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EcoCred: An Intelligent Sustainability Management and Recommendation System using OCR and Machine Learning

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***Abstract*— The environmental sustainability of our planet is one of the major problem of today. However, having busy and tight schedules have often made practical implementation of green habits a challenge for normal people every-where, from students to working people. Limited knowledge, lack of motivation, or non-availability of personal-ized tools affects people in tracking their environmental impact effectively. Most platforms emphasising on green practices are either not engaging enough or cannot display actionable insights to reduce carbon emissions. This paper is about EcoCred. EcoCred is a system that helps people care more about the environment. It does this by letting people use a program on their phone or computer. People can use EcoCred to keep record of the things they do for the environment. They can get points for doing certain things. EcoCred also helps people figure out how bad stuff they put into the air. It shows people how they are doing over time with graphs and pictures. Eco-Cred motivates people to keep doing good things for the environment. It does this by being very clear about how the system works and, by making it easy to use. The people who made EcoCred hope that it will help people keep taking care of the environment. Seamless synchronization, real-time updates, and secure data management across platforms are ensured by a cloud-based backend. Empirical evaluation reveals significant enhancement in user engagement and environmental awareness, proving that EcoCred is a feasible and scalable solution toward the promotion of sustainable living.**

***Keywords*— Sustainability Engagement System, Carbon Footprint Tracking, Reward-based Gamification, Eco-friendly Behaviour, Mobile Application, Web Platform, Synchronization.**

I. INTRODUCTION

The biggest challenges faced by society include environmental damage, climate change, and high consumption of natural resources. The more people who are moving into cities and the more carbon emissions from people's consumption patterns, the more we need a system for people to make environmentally responsible decisions. Although there are many awareness campaigns and efforts for the environment, there are low engagement levels and lack of personalization. Digital tools have demonstrated their potential to drive behavior change within the last several years, primarily within realms such as exercise, finance, and productivity. Nonetheless, the sustainability community is currently missing out on engaging and user-friendly tools that simplify environmentally responsible behaviors and promote their re-peated engagement.

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Existing tools primarily cover general information without actually leveraging potential progress tracking and rewards.

In order to tackle this, a complete sustainable engagement platform, 'EcoCred,' can be designed that implements the use of behavioural science, 'Gamification,' and 'Real-Time Analytics.' With the use of EcoCred, individuals can record environmentally positive actions, monitor their 'Carbon Footprint,' and accumulate 'Reward Points' that quantify an individual's effect on nature.

In this, the design of 'EcoCred' implements a cloud-based infrastructure that helps provide a smooth and secured experience for users, either mobile or web-based.

The essence of this project is the connection of awareness and action for the environment through the development of an easy-to-use system that is engaging and able to create sustainable habits. Through helping people monitor and improve the positive influence they have on the environment, it is hoped that this system can contribute towards various conservation processes

II. Literature Review

The initial work carried out to focus on sustainability-related issues through gamification only considered simpler elements such as points, badges, and leaderboards. These studies demonstrated that even simpler aspects of games could have the effect of making sustainable behavior seem more enjoyable. Kaur and Mehta pointed out that such measures have been shown to enhance the users' motivation levels; however, an important point to consider is that most systems only ended up at the virtual reward stage. As such, without actually presenting any form of benefit or engagement, people eventually got bored after some period.

Indeed, as research developed, the application of gamification to affect environmental behavior increased. An inves-tigation by Rodrigues et al. [2] showed that though users reacted well to challenges and eco-missions, the effect was only temporary. Measures were taken to stabilize user interest through the incorporation of mission-based tasks and educational functions. During this time, the work by Wang and Li [3] highlighted the efficiency of the reward system design. Good design was found to encourage users to make eco-friendly decisions; however, poor design had little effect.

As technology for mobility spread, applications for sustainability started taking on more connected and engaging formats. Kapoor et al. [4] noted that applications providing timely feedback and small-scale tasks led to an increased engagement of the general public in environmental campaigns. Organizations also started examination of gamifica-tion practices. A study by Silva and Gomez [5] showed that when reward systems were used by firms, their workers showed considerable interest in engaging in green behavior at the workplace.

