# Wildlife Marker: Mapping out Flora and Fauna using Flutter-Based Mobile Application, Firebase, and Image Crowdsourcing

An Undergraduate Special Problem

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for the Degree of Bachelor of Science in Computer Science

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## Biographical Sketch

The author, John Cristopher G. Cabanlong, is a BS Computer Science student from the University of the Philippines, Los Baños. Born on the 29th of September in year 1996, he is the second among the children of Jessie A. Cabanlong and Felisa G. Cabanlong. His hobbies includes playing mobile and computer games, following the League of Legends weekly outplays on YouTube, watching movies and series with his siblings, and having non-stop play time with his dog, Star. His dream is to build a better telecommunications company that will provide cheaper and more reliable internet connection for his countrymen.

## Abstract

This study aims to create a wildlife mapping system that is simple, low cost, and relevant. This study utilizes the customizability of Flutter UI development kit, along with a compatible cloud database that has free to use services, to locate and map out various wildlife species. A mobile application is created to enable user to upload necessary data for locating and mapping out various flora and fauna species, store the data to a Firebase realtime database, show images a user has uploaded on the app, and a web page to present all the gathered information from the database.

# I. Introduction

## A. Background of the Study

According to El Rabbany (2002), Global Positioning System was initially developed by the U.S. Department of Defense (DoD) for militaristic purposes but its use was further realized for commercial and public utilization [1]. Nowadays this technology is widely used for navigation on land, sea, and aerial transports due to its precision and high availability. When applied in mobile devices together with various software, GPS technology provides diverse benefit on people's daily lives [2].

In order for wildlife conservation efforts to be successful, efficient data collection as well as public awareness and participation to the cause must be equally achieved. The tracking of free-ranging animals, also known as biotelemetry, is achieved using various methods like very high frequency tracking (VHF), as well as the use of GPS through collars and tracking devices [3]. A study of Vincenot et al. (2015) concluded that public awareness, on the other hand, can be accomplished by improving public's perception and knowledge upon a specific species, as well as stronger conservation policies towards the said species [4].

## B. Statement of the Problem

Wildlife and ecological research are crucial in formulating conservation efforts of many species. Mapping out ecological habitats and migratory patterns often require invasive methods like capturing and attaching data loggers, which negatively affect animal welfare [5]. Animals born in wild usually get stressed undergoing different marking methods, which impact their locomotive behavior and survival rate.

Currently, there are several existing animal locating systems available on the market such as VHF trackers which are used hand in hand with directional transmitters in recording positional data, GPS collars that use satellite triangulation for location tracking, and Argos satellite Doppler system which utilizes polar orbiting satellites for marine monitoring, but these systems can be very complex and expensive [3].

## C. Significance of the Study

With the advancement of mobile technology. more and more problems become easier to accomplish due to the diverse operations it can execute, with the help of mobile applications. With the use of mobile application and an internet connection, a user will be able to contribute on locating various wildlife in a non-invasive approach. The location data will be of great benefit in home ranging and habitat identification. When this system is deployed on a large scale, it may be used to map out different wildlife species of varying endangeredness on both rural and urban setups.

## D. Objectives

This study aims to create an android application and a web application that will be able to map out various types of wildlife using images and the location-based data embedded to it.

More specifically, the proposed application aims to perform the following:

- To obtain an image of any plant or animal from a mobile device using a mobile application;
- To be able to save the data being sent from the mobile device to a cloud database platform;
- To be able to show user's specific upload data on the mobile app by applying authentication; and
- To be able to plot all the data in a web app.

## E. Scope and Limitations

This study will be limited to precollected sample images of different wildlife animals, each bearing location metadata or geolocation. The parameters that will be recorded are:

- Upload date of each image;

- Upload time of each image;
- Upload description of each image; and
- Uploader ID of each user;
- The images files to be uploaded; and
- Geolocation tag of each image.

The database component that will be used to store all uploaded information is:

- Firebase Realtime Database;

The mobile application was developed by the researcher himself and will not be uploaded to the Google Play Store. The accuracy of the data is dependent on the data shared by each user. Due to ongoing quarantines caused by the COVID-19 pandemic, obtaining raw data from the environment is not available, for collecting requires being exposed outdoors. Instead, random wildlife images with geolocation tags are obtained for testing.

# II. Review of Related Literature

## A. Conventional Wildlife Monitoring Methods

According to Kays et al. (2015), effective wildlife preservation requires collecting vital data about the animal to be protected, such as the home range where this organism lives and habitat classification. Improved technology in telemetry and tracking have produced greater insights to the study of ecology and physiology of animals [6]. However, Cooke et al. (2017) mentioned that studies in movement ecology literature may cause ethical concern when tracking rare species for some country [7].

