervisor
(Dr. Dharshana Kasthurirathna)

…………………
Date

ABSTRACT

The incorporation of advanced material recommendation systems has gained significance in the context of sustainable building practices. The goal of this research component is to create a machine learning-based material recommendation system for sustainable building that considers environmental factors like local climate and carbon footprint in addition to project-specific requirements.

The suggested system will make use of an extensive database of materials that includes information on their pricing, technical specifications, and influence on the environment. The system will be able to create customized material recommendations that meet the needs of the project, and the aims by using machine learning algorithms to analyze the input factors, such as building type, climate, and sustainability goals.

In summary, this research component focuses on creating a Material Recommendation System for Building that utilizes machine learning, steganography, and image compression to enhance the security, efficiency, and sustainability of material selection in construction projects. By providing real-time, data-driven recommendations, this system aims to support the construction industry's transition towards more environmentally responsible practices.

Keywords: Material Recommendation System, Machine Learning, Environmental Impact, Image Compression, Real-time Monitoring, Predictive Models.

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LIST OF ABBREVIATIONS

Keyword	Meaning
GCP	Google cloud Platform

1. INTRODUCTION

In recent years, the construction industry has increasingly acknowledged the significance of sustainability in building practices. The selection of appropriate building materials is critical for achieving environmentally responsible and resource-efficient projects. However, the extensive variety of available materials, each with distinct properties, costs, and environmental impacts, poses a challenge for engineers and customers in making informed decisions. This complexity is further exacerbated by the necessity to consider factors such as climate, building type, and local regulations, all of which significantly influence material suitability.

To tackle these challenges, this research proposes the development of a Material Recommendation System for Building Type. This system is designed to assist engineers and customers by providing data-driven recommendations for building materials that align with specific project requirements and sustainability goals. By leveraging machine learning, the system will analyze various input parameters such as building type, climate conditions, and sustainability objectives to suggest the most appropriate materials for a given construction project.

The system will incorporate a user-friendly interface that allows users to easily input project details and receive tailored material recommendations. Additionally, it will integrate location-based data and local regulations to ensure that the recommendations are not only sustainable but also practical and compliant with regional standards. This context-aware approach enhances the material selection process, enabling users to make decisions that are both environmentally responsible and customized to their unique needs.

2. BACKGROUND LITERATURE

In the pursuit of sustainable building practices, the integration of advanced technologies such as machine learning into material recommendation systems has garnered significant attention. Various studies have explored the application of machine learning to enhance the accuracy and relevance of material recommendations, particularly in the context of sustainability and environmental impact [1].

A model-based approach to material recommendation, emphasizes the importance of personalizing material choices based on user preferences and project-specific requirements [2]. Their research underscores how machine learning algorithms can be utilized to predict and recommend materials that not only meet the aesthetic and functional needs of a construction project but also align with the sustainability goals of the users. This approach is particularly valuable in scenarios where the environmental impact of material choices is a critical consideration [3].

Expanding upon this basis, further investigators have concentrated on the more extensive utilization of machine learning in recommendation systems throughout diverse fields. In their exploration of the design of these systems, James et al. demonstrate the efficacious prediction capabilities of algorithms such as content-based filtering, collaborative filtering, and hybrid models. By providing more accurate and contextually appropriate recommendations, these methodologies have the potential to greatly enhance decision-making when used for material recommendation for sustainable building.

By examining several machine learning methods, like decision trees and neural networks, that can be used with recommendation systems, Patel et al. add even more to this conversation. Their work demonstrates how machine learning can be used to analyze large, complicated datasets and choose the best materials to use while taking durability, cost, and environmental impact into account. Applying these methods to material recommendation systems is a big step in the direction of more environmentally friendly building methods.

When taken as a whole, these studies offer a thorough grasp of how machine learning may be used to improve material recommendation systems, especially when it comes to sustainability. Material selection in the construction business might be revolutionized by combining environmental factors, cutting-edge machine learning techniques, and tailored recommendations into a single platform [4].