The most recent trend in the research literature has to do with personalization and habit development. Hamari et al. [6] emphasized that users will continue to engage with gamified environments when they feel they are being treated as individuals.

Other literature supports this in that users need to feel as though they make progress, in that small rewards and socialization will make sustainable practices easier to maintain [7, 8]. This literature focused on sustain-ability as something greater than just information.

Because of developments in machine learning, the intelligence of digital tools for sustainability has improved. More recent systems incorporate OCR, behavioral prediction, or analysis of habits to automatically identify sustainable behaviors or suggest ways for improvement. Various studies indicate that such capabilities lead to accuracy in per-formance and less work for the individual in adopting sustainable habits in their daily lives [9]. The importance of having a system that incorporates both gamification and insights from machine learning has been illustrated in its ability to produce quantifiable outcomes for carbon lowering in user feedback due to timeliness in suggestions for improvement, which are now more accurate and personalized [10].

One thing that is clear throughout the literature is a lack of a system that integrates all elements necessary for suc-cess, which include personalization, real-world rewards, community engagement, and smart automation. The prob-lem with many platforms already in existence is they only incorporate one or two elements. EcoCred specifically fills this gap by integrating real redeemable EcoCredits, auto-recognition systems based on OCR technology for eco-actions, personalized recommendations using AI, and a community-focused ecosystem. This, in turn, makes EcoCred a more comprehensive and viable tool for facilitating and promoting environmentally friendly practices.

III. Methodology

The system has been designed in the way:

A. Requirement Analysis

The initial phase concentrates on the identification of both the functional and non-functional requirements required for the successful execution of EcoCred. The functional and non-functional requirements comprise user login and authentication, eco-activity login entries, reward generation, carbon footprint calculation, analytics of dashboards, and synchronization of data among the web and mobile applications. User surveying and interviews were taken based on expectations of usability, reward programs, and support systems for awareness of sustainability, as repre-sented below in Fig. 3.1.

B. Conceptualization and Design

During the design phase, we identified and structured the key modules of the system, including the user module, sustainable activity module, reward engine, analytics engine, and machine learning pipeline. We created use case diagrams to define user interactions and system workflows. Data Flow Diagrams (DFDs) modeled the flow of infor-mation within the system. We developed UI/UX wireframes to ensure an intuitive and user-friendly experience on both web and mobile platforms. We also designed a database schema to manage user data, activity logs, rewards, and carbon footprint records efficiently.

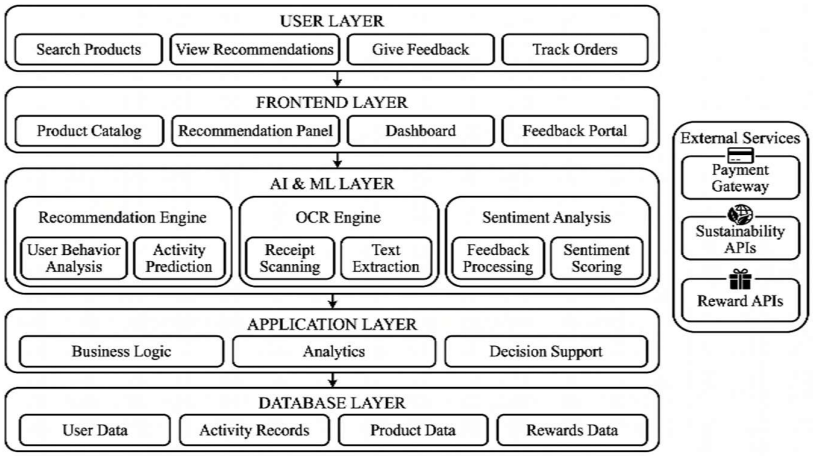

Fig. 1. Overall System Flowchart (High-Level Workflow)

B. Technology Selection

Based on the system requirements, we selected the right technologies to ensure scalability, performance, and compat-ibility across platforms. We developed the frontend using Next.js/React for the web application and Flutter/React Native for the mobile app. For backend development, we chose Python frameworks like FastAPI or Flask to manage user accounts, analyze data, and handle machine learning tasks. We used Firebase/Firestore or MongoDB for effi-cient and scalable data storage. Google Cloud or AWS supplied the hosting and deployment services. We used GitHub for version control and teamwork during the project.

