EnviRevive - Promoting environmental awareness through a crowdsourced image analysis

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ABSTRACT

UPDATED—April 13, 2021. EnviRevive is an android mobile application that utilizes Google-based resources to build a product revolving around sustainability. The core technology behind the development utilizes Cloud Vision AI to classify images according to a set of labels available from the Google Cloud Platform service.

In this paper, the developers outline various procedures to develop an environmentally aware application. In particular, the application demonstrates a clustering technique to accumulate classified images to build correlated clusters of our environment. The application also provides a set of features that allow dynamic updates to a map activity. Along with that, EnviRevive explores common android functionalities that would benefit the user experience. Specifically, an external and remote database to store image-related data, a rotating widget to promote feature hiding, and an authentication system to create unique profiles. The resulting application seeks to improve environmental well-being through pollution awareness by applying classified images for specific parts of the world.

INTRODUCTION

Android mobile development is a software development that happens in the Android Emulator. It is a full-stack mobile software development environment, which means that most Android development platforms that exist today (such as Eclipse, Android Studio, etc.) work on Android Emulator (source and binary). EnviRevive utilizes the full-stack capabilities of Android Studio's development environment, along with incorporating cloud services to deliver a sustainable application.

In recent years, the Google Cloud Platform has introduced different cloud-based APIs. Vision AI is one of GCP's newer API that provides image analysis. It utilizes machine learning techniques to classify and label images. Vision AI demonstrates its capabilities on its website by analysing image files and reproducing a set of features, including objects, labels, and text. The underlying field of research is regarded as computer vision. The development of EnviRevive aims to utilize this Machine Learning-as-a-service to identify pollution objects on a given image.

Along with that, EnviRevive joins multiple Google Cloud API services to increase the functionality of the application in promoting environmental awareness. Google's Map functionality illustrates earth in different magnitudes. Different objects such as markers, user indicator, and historic structures can be viewed and implemented onto the Map functionality. The Map API also simplifies the process of developing visual indicators by providing map overlay tools to indicate unique features. Within this process, this paper will examine the HeatMap API as our overlay tool to display pollution onto the map.

With a significant amount of data to be handled for this application, a storage solution is required. As a result, the development process utilizes both remote and external storage systems. The usage of external storage systems is to provide quality images at fast retrieval times, without the necessary bindings of a network. On the other hand, the remote storage service, Firebase is EnviRevive's solution to store and retrieve image data for the Map activity. This solution hopes to indicate to users the available pollution, waste, and litter surrounding their area through colour representation. The increased awareness hopes to push people to physically clean our environment similarly to a recent trend of "#TrashTag", which gave a drive for people to bag up litter and waste and to improve Earth's environment for future generations.

The rest of the paper is organized as follows. The aims and objectives of this application will be outlined in a subsequent section. Section I will present related works in the Android Market. Section II reviews the related literature that helps introduce our feature ideas. In Section III, a brief description describes the uniqueness of the application. A description of key design consideration is outlined in Section IV, followed by a short description of technical achievements for EnviRevive in Section V. Section VI explores the evaluation success of the application and finally, Section VII concludes the project.

Aim and Objective

Aim: To develop an android application in Java that detects the environment's "cleanliness" through image analysis and to promote environmental sustainability awareness.

Objectives:

- To identify a suitable team framework to help increase development.
- To implement cloud services to carry out the map, storage, and image analysis activity.
- To implement common android features like authentication.
- To visualize data onto a map activity.
- To main the concept of sustainability in the development of the application.

I. RELATED WORK

In this section, an insight into relevant Android apps available in the Android Market will be analyzed. A short description will detail the differences between EnviRevive and existing applications.

Snapcrap

Snapcrap [9] is an application created by Sean Miller that organizes cleaning duty for the Public Works department in San Francisco. The app allows users to take a photo and submit a report to the department along with sharing the user's location. The image contents usually consist of something gross like feces on a public pathway, and the users can then track their ticket and check if the problem is resolved.