Furthermore, Fankhauser et al. critically analyze the environmental effects of material use, especially considering climate change. Their study emphasizes how important it is to consider the carbon footprint and total environmental impact of building materials17. It is feasible to direct consumers toward more environmentally friendly decisions by including these factors into a material recommendation system

When taken as a whole, these studies offer a thorough grasp of how machine learning can be used to improve material recommendation systems that prioritize sustainability. The potential for revolutionizing material selection procedures in the construction sector and promoting more sustainable and efficient building practices lies in the convergence of modern machine learning techniques, robust environmental data, and user-centric design. Future studies are expected to expand on the integration of cutting-edge technologies like augmented reality and blockchain for immersive material visualization and supply chain transparency, thereby enhancing the potential and influence of material recommendation systems in accomplishing sustainability goals16.

Machine learning and artificial intelligence (AI) are still essential for developing climate-responsive material recommendation systems. A deep learning model that forecasts the long-term performance of materials under different climate scenarios was put into practice by Chen et al. [8]. Their method can select materials that optimize both environmental and functional outcomes because the model was trained on large datasets, including material attributes, historical performance data, and climate projections. More precise and trustworthy material recommendations are made possible by this AI-driven method, especially when it comes to climate adaptation18.

In conclusion, a major development in sustainable construction practices is the incorporation of climate change considerations into material recommendation systems. These technologies address the issues faced by a changing climate by merging environmental science, machine learning, and real-time climate data to deliver highly customized and resilient material recommendations. The building industry will profit from more affordable, eco-friendly, and climate-resilient material options as this field of study develops.

3. RESEARCH GAP

Identifying research gaps is an essential part of advancing knowledge in any field, particularly in the development of a Material Recommendation System for Building. A research gap refers to an area that has not yet been sufficiently explored, offering opportunities for new insights and contributions. By identifying these gaps, researchers can define the scope of their study and focus on unexplored areas that hold potential for innovation and impact [5].

In the context of material recommendation systems, several research gaps have been identified through a comparative analysis of existing studies. These gaps highlight the unique aspects that the proposed system aims to address, such as the integration of sustainability criteria, the incorporation of real-time environmental data, and the personalization of recommendations based on project-specific requirements.

One study explores a model-based approach to material recommendation, focusing on the prediction of user preferences. While this research offers valuable insights into personalized material selection, it does not fully address the need to integrate environmental sustainability into the recommendation process. As sustainability becomes an increasingly critical factor in construction, there is a clear gap in the development of systems that can balance user preferences with the environmental impact of material choices [3].

Another study [2] discusses the use of machine learning in building recommendation systems, emphasizing the prediction of material suitability based on technical specifications. However, this study does not consider the dynamic nature of environmental data, such as changes in local weather conditions or material availability, which can significantly affect the sustainability of a project. Therefore, there is a need for research that integrates real-time environmental data into material recommendation systems, allowing for more adaptive and sustainable decision-making [5].

A third research paper [3] examines various machine learning techniques for recommendation systems but focuses primarily on technical performance metrics, such as accuracy and efficiency. While these aspects are important, the study overlooks the importance of incorporating sustainability as a core criterion in material selection. As the construction industry moves towards greener practices, there is a growing need for systems that prioritize sustainability alongside other performance metrics.

Finally, a study on the impact of material uses on climate change [3] provides a comprehensive analysis of the environmental implications of construction materials. However, it does not explore how these insights can be operationalized in a recommendation system that supports sustainable building practices. There is a gap in research that bridges the theoretical understanding of material sustainability with practical tools that can guide material selection in real-world construction projects.

In summary, while significant advancements have been made in the development of material recommendation systems, several key areas remain underexplored. These include the integration of sustainability criteria into the recommendation process, the use of real-time environmental data, and the development of personalized, adaptive systems that respond to the dynamic nature of construction projects. Addressing these gaps will be critical in advancing the field and supporting the construction industry's transition towards more sustainable practices [6].

Aspect	Details
Lack of Recommendations	Current research does not provide precise recommendations tailored to specific building plans and local weather conditions.
Integration Challenges	Existing methods fail to effectively merge architectural and climatic data, compromising material selection accuracy.
Development of a New System	Proposes using advanced machine learning algorithms to extensively analyse building plans and weather data.
Optimized Material Selection	Recommends materials best suited to the specific conditions and requirements of construction projects.