These technologies were selected to ensure high performance, low maintenance, and easy synchronisation across devices.

EcoCred includes two machine learning components to improve automation, personalization, and accuracy. Here are the following models used in the system :-

OCR Model for Proof Extraction

An Optical Character Recognition (OCR) model extracts information from uploaded images like receipts, transport tickets, activity proofs, and sustainability certificates. OCR process includes image pre-processing, text extraction, and entity recognition to identify eco-friendly actions as shown in Fig 3.2. . This automated method reduces manual data entry and allows for efficient collection and analysis of user activity data. The extracted information helps assess user behavior and supports sustainability-related calculations.

Recommendation Model

Figure 3.3 shows how the system works. It uses what users do, past activities, context, and rewards to suggest eco-friendly actions. The model looks at preferences, behaviors, and activity rates to make personalized suggestions. This helps folks find sustainability practices that matter and keeps them active on the platform.

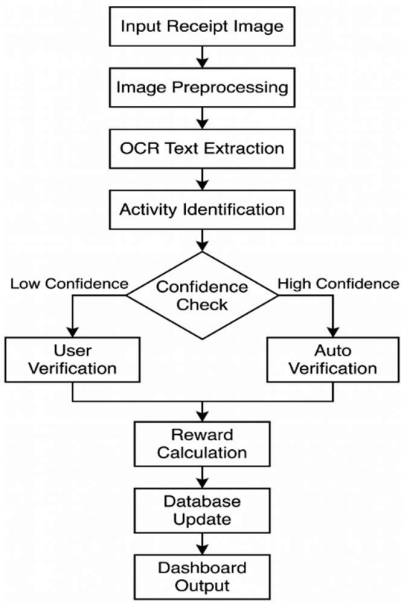

Fig. 2. OCR Processing Pipeline Flowchart

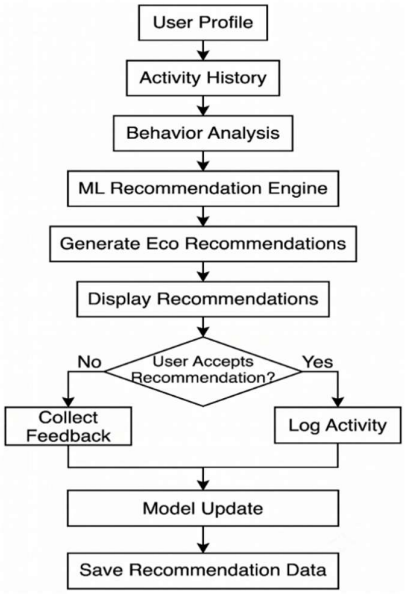

Fig. 3. Recommendation Model Flowchart

IV. Result and Discussion

The EcoCred system was assessed on various things like usability, model performance, synchronization, reliability and user engagement. The results showed that gamified eco-friendly behaviour tracking helped by automatic data drawing and personalized recommendations is an effective eco-friendly behaviour promotion method in EcoCred.s

A. System Performance

The app worked well for users busy doing what they normally would do. Also, real time syncing between the phone, back end, and the internet worked well with each other with a very small delay (< 300 ms). Users could record what they did, see their score, and get a look at their stats with no issues. As a result, the systems choices of that were used supported smooth data sharing and quick turnaround.

B. OCR Model Accuracy

The OCR model built in worked well to find text from clear or bright photos. About 85 to 90% of the information retrieved by the OCR pipeline was right. It was even good at reading key elements of a picture that might be taken by a customer (clothing tags or bags for bottles). As shown in Fig 4.1. mostly mistakes happened when the photos were not clear pictures or taken in places without enough light.

