International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

EcoTrack+: A CO_2-Saving Activity Monitoring and Community Engagement System

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Abstract

EcoTrack+ is a sustainability-focused mobile application designed to track and promote eco-friendly behavior by calculating CO_2 saved. Unlike traditional carbon tracking applications that measure emissions, EcoTrack+ provides a fully positive experience by rewarding users for actions that reduce their carbon footprint. When users log sustainable activities such as walking instead of driving, saving electricity, recycling, or using renewable energy, the system calculates the amount of CO_2 avoided and records it as CO_2 saved. The application provides real-time insights through a simple dashboard showing daily, weekly, and overall CO_2 savings. Users can also join or create groups to collectively save CO_2, with group rankings encouraging friendly competition. A global leaderboard highlights top-performing users. A built-in AI chatbot powered by the Gemini API offers guidance on sustainability practices, app usage support, and suggestions for improving daily CO_2 savings. EcoTrack+ aims to foster individual and community-driven environmental responsibility through an intuitive, positive, and gamified approach.

Keywords: Carbon Footprint, CO_2 Savings, Sustainability, Mobile Application, Gamification, Community Engagement, Environmental Awareness

1. Introduction

Environmental sustainability has become one of the most critical global concerns in recent years due to the increasing impact of climate change, pollution, and excessive carbon emissions. Carbon dioxide (CO_2) is one of the major greenhouse gases contributing to global warming and environmental degradation. Everyday human activities such as transportation, electricity consumption, and waste generation contribute significantly to CO_2 emissions. Although many individuals are aware of environmental issues, it is often difficult for them to understand how their daily activities affect the environment or how small changes in behavior can contribute to reducing carbon emissions.

To address this challenge, technology can play an important role in promoting sustainable practices and encouraging environmentally responsible behavior. Mobile applications and digital platforms have the ability to track user activities, analyze environmental impact, and provide feedback that helps individuals adopt eco-friendly habits. However, many existing carbon tracking applications mainly focus on measuring carbon emissions, which may create a negative perception and discourage users from actively participating in sustainability efforts.

EcoTrack+ is designed to promote environmental awareness and encourage eco-friendly behavior by focusing on a positive metric — CO_2 saved rather than CO_2 emitted. The system allows users to track daily activities that contribute to reducing carbon emissions, such as walking instead of driving, using

public transportation, conserving electricity, recycling materials, and adopting renewable energy sources. When users record these activities, the system calculates the estimated amount of carbon dioxide avoided and records it as CO_2 saved.

The application provides users with real-time insights into their environmental impact through an interactive dashboard that displays daily, weekly, and overall CO_2 savings. Another important feature of EcoTrack+ is its community engagement mechanism. Users can join or create groups where members collectively contribute to saving CO_2 through sustainable actions. The application also includes a global leaderboard system that ranks users based on their total CO_2 savings. In addition, the system integrates an AI-powered chatbot that assists users by providing guidance on sustainable practices, answering questions about environmental conservation, and offering suggestions for improving daily CO_2 savings.

2. Literature Survey

[1] Hoffmann S., Welsch H., and Blasch J. (2024) Conducted a study on carbon footprint tracking applications and their influence on user behavior. The research analyzed how digital platforms that monitor carbon emissions can encourage individuals to adopt sustainable lifestyle practices. The study showed that when users receive regular feedback about their environmental impact, they become more aware of their daily habits and are more likely to reduce carbon emissions.

[2] Andersson D., Nässén J., and Larsson J. (2020) Proposed a system that calculates individual carbon footprints using financial transactions and consumption data. The system analyzes spending behavior and maps it to carbon emission factors to estimate environmental impact. This approach reduces manual data entry and provides continuous tracking of carbon emissions.

[3] Ajufo C.A.M. and Bekaroo G. (2021) Developed an automated personal carbon footprint calculator focused on transportation activities. The system calculates carbon emissions generated through various transportation methods such as driving, public transport, cycling, and walking. The research demonstrates how automated carbon estimation tools can promote environmentally friendly transportation habits.

[4] Mabalay A.A. (2024) Conducted a systematic review on the use of gamification in sustainability-focused digital systems. The study found that gamification significantly increases user engagement and participation in environmental initiatives. This concept is important for sustainability applications because it transforms environmental actions into interactive and motivating experiences for users.