In terms of EnviRevive, the image taken is stored onto a public cloud service. Users can access the data through map interactions and carry out image analysis to report their findings. However, unlike Snapcrap, it does not report to a facility to demand a cleanup service. Instead, the report generates data clusters for a map, and the clusters mutate as new photographs are collected for a distinct area. As a result, the aim of the applications differs. EnviRevive encourages worldwide community cleanups for towns or cities that are labeled as dirty, whereas Snapcrap [9] forwards reports to a department to cleanup set areas.

II. LITERATURE REVIEW

The development of this project requires a reasonable amount of knowledge on the surrounding tasks related to web-based applications. A period is covered where developers choose tools that will define the functionalities of the development. Therefore, the purpose of this section is to research topics and tools that will help incorporate different technologies in building EnviRevive.

Data Storage and Authentication

Data, a critical aspect of the digital world, requires considerate attention when developing an application. Seamless processing and storage of data create a responsive and fluid application. There are two main uses of data that need to be explored and implemented, Storage and Security.

When developing an android application, data can be stored using two broad categories, locally or externally. Local storage of android devices follows a core architecture, Internal Storage, External (detachable memory devices), Shared Preferences and SQLite. For the purpose and relevancy of this application, we will focus on external storage solutions.

Following the release of Elastic Compute Cloud product in 2006, cloud computing has seen an ever-growing rise in popularity due to the scalability. Services can range from Software-as-a-service to Infrastructure-as-a-service. Cloud storage solutions have spiked in relevancy nearing the end of the decade, with services such as Google offering up to 15GB of free storage space on their servers. Stemming from this, a cloud computing service provided by Google named Firebase allows users to avail of many different products, including NoSQL databases, Machine learning kits, and General storage.

EnviRevive processes and stores Image data, leading to the need for a scalable storage solution. While android natively provides an SQLite database in the internal files, upon analysis it was deduced that our vision of the application would warrant on-demand resources. Each time a user submits a photograph for analysis it is stored in firebase Storage using a unique identifier corresponding to a Firestore Document. Our images are used to create a Real-Time heat map of litter and pollution detected in local areas.

Lazar Berbakov et al. [2] were faced with a parallel issue when developing an application for Collaborative Mapping in Emergency Situations. Their application was designed to allow emergency services to share data on a google map view relating to the current emergency. As such, scalable storage and ease of access were necessary. Similar to EnviRevive this application utilizes firebase storage to log videos and images due to the scalability, conversely, they make use of firebase RealTimeDatabase to keep track of user location on the collaborative map at all times as opposed to firebase Firestore implemented in EnviRevive.

In parallel with ensuring adequate storage space, a need for authenticating the data being accessed is required.

When processing personal data, great care needs to be taken in order to comply with regulatory requirements such as GDPR. Regulatory compliance in the context of personal data is facilitated by the need to design and implement specific, well-defined procedures of storage and processing of the personal data collected.

Ayesha Anzer et al. [5] approached the implementation of a Food Wastage reduction Mobile Application using Firebase Authentication for handling user data. This application provides alternative signup solutions for corporate entities and personal users through, generating accounts with the Firebase Authentication API. Although EnviRevive has a vastly different core functionality, the registration system is very similar. The user objects are created with email and password, and on completion, they are assigned unique string identifiers. Their unique string is used to link Firestore Documents with the account object. Both this application and EnviRevive require adequate protection of data due to email addresses and passwords being processed, leading to the use of cloud authentication methods

Heatmap

The heat map is a graphic representation of the area of the page that the visitor is passionate about or the geographic area where the visitor is located. For example, the distribution of users

may follow a certain patter. We can collect the geographic location information of the users and then apply a certain algorithm on the information to easily find out the pattern of their distribution. Those areas with more users will be highlighted whereas areas with less users will be colored with some light colors such as green.

Heat map provides more than the graphic representation. The real valuable information is the reason that causes the difference of the color on the heatmap. In the previous example, people can user the heatmap to analyze the difference between the area which has more users and the area which has less users. They can explore the reason why users prefer to go to a place instead of other places. These are the data behind the heatmap. Companies can use this data to adjust business strategies to gain more user and earn more profits.