Figure 3.1:Research Gap

4. RESEARCH PROBLEM

What strategies can be implemented to ensure the effective and efficient use of machine learning techniques for recommending sustainable building materials that align with project-specific requirements [2], while considering environmental impact, cost, and local regulations?

The process of choosing the right building materials for construction projects has grown more difficult as the sector adopts more environmentally friendly procedures. Because there are so many materials available, each with unique qualities, prices, and environmental effects, engineers and customers find it challenging to make well-informed judgments. The process of choosing materials is further complicated by the need to consider variables including local laws, building type, and climate [5].

The main objective is to create a machine learning-based system that can make precise and situation-specific suggestions for building materials. To recommend materials that satisfy a project's particular requirements, this system must efficiently evaluate input characteristics including building type, climate, and sustainability objectives. To guarantee that the suggested materials are not only practicable and in compliance with local laws, but also sustainable, it must also consider location-based data and local rules [6].

Finding a solution that strikes a balance between the need for an intuitive user interface and accurate recommendations is another problem. Users should be able to readily understand and apply the system's clear and succinct recommendations, which should be simple to use. Simultaneously, it must provide flexibility to suit various project conditions, including variations in building types and climates [7] [8] [9].

Ultimately, it is critical to make sure the system is flexible enough to adjust to shifting sustainability criteria, variations in material availability, and changes in cost. For the recommendations to remain current and applicable, real-time data must be integrated with continuous learning capabilities.

5. RESEARCH OBJECTIVES

5.1 MAIN OBJECTIVE

The primary goal of this study is to develop a Material Recommendation System for Sustainable Building that assists engineers and customers in selecting the most suitable building materials based on project-specific requirements, environmental considerations, and local regulations. The study aims to explore the effectiveness of using machine learning techniques to analyze factors such as building type, climate to provide data driven recommendations for materials that align with both practical and sustainability objectives.

5.2 SPECIFIC OBJECTIVES

Specific

- Collect data on various building materials, including their properties, costs, and environmental impacts.
- Develop a machine learning algorithm to recommend suitable building materials based on project-specific requirements.
- Incorporate location-based data and local regulations into the recommendation system to ensure compliance and practicality.

Measurable

- Evaluate the accuracy of the material recommendations by comparing them to industry standards and expert opinions.
- Assess the system’s ability to recommend materials that align with sustainability goals, such as reducing carbon footprint and promoting resource efficiency.
- Analyze the system's effectiveness in adapting to different project scenarios, such as varying climates and building types.

Achievable

- Ensure the data collection process is comprehensive and representative of real-world construction projects.
- Validate that the machine learning algorithm is reliable and can be applied effectively in real-world construction scenarios.
- Confirm that the integration of local regulations and location-based data into the system is feasible and enhances the practicality of the recommendations.

Relevant

- Address the need for sustainable building practices by providing a tool that helps engineers and customers select environmentally responsible materials.
- Meet the growing demand for data-driven decision-making tools in the construction industry.
- Support the industry’s transition towards greener building practices by promoting the use of sustainable materials through informed recommendations.

6. METHODOLOGY

6.1 METHODOLOGY INCLUDING THE SYSTEM DIAGRAM

The user interface, backend processing, and data storage make up the three primary layers of the entire system design. Users can enter data and view recommendations using the React-built user interface. The backend, which is written in Python, manages prediction, model training, and data processing. It uses RESTful APIs to interface with the frontend. The system stores user data, energy usage records, and model outputs in MongoDB, which is accessible via pymongo [7].