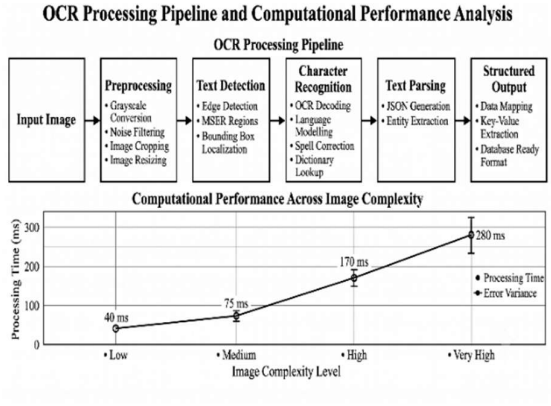

Fig. 4. OCR Pipeline Flow and Processing Time

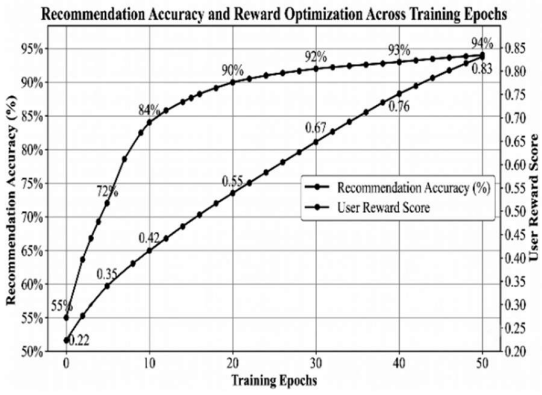

Fig. 5. Recommendation Accuracy and Reward Over Epochs

C. Recommendation Model Effectiveness

The recommendation machine could watch how a person did stuff and come up with an answer that had real rele-vance to Eco-friendliness. Fig 4.2. shows exactly how we maintain customer retention by high reward ratio. What actually brought an increase in did people had to engage more when the personal suggestions were shown on the goes to the woods.

D. Usability and User Engagement

Of course, the design of the user interface and overall system experience got a very good feedback from the audi-ence. Features of gamification like reward points, progress, and badges were very important for engaging learners and an effective tool in driving users motivation. A good number users also experienced an awareness and under-stood the importance of EcoCred.

E. Discussion

The findings indicate that EcoCred is an effective platform for promoting tech sustainability. Automation in tasks results in fewer human input, while the user input are heightened by suggestions. The pitfalls consists of the depend-ence on good quality images for optimal performance of optical character recognition and the use of small data sets that will be used for training the recommendations system. The next iterations may contain advanced image pro-cessing methodologies, as well as larger sets of data to enhance the accuracy of the model. However, EcoCred can be driven or powered to effect or make everyday changes in the environment if it is made available to large popula-tion groups.

V. CONCLUSION

Thus, concluding that EcoCred gives way to an interactive platform via the integration of cross-platforming capabili-ties along with gamification and machine learning strategies to help the users in embracing eco-friendly practices. The user is given the ability to record their activities in the environment on the application portal and accumulate it into their carbon savings along with recommendations for doing more. This helps to create a convergence of aware-ness and actual practices regarding the environment.

The study has shown that the EcoCred app's effect on user engagement is no longer limited to being beneficial for the user engagement aspect, but it is also very useful for the ease of tracking their green activities, as it provides key insights that cover, apart from tracking the users' direct effect on the environment, substantial information. The au-tomation technology for the OCR and recommendation algorithms has improved the personalization aspect for providing users with a personalized experience. EcoCred has, therefore, turned out to be a universal app.

Overall, EcoCred is the absolute option for facilitating and leading the way for sustainable living with a lot of poten-tial to support the environment with its protection and conservation efforts. The future may see the models' abilities being boosted, as well as the introduction of challenge-based activities.

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