On mobile, heatmaps make it easy for viewers to understand the distribution and relative intensity of data points on a map. Rather than placing a marker at each location, heatmaps use color to represent the distribution of the data. In our APP, heatmap is used to display the how good the environment is. If the area is detected as dirty area, its color on the heatmap will be darker than those clean areas. This helps our user to have a intuitive feeling of the changing of the areas' sanitation.

In [8], the users introduced a system called HotCity. It was a city-qide social context crowdsourcing platform that utilises user's current location and geo-tagged social data to autonomously obtain insight on a city's tacit social awareness. It is available as a mobile application for Android and as an interactive application on pervasive large displays, showcasing a heatmap of social buzz. The thoughts of using heatmap are similar, we want to show the trends and compare the difference. As mentioned by the author, a heatmap layer that is used as a "recommender" system for areas, compared to highlighting individual points, provides distinct advantages in provision of social contest. If a heatmap is used, users may prefer to choose those areas with darker color on the heatmap as their destinations, which shows that a heatmap can indeed act as an attractor to specific regions. We believe that, by using the heatmap, people will be more interesting in those highlighted areas based on what the authors said in the article. Because those highlighted areas on the heatmap are dirty areas, it is a good way to involve people into the event of cleaning that area. In general, the heatmap attracts the user by its color system and leads them to the events of cleaning dirty areas. This matches a lot to our goal of building this APP and raises people's awareness of cleaning the area as you go thus protecting the environment.

Computer Vision

Computer vision pioneered in the late 1960s through artificial intelligence is a tool that helps computer systems make better decisions by recognizing and understanding the information from a collection of images. Standard hardware, like the camera, provides the necessary gathering of photos to utilize an aspect of computer vision - image analysis. The study of image analysis involves interpreting the content of an image such as a person's facial structure, the number of cars parked and the scanning of text.

Google has developed a product that offers image analysis served on its Google Cloud Platform. The technology behind their Cloud Vision AI can be accessed through its API. The GCP offers two ways to analyze images. AutoML Vision is a tool that allows users to train their own datasets. Therefore, it is useful for niche ideas on image analysis or label contents not available on their Vision API. Vision API provides a fully trained model on classifying the contents of an image.

Mulfari et al. [10] brought the technology provided by Google's Vision AI to help people with disabilities. They utilize a Raspberry Pi 2 Model B board along with a Raspberry camera module to capture an image, send the image data in the form of a base64 string over an HTTPS connection. The GCP then processes a JSON response to the end-user through a text-to-speech process. An important find that Mulfari et al. discovers is that the Cloud Vision AI can detect through safe search. Safe search is an important function as it limits the content users are allowed to emit online.

Mulfari et al. [10] approached Vision AI through the 'LABEL_DETECTION' feature which allowed them to get classified labels of an image. The labels returned were used to vocalize words to disabled people in text-to-speech. A sample application that the authors gave, was supporting blind people walking around the street. Although their application is rather different from Envi Revive, the way they handle the Vision AI is relatively similar to the group project. Furthermore, Mulfari et al. introduced some key features of Vision AI which the project did not consider before, such as having a safe search detection in preventing users to post inappropriate images and that it supports multiple languages that would enable Envi Revive to be ported to other languages.

On the contrary, there are some downsides with Vision AI. Hosseini et al. [7] explore the capabilities of Vision AI by introducing impulse noise or Gaussian noise to images. The goal of their work was to check how robust Vision AI was with different image inputs. Within their findings, the results show that the API generates a similar amount of outputs between the original image and the image with noise filtering. Hosseini et al. used an adversarial example that distinguished an AI perception of an image to a human, they called this as a form of an attack and that the noise implemented was at random, resulting in a more serious attack. The experiment [7] involved increasing noise levels of an image by iterations of 5% until the AI was no longer able to label the image content accordingly. The results from a sample size of 100 of the ImageNet datasets showed that when the impulse noise is at 35%, the attack always succeeded. The solution was to use a noise filter, and that Vision AI with a noise filtering algorithm would benefit the tool.