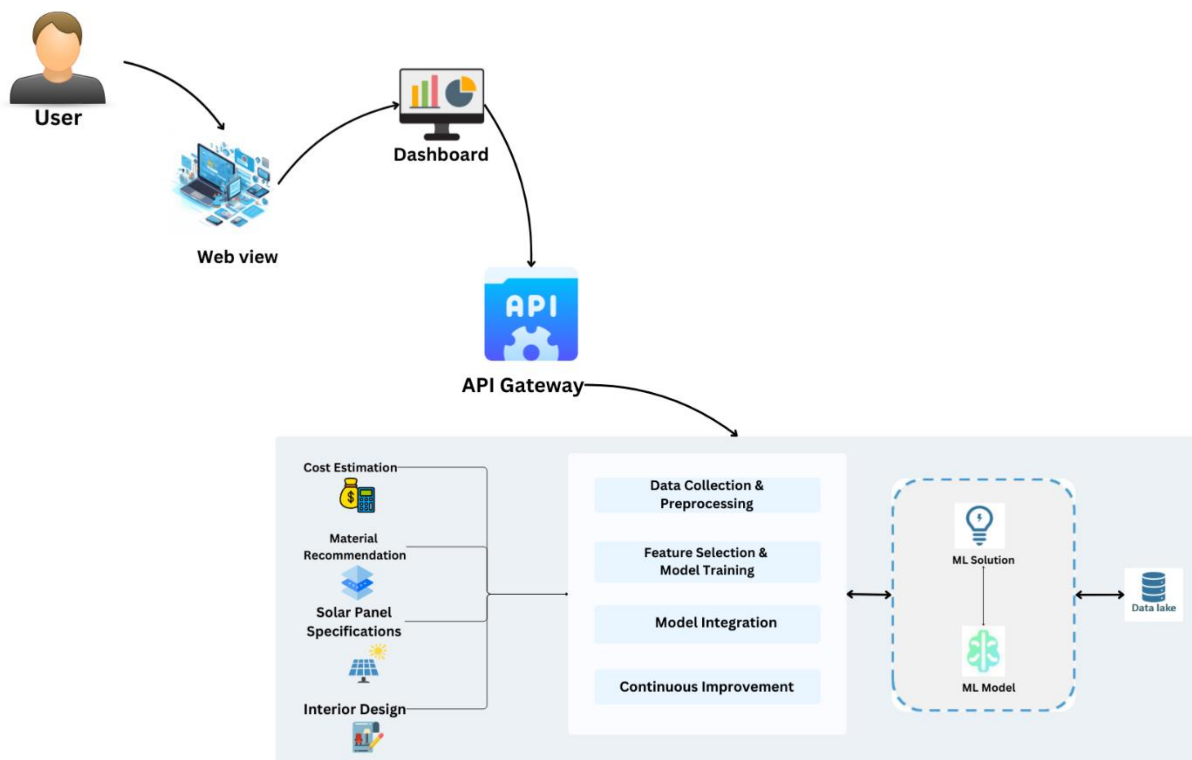

Figure 6.1:System Diagram

6.1.1 Component Architecture

1. User Interface (Frontend)

    The frontend, developed using React, provides a user-friendly and responsive interface where users can input project details, explore recommended building materials, and view relevant information about sustainability and compliance with local regulations [8].

2. Backend Processing

    The backend, implemented in Python, handles user data, processes queries, and develops machine learning models for material recommendation based on project-specific criteria. It also incorporates algorithms for considering environmental impact, material properties, and cost analysis [9].

3. Data Storage

    All relevant data, including user inputs, material properties, historical project data, and model outputs, is stored in MongoDB [10], accessed via Pymongo. The database is designed to handle read and write operations efficiently and scale with the growing dataset [7].