[5] Sun S., Geng Y., and Yang M. (2022) Examined the role of incentive mechanisms in encouraging sustainable consumption through mobile applications. The results showed that when users receive incentives or recognition for their sustainable actions, they are more likely to maintain eco-friendly habits over time.

[6] Hsu A. et al. (2021) Discussed the growing role of mobile applications in promoting environmental sustainability, showing that technology plays a crucial role in supporting global sustainability initiatives.

[7] Duhigg C. (2012) Analysed the psychology of habit formation, explaining that habits are formed through repeated actions supported by triggers and rewards.

[8] Clear J. (2018) Presented strategies for building positive habits through gradual behavioral improvements, highly relevant to sustainability applications that encourage daily activity tracking.

[9] Oinas-Kukkonen H. and Harjumaa M. (2009) Introduced the concept of persuasive system design, highlighting techniques such as reminders, feedback, goal tracking, and social comparison to motivate users.

3. System Analysis

3.1 Existing System

In recent years, several digital platforms and mobile applications have been developed to help individuals understand their carbon footprint and environmental impact. Most of these systems focus on measuring the amount of carbon dioxide emitted due to daily human activities such as transportation, electricity usage, and consumption patterns. These applications generally require users to enter information about their daily activities, after which the system calculates the estimated carbon emissions generated.

However, most existing systems focus primarily on measuring carbon emissions rather than highlighting the positive actions users take to reduce their environmental impact. As a result, users often see reports that emphasize the amount of pollution generated rather than the environmental benefits of their sustainable activities. This negative approach may reduce user motivation and engagement over time. Another limitation is the lack of user engagement features such as gamification, community participation, or reward systems.

3.2 Proposed System

The proposed system, EcoTrack+, is designed to overcome the limitations of existing carbon tracking applications by introducing a more positive and engaging approach to sustainability monitoring. Instead of focusing on measuring carbon emissions, the proposed system focuses on calculating and displaying the amount of CO_2 saved through eco-friendly activities performed by users. This approach helps users clearly understand the positive environmental impact of their actions and motivates them to continue practicing sustainable habits.

The system allows users to record daily eco-friendly activities such as walking instead of driving, using public transportation, saving electricity, recycling waste materials, and adopting renewable energy sources. The advantages of the proposed system include:

- Encourages eco-friendly behavior by focusing on CO_2 savings instead of emissions.
- Provides an easy method to track daily sustainable activities.
- Displays real-time environmental insights through dashboards and reports.
- Promotes user engagement through leaderboards and community participation.
- Improves environmental awareness and motivates users to adopt sustainable habits.

3.3 Architecture Design

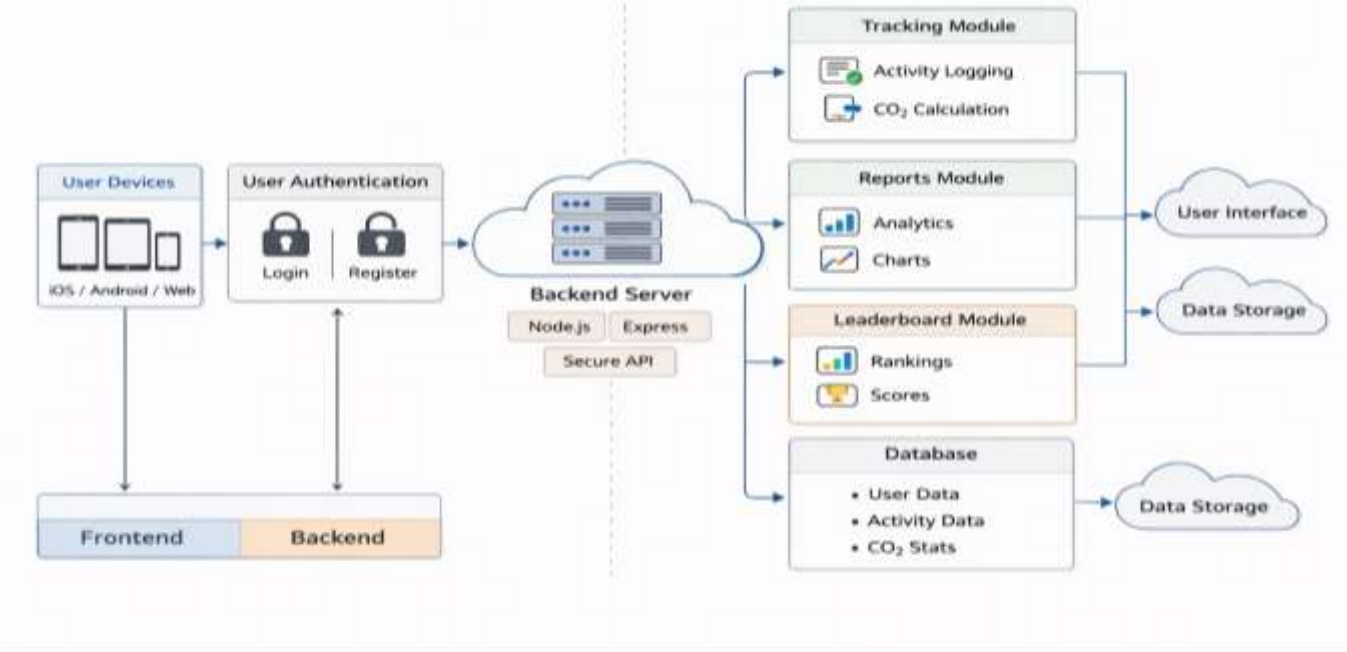
The architecture of the EcoTrack+ system is designed using a layered structure to ensure efficient processing, secure data management, and smooth interaction between system components. The architecture consists of the following layers:

User Interface Layer (Mobile Application): Users interact with the EcoTrack+ mobile application to log eco-friendly activities such as walking, recycling, and saving electricity. It displays dashboards, reports, and CO_2 savings statistics, and provides features like user registration, login, activity tracking, and leaderboard viewing.

Application Processing Layer: This layer processes the activity data entered by users, calculates the amount of CO_2 saved using predefined emission factors, generates analytics such as daily, weekly, and total CO_2 savings, and handles activity tracking, report generation, and leaderboard updates.

Backend Services Layer: This layer manages communication between the mobile application and the database, handles user authentication and authorization, processes API requests, integrates chatbot assistance, and applies standard environmental conversion factors for accurate CO_2 estimation.

Database Layer: This layer stores user information, activity records, CO_2 savings data, leaderboard rankings, and community participation records. It performs data aggregation to summarize user activities and generates weekly and monthly performance reports.



3.4 Data Flow

The data flow of the EcoTrack+ system follows five key phases. In the Input Phase, users enter eco-friendly activities such as walking, cycling, using public transport, recycling, or saving electricity. The Processing Phase validates the information and maps the activity to predefined emission factors. The Calculation Phase computes the amount of CO_2 saved based on the recorded activities. The Output Phase displays the calculated CO_2 savings through dashboards and leaderboards. Finally, the Data Storage Phase stores user information, activity records, and CO_2 savings data in the database for report generation and progress tracking.

4. System Requirements

4.1 Hardware Requirements

The minimum hardware requirements for the EcoTrack+ system are as follows: Processor – Intel Core i3 or above; RAM – 4 GB (8 GB recommended); Hard Disk – 250 GB or higher; Monitor – 1024 × 768 resolution or above; Input Devices – Keyboard and Mouse; Internet Connection – Required for accessing application features and updates. Recommended specifications include Intel Core i5 or higher, 8 GB RAM, 500 GB SSD storage, and a stable internet connection.

4.2 Software Requirements

The EcoTrack+ system utilizes the following software technologies: Operating System – Windows 10/11 or Linux; Programming Language – JavaScript, Node.js; Frameworks and Libraries – Express.js (backend), React (frontend), Mongoose (MongoDB object modeling), CORS and Dotenv for configuration; Database – MongoDB (NoSQL); Development Tools – Visual Studio Code (IDE), GitHub (version control), Postman (API testing).