UX Trends

A key component of any device application, measured by today's standards, is the ability to be able to enjoy fast access to information encapsulated by excellent user experience. A UX statistic released by Amazon Web Services on online shopping showing that 88% of visitors would not return to a website after having a bad user experience and a group study on online clicks conducted by the Nielsen Norman Group

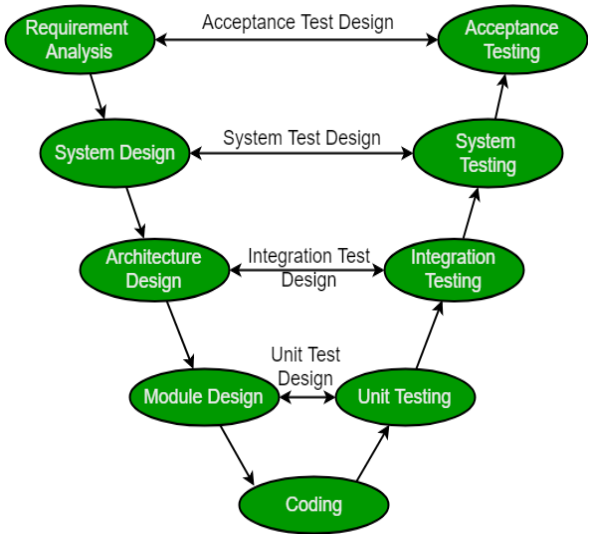

Figure 1. V-Model in software testing.

showed that 84% of the people would rather scan for hook elements such as bold headlines or images than read everything word by word [4]. The Android operating system can deliver a flexible baseline for developers to practice new user interface trends as they transpire in an open-source environment.

Our prototype development schedule allowed us to test and evaluate Envi Revive on the fly, opening up a multidirectional flow of feedback between team members. This was one of the ways we evaluated our high fidelity prototypes alongside continual production [11]. One vision we had for the future of Envi Revive is establishing greater testing and validation effort through the use of qualitative focus discussion groups and designated app QA testers 1

III. APPLICATION ORIGINALITY

Envi Revive was designed with a vision to have a more unique experience for the users. The colour green is the main colour scheme as it is appropriate to the environmental theme. Visual consistency of the application is kept intact while the user interface is maintained minimalistic so as not to obstruct the important parts of the screen, for example: the navigation wheel is kept in the corner, when it is selected, displays the rest of the features that the application can offer.

Navigating any mobile application should not be a difficult task. The quality of the user experience with the application determines how the application is characterized. The application is built with large texts and layout for intuitive reading to reduce cognitive capacity usage. The app was intended to have simple instructions with simple language to not overwhelm users with too much information and still getting the message across. Another important aspect of this is to entice a user to continue using your application (and continue learning new things) frequently using the best UX practices and leveraging resources. For example, open-source libraries (Google APIs) and web views to help with retrieving relevant environmental news.

The industry standards for today's mobile development consist of strict security and protection from data leak. The application should not be able to access or collect the data except when it is required. Having a straightforward authentication of user is required. EnviRevive uses a secure firebase authentication that obeys to the regulatory compliance.

IV. DESIGN CONSIDERATION

A key aspect of any application is the design of its user interface. To tackle this, the team used the 'Why, What and How' conceptual model which emphasises the effort of better understanding of how an application will provide contributions to its users and society [6].

Experience design is one such approach to first determine why a person would be motivated to use an application – we wanted to pose this question for EnviRevive. An experience which caters to the emotional and stimulatory needs of the user will be expected. In other words, the user should feel like they are partaking in a special sequence of events in EnviRevive - cleaning the landscape and feeling like the app stresses the value of their contributions in a socially-orientated, digital platform. Moreover, Envi Revive has been conceived in a time where environmental protection is a growing forefront in political discussions and especially on social media. For example, the '#trashtag' was developed in 2015 by UCO as a campaign to boost outdoor pursuits and has only recently exploded due to discussion forums on Reddit [3]. It involves posting a before and after picture of a local environment which has been cleaned, accompanied by the hashtag '#trashtag' on a social media platform of the user's choice. EnviRevive hopes to encapsulate this idea to connect more people and improve waste management whilst keeping things engaging with a dedicated points system based on event completion.