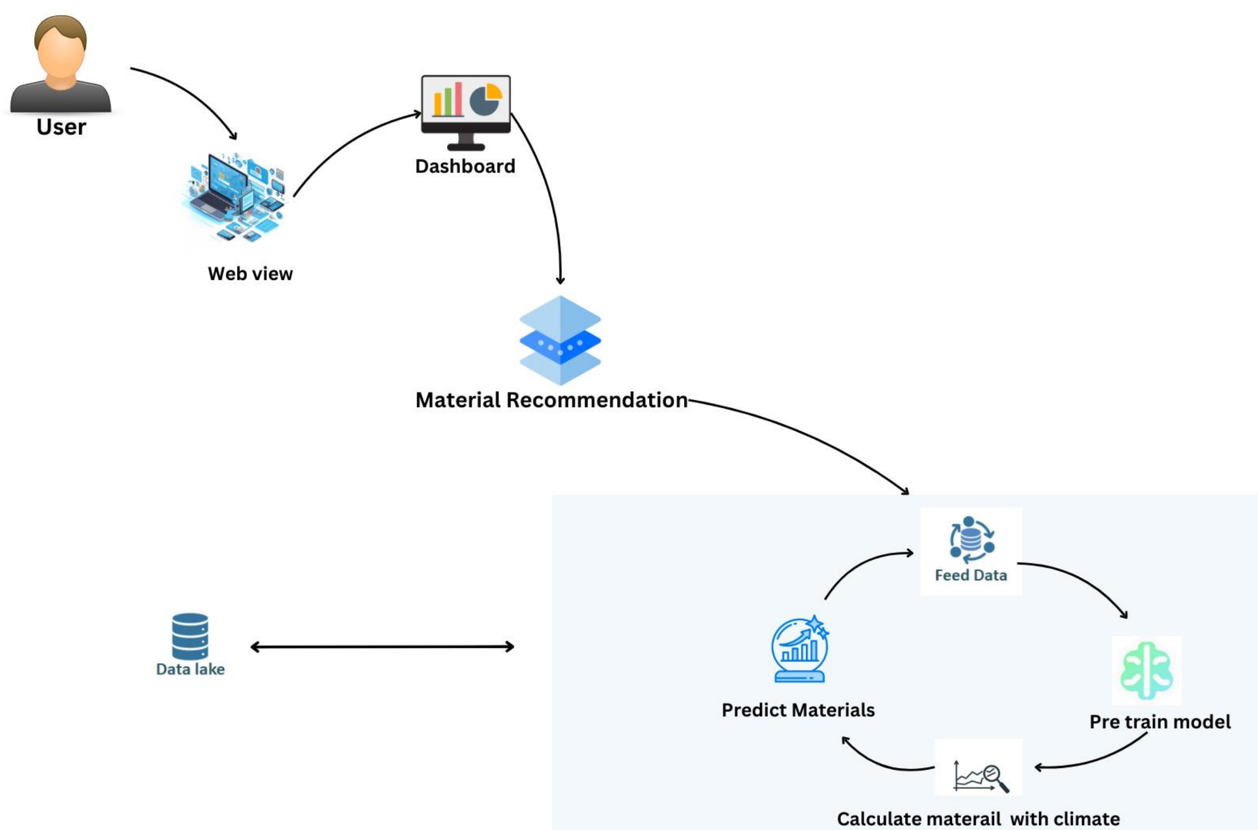

Figure 6.2:component Diagram

6.1.2 Functional Requirements

1 User Registration and Authentication

- Users must be able to register, log in, and securely access their data within the system.

2 Data Input and Processing

- Users should be able to input project-specific details such as building type, climate, and sustainability goals, with this data being processed for material recommendation analysis.

3 Material Recommendation

- Utilize a machine learning model to recommend suitable building materials based on the user's input, considering factors like environmental impact, cost, and compliance with local regulations.

4 Context-Aware Recommendations

- Incorporate location-based data and local regulations into the recommendation process to ensure the materials suggested are practical and compliant with local conditions.

6.1.3 Non-Functional Requirements

1. Scalability

   The system must support large datasets and multiple users simultaneously without any performance degradation.

2. Security

   Make Ensure that robust authentication and encryption methods are implemented to securely store and transmit all user data, protecting sensitive project information.

3. Usability

   The user interface should be simple and intuitive, catering to users with varying levels of technical expertise

4. Performance

   The system should aim to process recommendations in real-time or near real-time, providing timely and efficient responses to user queries.