5. Implementation

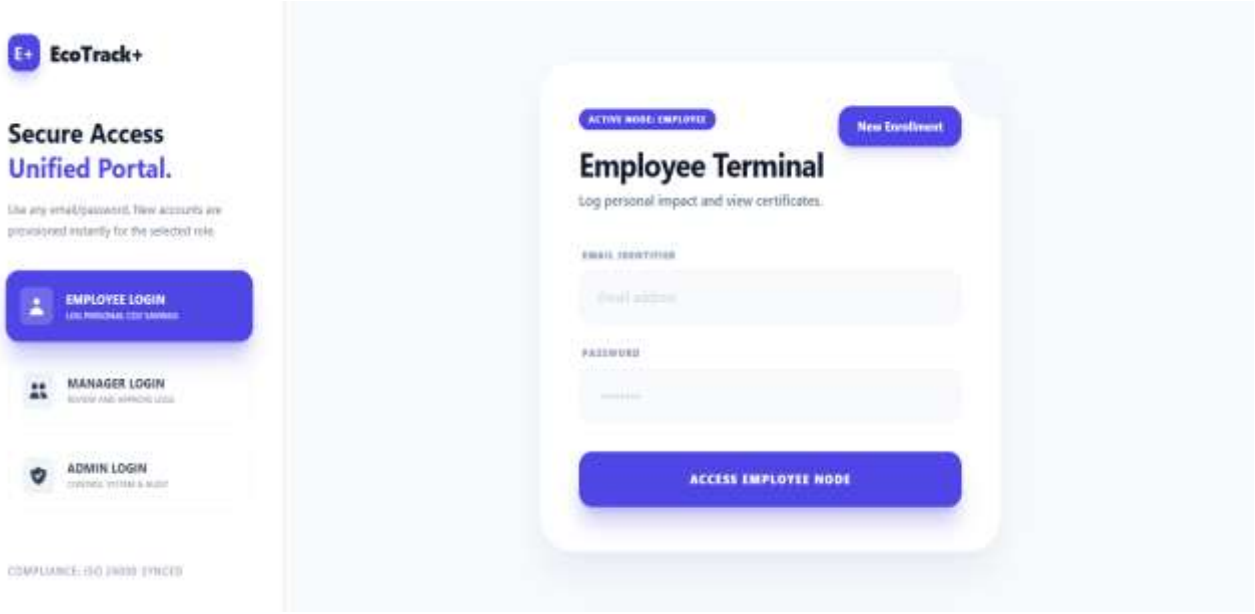
5.1 Data Collection

Data collection is an important step in the development of the EcoTrack+ system. The system collects three primary types of data. User Activity Data includes information about eco-friendly activities performed by users such as walking, using public transportation, cycling, reducing electricity consumption, recycling, and conserving energy. Each activity is stored with the activity type, date, and duration. Emission Factor Data consists of predefined emission factors associated with different activities, representing the estimated carbon emissions that would have been produced if a less sustainable option had been used. User Profile Data includes basic user information such as name, email, login credentials, and activity history used for authentication and personalized reporting.

5.2 Component Design

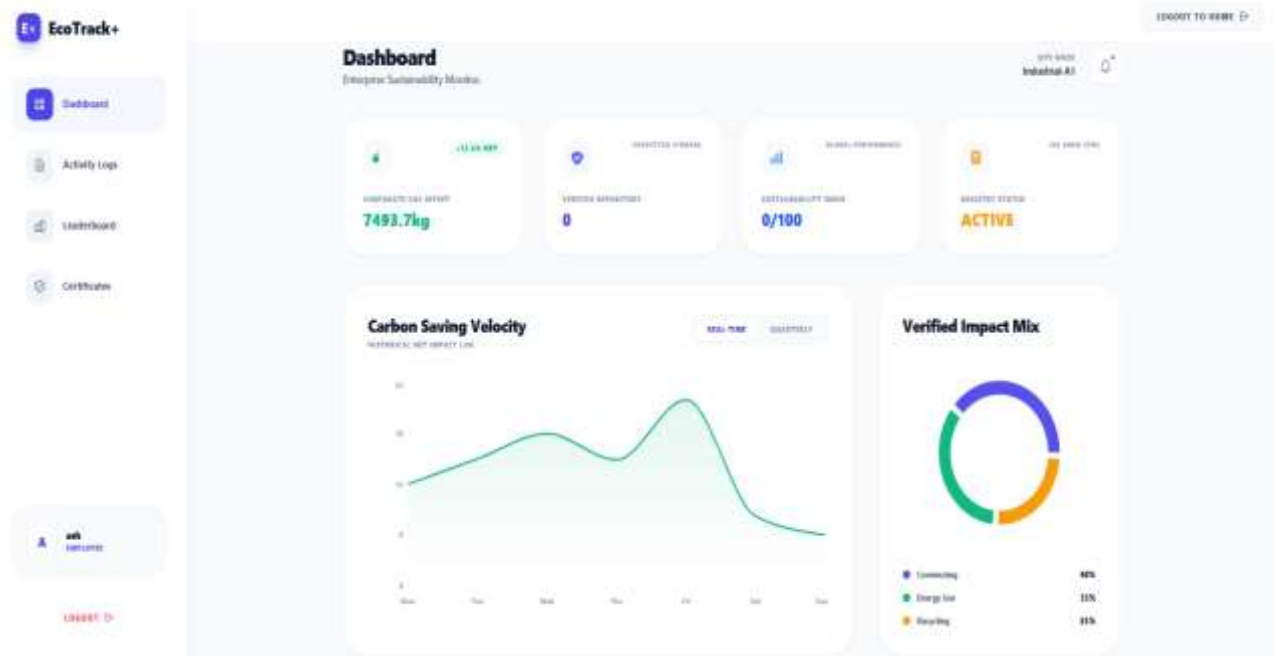
The EcoTrack+ system is designed using a modular component structure where each component performs a specific function. The key components are:

User Interface (Frontend): Provides the front-end interface through which users interact with the system. It allows users to register, log in, record eco-friendly activities, and view dashboards with charts and progress indicators.



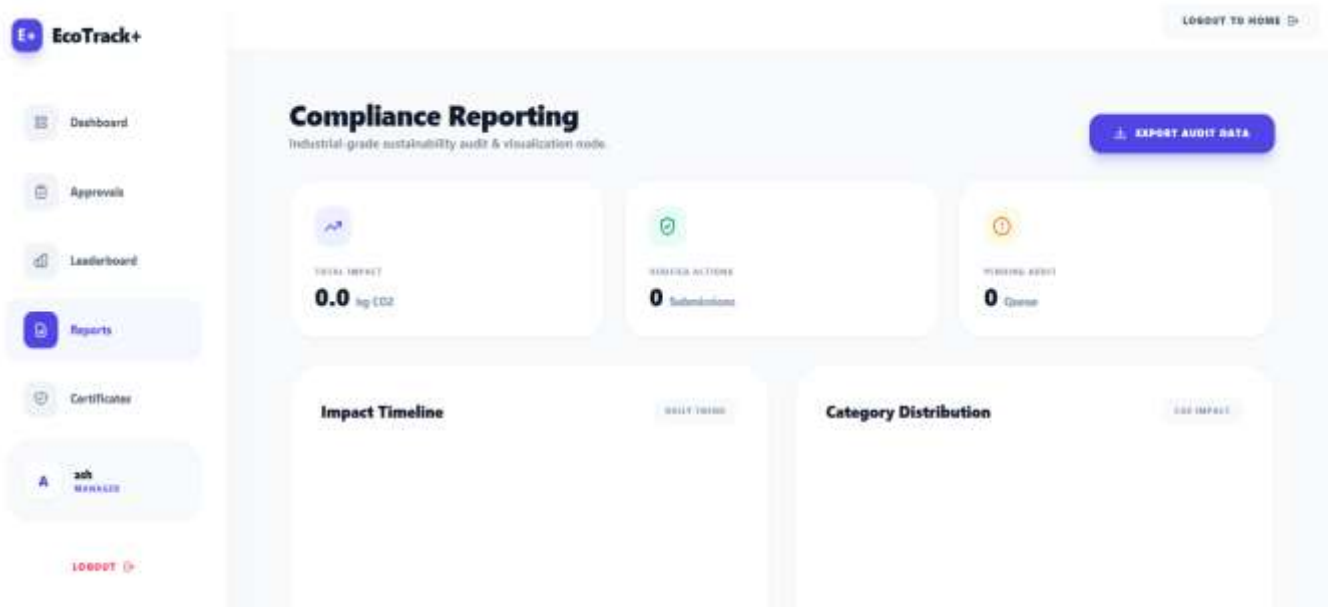
Authentication Component: Handles user registration and login functionality. It verifies user credentials, ensures secure access to the system, and manages session control and user identity verification using JSON Web Tokens (JWT).