This progresses to moulding the functionality of the app around this motivation, for example, its genre or how it expects the user to perceive it. Hence, the Map activity will make use of Google's Heat Map API to captivate the cleanliness of the user's surroundings. As a group, we decided to incorporate a discrete navigation button which expands into a cyclic menu of activities with dedicated icons to flick and scroll through. The 'endless scrolling' feature is satisfying to interact with and the button itself is proportioned so that once it is overlaid onto an activity, it does not disrupt any functionality but can easily be clicked. What's more, the cyclic design portrays social circles which a user can develop during their time on EnviRevive and good practices of environmental sustainability supporting a majority of natural biological cycles such as Hydrology and Bio-geochemistry.

It is hoped that EnviRevive will provide visitors with a sense of belonging through the art of social connection. A well-designed interaction is perceived as efficient and more suited to meet the goals and expectations of EnviRevive's user crowd.

The last stage of the model is more in touch with the resources and methods required to construct the user interface. The human eye tends to scan anything in an 'F Pattern' , as discovered by the Nielsen Norman Group, where the eye moves horizontally with a tendency to skip to content below missing

large chunks of information [1] . Thus, it is important to strike the right balance when implementing certain functionalities - such as dynamic pieces in contrast to text overlays - to adapt to the way the eye is trained to observe things. Envi Revive is very visually orientated. The Events Recycler Menu have cards to view event descriptions which are ratioed to visuals of its location on a Google Maps fragment. The use of 'Lottie Animations' helps to engage and Text View animations enhance the overall appeal.

V. IMPLEMENTATION

User authentication is established through the user of Firebase Authentication. This API handles password storage and data protection compliance. In tandem with services written to ensure that the user inputs the correct format of email and password, an efficient solution to authentication was established. Our authentication system runs alongside Firestore that holds all the user-specific data. A User ID bridges these two technologies to create a seamless link between authentication and storage of data. Each document in the "user" collection has a unique String identifier that corresponds to an Authentication userID and an image folder within Firebase Storage.

Google Maps API provides many functionalities that are made use of in the application. A HeatMap (a graphical representation of data) is generated on the main screen of the application. Lat/Lng are weighted based on how polluted the Geo-Location, which give the HeatMap the required data to produce an appealing view of the cleanliness of a local area.

To produce these weighted values, Cloud Vision API is incorporated to analyze the image taken by a user. Certain tags are specified such as "Litter" and "Pollution" if such tags are present in the analysis the Geo-Location is given a heavier weight to present an accurate rating of the specified area.

The devices' native camera application is used for image capturing, voiding the need for requesting permissions and allowing the app to run on many different devices regardless of the camera architecture. Similarly, the device stores the image captured in the shared external storage.

VI. EVALUATION

A large part of the project dealt with project management techniques to keep the team on track, it provided core learning experiences to adapt to changes and overcome problems as a group. One of the fundamental lessons learned was to approach Agile development effectively. The team as a whole pinpointed out core functions such as authentication, maps, and a menu button to define the basis of the application. However, as the development progressed we realized that the components were too vaguely understood. One core example was the color-coded map to define dirty and clean images. The team approached this solution in terms of a heatmap. A heatmap is simply a cluster of data visualized by interpolating colors. The idea sounded effective having the green end of a heatmap representing clean images and red-colored spots represent dirty images. However, the team did not expect that a single dirty image would create a green ring around the heatmap cluster. As a result, the task was redeveloped as

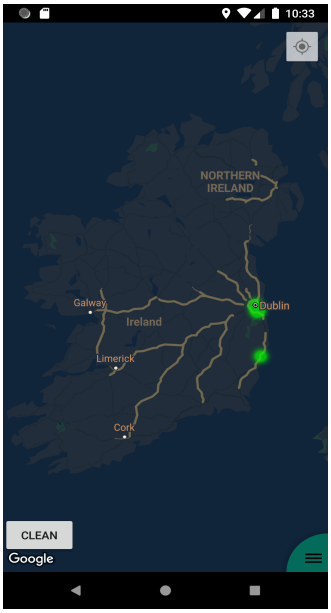

Figure 2. The clean setting displays green clusters using heatmaps on EnviRevive.

shown on Figure 2 having a switch button to configure a map with only clean or dirty images.