6.1.4 Gant Chart

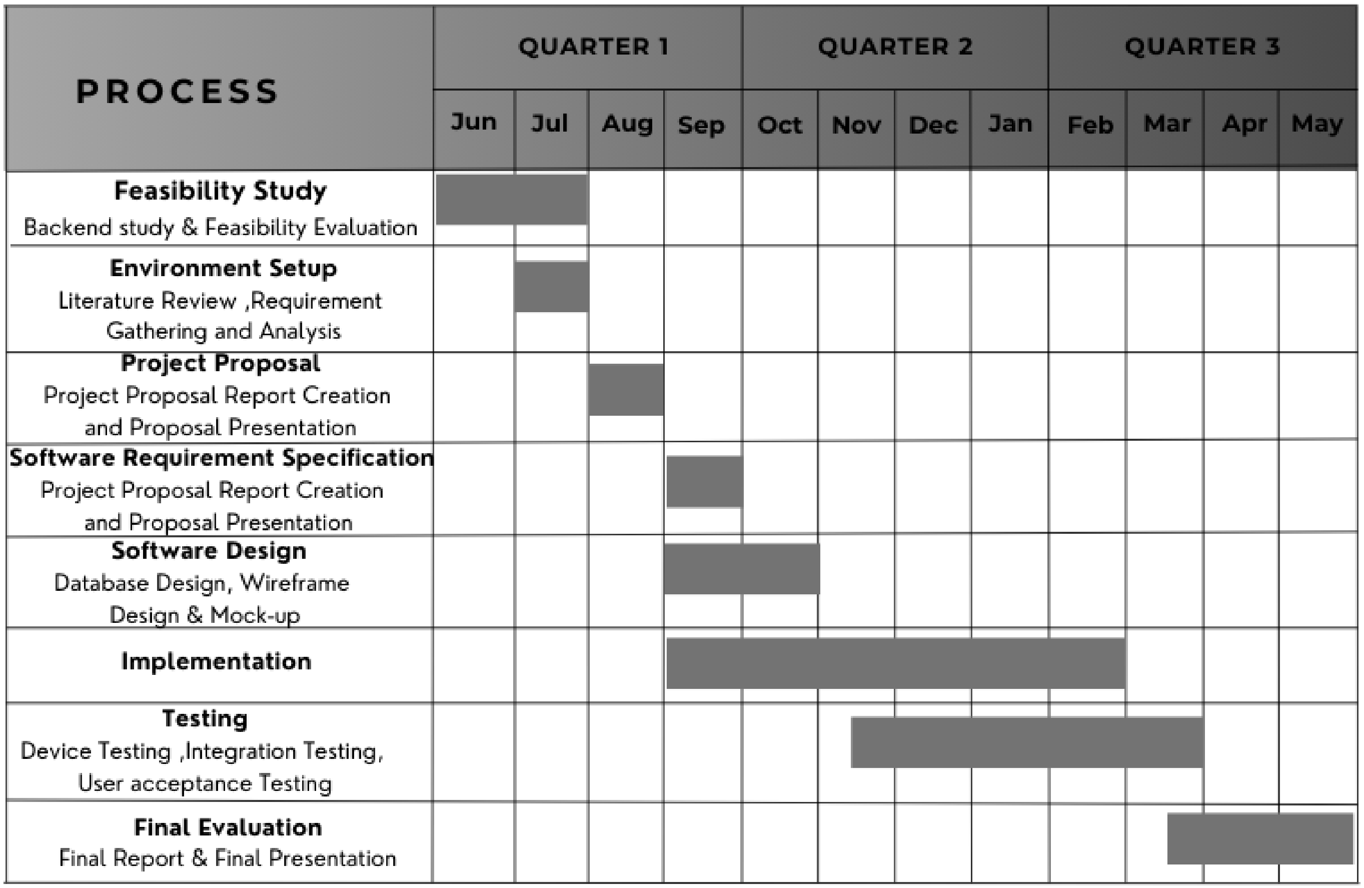

Figure 6.3:Gant Chart

6.1.5 Work Breakdown Structure

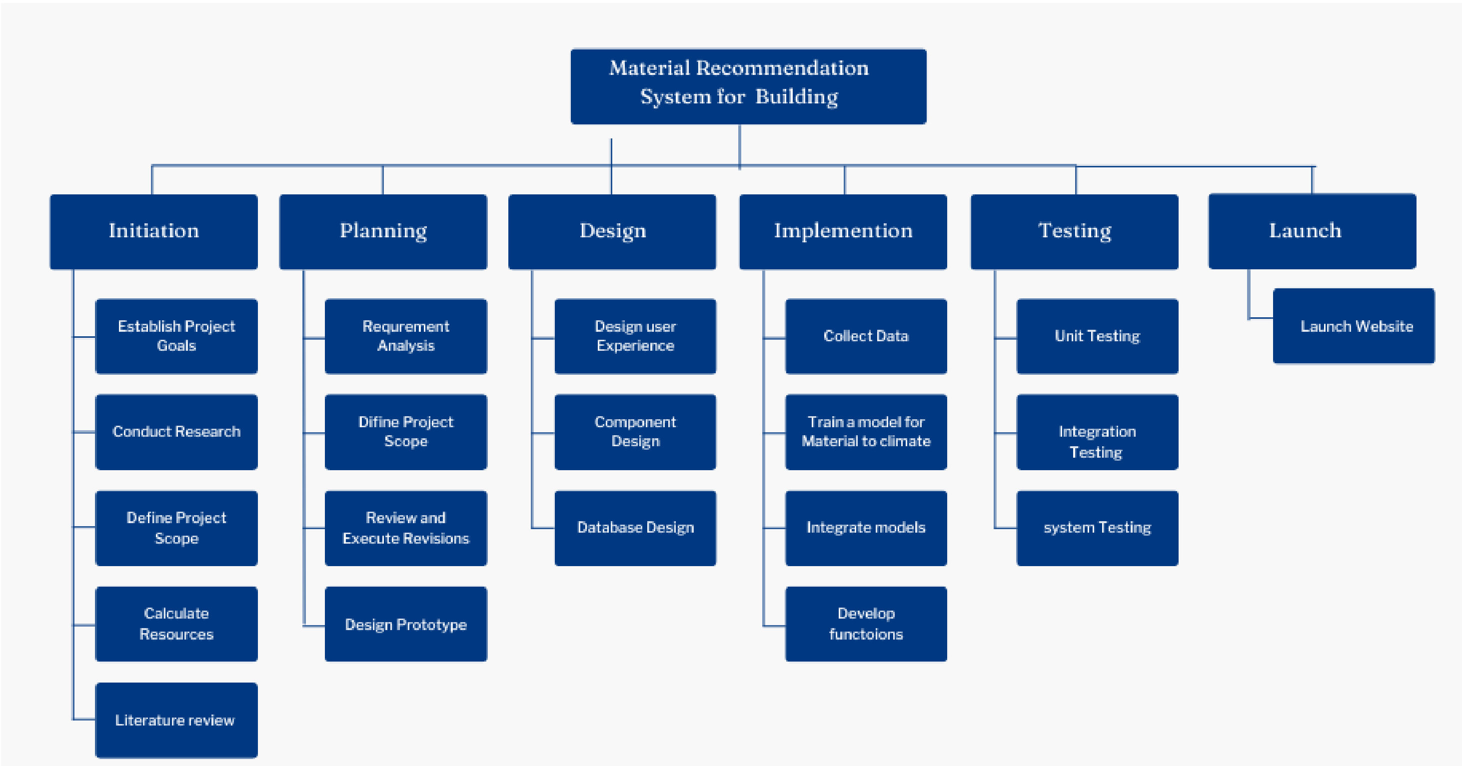

Figure 6.4:workbreakdown structure

6.2 COMMERCIALIZATION OF THE PRODUCT

The ultimate objective of this project's commercialization approach is to make the Material Recommendation System for Sustainable Building a viable product that can be adopted by a wide range of stakeholders in the construction and architecture industry. The target customers include architects, engineers, construction companies, and property developers who require accurate, data-driven recommendations for sustainable building materials that align with environmental goals and regulatory requirements.

6.2.1 TARGET USERS

The proposed Material Recommendation System for Sustainable Building is designed to address the global challenge of promoting sustainability in the construction industry, making it relevant to a wide audience. While the system is broadly applicable, certain components may be more beneficial to specific user groups. For instance, the system's ability to recommend materials based on local climate and environmental regulations may be particularly useful for architects and construction companies operating in regions with strict sustainability guidelines.