Activity Tracking Component: Records the eco-friendly activities performed by users including activity type, duration, and date. The data is validated and forwarded to the processing module for CO_2 calculation.



CO_2 Calculation Component: Processes the activity data and calculates the amount of carbon dioxide saved using predefined emission conversion values. The calculation compares eco-friendly actions with conventional activities that produce carbon emissions.

Reporting and Analytics Component: Generates reports and graphical representations of user activity data including daily, weekly, and total CO_2 savings through charts and progress indicators.



5.3 Software Description

Node.js is used as the primary backend runtime environment, allowing developers to build scalable and high-performance server-side applications using JavaScript. Express.js is a lightweight web framework used with Node.js to develop the backend and simplify the creation of REST APIs. MongoDB is used as the NoSQL database for storing user profiles, activity records, CO_2 savings data, and leaderboard

information. Mongoose provides a structured way to define database schemas and manage data within the application. JWT is used to implement secure user authentication by generating tokens that verify user identity. RESTful APIs enable communication between the frontend and backend, ensuring smooth interaction between all system components.

5.4 Results

The EcoTrack+ system was tested using different eco-friendly activities and user scenarios to evaluate its performance and functionality. The results showed that the system can effectively record user activities and calculate the estimated amount of CO_2 saved based on predefined emission factors.

Sample Test Case: User Ashwin logged walking 2 km instead of driving. The system estimated CO_2 Saved as 0.42 kg, the activity was successfully recorded, CO_2 savings were added to daily and total records, and the leaderboard ranking was updated based on total CO_2 saved.

The evaluation metrics obtained are summarized in Table 1 below.

Table 1: System Evaluation Metrics

Metric	Result
CO_2 Calculation Accuracy	~90%
System Response Time	~2 seconds
User Activity Tracking	88%
Database Retrieval Speed	Fast and Efficient

6. Conclusion

The EcoTrack+ system provides an effective solution for promoting environmental sustainability by encouraging individuals to adopt eco-friendly habits in their daily lives. The system focuses on tracking activities that help reduce carbon emissions and calculates the amount of CO_2 saved through these actions. By presenting environmental contributions in a positive and measurable way, the application motivates users to actively participate in sustainability efforts.

During the development of the EcoTrack+ system, various modules such as user authentication, activity tracking, CO_2 calculation, reporting, and leaderboard ranking were successfully implemented. The implementation and testing demonstrated that EcoTrack+ can efficiently track eco-friendly activities and accurately estimate the amount of carbon dioxide saved with approximately 90% accuracy. The system successfully integrates technology, environmental awareness, and user engagement to create a platform that supports sustainable living and encourages communities to contribute toward reducing carbon emissions.

7. Future Scope

Although the EcoTrack+ system functions effectively in its current form, several enhancements can be implemented in the future:

- Integration with Smart Devices: The system can be integrated with fitness trackers and smart meters to automatically track user activities, reducing manual data entry and improving accuracy.

- Advanced AI-Based Recommendations: Advanced artificial intelligence models can be incorporated to analyze user behavior and provide personalized recommendations for reducing carbon emissions.
- Expansion of Activity Categories: Additional eco-friendly activities such as water conservation, waste reduction, and sustainable shopping can be included.
- Integration with Government and Environmental Programs: The application can be integrated with environmental initiatives and government sustainability programs, allowing users to earn incentives for participating in carbon reduction activities.
- Cloud-Based Deployment: Future versions can be deployed on cloud platforms such as AWS, Microsoft Azure, or Google Cloud to improve scalability and accessibility.
- Community Challenges and Rewards: Community-based sustainability challenges with reward systems and digital badges can further motivate users to consistently participate in eco-friendly activities.

Acknowledgement

The authors express sincere gratitude to Dr. R. Radhakrishnan, M.E., Ph.D., Principal, Adhiyamaan College of Engineering, Hosur, for providing the opportunity to carry out this work. Heartful gratitude is extended to Dr. G. Fathima, M.E., Ph.D., Professor and Head of the Department of Computer Science and Engineering, for her guidance, valuable suggestions, and encouragement throughout this project. The authors are highly indebted to Mrs. M. Malathi, M.E., Supervisor, Assistant Professor, Department of Computer Science and Engineering, whose immense support and valuable guidance were responsible for the successful completion of this project.

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