Overall the performance of the design stage benefitted the team hugely in the developing phase. A significant amount of time was dedicated to producing ideas for a sustainable application. Furthermore, the Agile experience in developing EnviRevive provided a team bonding experience over a multitude of sprints. The team morale became increased as concept ideas were in sync during the "10 plus 10 Method" process. Along with that, the Kanban board became a great tool to display the tasks at hand and outlining the roles of individual members.

On the other hand, different learning experiences can be unraveled from the development stage. One key lesson learned was through version control. GitHub was EnviRevive's version control platform as it provided other tools such as the Kanban board to maintain the application. During the development, GitHub managed the app through a series of commits, push, and merge. As there were five members on the team, conflicts arose often. A considerate amount of time was spent merging rather than coding and solving merge issues. As a result, it is understood that one of the key lessons was to develop under separate branches rather than working on the master branch.

The development of EnviRevive consisted of many issues outside the realm of version control. An issue occurred when one member decided to operate under an older version of the application. As a result, the image saved to Firebase contained null references to specific labels. When an updated version of EnviRevive retrieves this data, the application freezes, and collapses. The underlying issue took a considerate amount of time to fix, as it was believed that the issue originated from the updated version. Therefore, the learning lesson for this particular occurrence is to use updated versions of the application when dealing with remote storage services.

VII. CONCLUSION

EnviRevive incorporates many aspects of modern application development to produce a smooth system. Using CloudVision, GoogleMaps API and Firebase Authentication, a fluid and intuitive application was developed. While EnviRevive has some similarities to application on the market in terms of sensors and core ethos. The app strives to promote environmental awareness by analyzing images submitted by users, resulting in Heatmap clusters being displayed on the application's main screen. The application presents a modern approach to stimulating a connected society through promoting participation in local clean-up events.

ACKNOWLEDGMENTS

This project would be a difficult task if we were not working together. But, finally, our team withstood the pressure and overcome many difficulties. Here, we express our gratitude to our great teammate Kiowa Daly for his work on database setup and user authentication. Database is one of the significant parts of the APP. With Kiowa's work, our APP can interact with data and then provide a foundation for other functionalities. The user authentication part makes our APP secure and makes user to publish event possible.

We also pass this sincere gratitude to our UX designer Rebecca Lobo. The UX decides whether or not the user will like our APP. APP with bad UX will be difficult to survive in the application market. The nice icon, app lunching animation and the tutorial for new users designed by Rebecca, are the key points for our APP to attract users. Only if the APP attracts users can we spread our concept of protecting the environment.

The appreciation is given to our great teammate Gajun Young. He introduced the google map which became the backbone of our APP. Most of the functionalities were based on the map. We also thank him for introducing the Cloud Vision API which served as the image analysis tool in our application. This APP is aimed at publishing events to remind people of cleaning any dirty areas. With the analyzed images, other functionalities such as heatmap and news can work properly based on the result of the analysis.

Heatmap is also one of the key parts of our application. We want to give our users a intuitive feeling of the sanitation of some areas. Our teammate Ju Zheng develop this for us. With heatmap, based on the result of image analysis, all the data that we collected can be visualized on the google map. Areas are heated on the map with different colors. We believe this can attract people to take part in the clean up events thus protecting the environment.

We also express our gratitude to Joiedel Agustin for developing the news system. As we want to publish events to rise people's awareness of keeping the environment clean, a system that enables users to interact with each other and check any news or events is very important to our application. Thank for Joiedel to make our application social.

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