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6.2.2 MARKETING APPROACH

The marketing strategy for the Material Recommendation System for Sustainable Building will focus on building a strong brand presence, targeting key audience segments, and leveraging strategic partnerships. The following marketing methods will be used to effectively promote and sell the product:

1. Launch online advertising campaigns targeting architects, engineers, construction firms, and sustainability consultants on platforms such as Google Ads, LinkedIn, industry-specific forums, and social media. The advertisements will emphasize the system's core features, such as its ability to provide data-driven, environmentally friendly material recommendations tailored to specific project needs.

2. Develop and share educational and engaging content, including blog posts, whitepapers, case studies, and video tutorials that demonstrate the capabilities and impact of the Material Recommendation System on sustainable building practices. By positioning the system as a leader in sustainable construction, the content will build awareness, credibility, and trust among potential users and industry stakeholders.

3. Form partnerships with green building councils, construction associations, and sustainability-focused organizations. Collaborating with these partners will help expand the product’s reach, tap into established networks, and gain endorsements that enhance credibility and market acceptance. Participation in industry conferences, webinars, and workshops will further solidify the system’s position as an essential tool for sustainable construction.

4. Prioritize providing exceptional customer service to ensure a positive user experience. This includes prompt responses to inquiries, offering training and support resources for optimal use of the system, and actively seeking feedback to improve the product. Satisfied customers are more likely to recommend the system to others, leading to increased customer loyalty and positive word-of-mouth referrals.

7. BUDGET AND BUDGET JUSTIFICATION

Most of the expenses are associated with purchasing the components for the HRV sensor, which will measure heart rate dynamics. In addition to this, costs related to storing data on cloud platforms like AWS or Azure must also be taken into account. Moreover, expenses such as travel fees for meeting external supervisors must also be considered.

Item	Description	Cost Estimation
Google Cloud Platform (GCP)	Compute, storage, and database services for deployment and model training.	$300/month
Data Storage	Costs for storing datasets, user data, and model outputs on Google Cloud Storage (MongoDB).	$100/month

1 **Google Cloud Platform (GCP)**

- GCP is selected as the deployment platform due to its scalability, reliability, and comprehensive suite of tools for machine learning and data storage.

2 **Data Storage**

- Storing large datasets, including material properties, user input data, and model outputs, is critical for the project.

8. CONCLUSION

In conclusion, this study proposes a Material Recommendation System for Sustainable Building that assists engineers, architects, and customers in selecting appropriate building materials based on project-specific requirements and sustainability goals. By leveraging machine learning and data-driven analysis, the system aims to provide accurate and context-aware recommendations that consider factors such as building type, climate, and local regulations.

The proposed system has the potential to significantly impact sustainable building practices by simplifying the material selection process and promoting the use of environmentally responsible materials. Through the integration of various data sources and advanced machine learning techniques, the system is expected to offer more precise and tailored material recommendations, contributing to more sustainable construction outcomes.

The anticipated benefits of the proposed research include enhanced decision-making in the construction industry, leading to more eco-friendly and resource efficient projects. Additionally, the findings from this research may also be applicable in other fields where material selection plays a crucial role in achieving sustainability objectives.

A comprehensive project plan and timeline have been developed, outlining the various stages and activities involved in the research to achieve the expected objectives and deliverables. The proposed project plan and budget, which considers the necessary costs for data storage, cloud services, and development resources, demonstrate the feasibility of the research.

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APPENDICES

Data Sources

- ✓ Climate Data for Building Material Recommendations- https://www.kaggle.com/datasets/berkeleyearth/climate-change-earth-surface-temperature-data
- ✓ Global Environmental Data for Material Impact Analysis- https://www.kaggle.com/datasets/selvaabhishek/global-environmental-datasets
- ✓ Regional Climate Projections for Construction Materials - https://www.kaggle.com/datasets/peeyush12/climate-change-global-temperature
- ✓ Material Carbon Footprint Data- https://datahub.io/core/co2-ppm
- ✓ Real-Time Climate Impact on Material Performance[24] - https://climate.weather.gc.ca/climate_data/daily_data_e.html

Technology Stack

- Frontend - React
- Backend - Phyton
- Database [16] - MongoDB, using pymongo for data interaction