Caswell (2020) emphasized that it is vital to locate and identify an animal's habitat in order to understand how it could be protected. Habitats play an important role on vital rates, such as survival and reproduction, which mutually affect both evolution and population growth [8]. On the other hand, Powell et al. (2012) defined home range as an estimated area where an animal restricts its movement and where it spends time in a periodic basis [9]. This specific domain is where an animal is familiar with, and knowing where to look for food, to drink, and to hide, essentially increase their chances of survival.

A research by De Solla et al. (1999) reported that early of the biotelemetry systems like the VHF tracking proved effective in measuring home range [10]. Mech (2002) stated that the main components of the VHF transmitter consist of a propagating antenna, power source and radio transmitter, while as for the receiver, a receiving antenna, a reception monitor, and a power source [11]. Animal activities like predation, breeding behavior, and even disease transmission have been have been studied further with the help of this technology.

Devices incorporating GPS technology became the modern day standard for wildlife telemetry. According to Tomkiewicz et al. (2010), this system utilizes transmission from at least 3 out of the 24 GPS satellite constellation that are 20,000km above Earth's surface [12]. Robertson et al. (2012) stated that GPS based telemetry offers more accuracy in terms of data recording without the immediate presence of a researcher [3]. Tomkiewicz et al (2010) also added that with the 24-hour availability of satellites, as well as its strategic location above ground, GPS offers tracking convenience over any weather condition [12].

## B. Flutter UI Development Kit

Being a portable UI development kit, Google's Flutter is a desirable framework in building mobile applications. What makes application development in Flutter easier and more customizable is that it utilizes widgets, building blocks that dictates UI configuration and behavior, unlike the conventional mobile application building which requires the developer to manually structure interface from the ground up. Other than that, Napoli (2019) said that Flutter also utilizes Dart packages, functions of various task specialization, written in Dart language and are easy to import and augment to any existing Flutter-based application [16].

An article by Biswas (2019) detailed how Flutter-based development offers cross platform compatibility while having the same stability offered by natively developed applications, as well as hot reload feature which lets developers recompile any modification within source codes almost instantly and see the changes while the app being modified is running [17]. Lastly, flutter-based development offers cross platform development, stability since it natively compiles applications, as well as hot reload feature which lets developers recompile any modification within source codes almost instantly and see the changes while the app being modified is running [18].

## C. Exchangeable Image Format (EXIF)

According to Krogh (2015), an American photographer who's serving the American Society of Media Photographers as the Digital Standards and Practices Chairperson since 2014, exif is a standard that identifies information about a specific image or other media recorded by any digital image capturing device [13]. This term was first defined in 1985, with the standard being handled by Japan Electronics and Information Technology Industries (JEITA) as of this day [14].

Camera-related information such as settings and device model are included within the data, along with tagged geographic information the device adds whenever a media is captured. These records are generally being used as reference on how a particular photograph was produced, as well as copyright information for legal purposes [15].

## D. Firebase Service

Firebase is an online backend-as-a-service (BaaS) platform that supports both mobile and web applications, simultaneously if needed be. This platform provides a large number of services developers would normally need to create and develop themselves, eliminating the traditional app development which requires both backend and frontend functionality to be written [19]. Utilizing Firebase for an application helps developers focus on frontend building, what the app needs is to have a unique API for the specific Firebase project to be used, as well as its dependency package, and with those the system will be able to call predefined Firebase functions to access and update data [20]. Regarding service charges, Firebase platform offers 2 main plans, one of which is the startup plan called Spark, a free limited service package for developers who would like to avail and test out its functionality, while Blaze, the pay as you go plan, offers pricing that is dependent on service usage of the application that will avail it [21].

## E. Similar Studies

A study by Stapleton et al. (2014) assessed the efficacy of satellite imagery as a tool in monitoring Arctic polar bears. The researchers used satellite imagery, as well as GPS during aerial surveys, and cross-referenced the two different sets of data to identify possible locations and distribution of the said species. The system had a big advantage compared to the conventional tracking methods that uses need-to-install trackers because while they employed GPS in plotting positional data of the bears, they also used imagery, a non-invasive measure to monitor their subject

Another study by Vatresia et al. (2016) is making use of a mobile based application for collecting and monitoring conservation activities of forest rangers in Indonesia. The application has authentication function and database saving for its data to be secured and saved. The user which are the rangers can record accomplishment of any conservation-related tasks as well as report suspicious or illegal activities and plot its position in a map using the said app.

# III. Materials and Methods

1. ) **Hardware:**

A.) 64-bit laptop computer running on 8GB RAM and AMD© A12 9720P processor;

B.) Huawei P9 mobile phone;

C.) USB to type-C data connector;

2. ) **Software**

A.) Ubuntu 18.04 Operating System

B.) Android Studio version 3.6

C.) Flutter plugin for Android Studio release 47.1.2

D.) Android 7.1

E.) Google Firebase Realtime Database

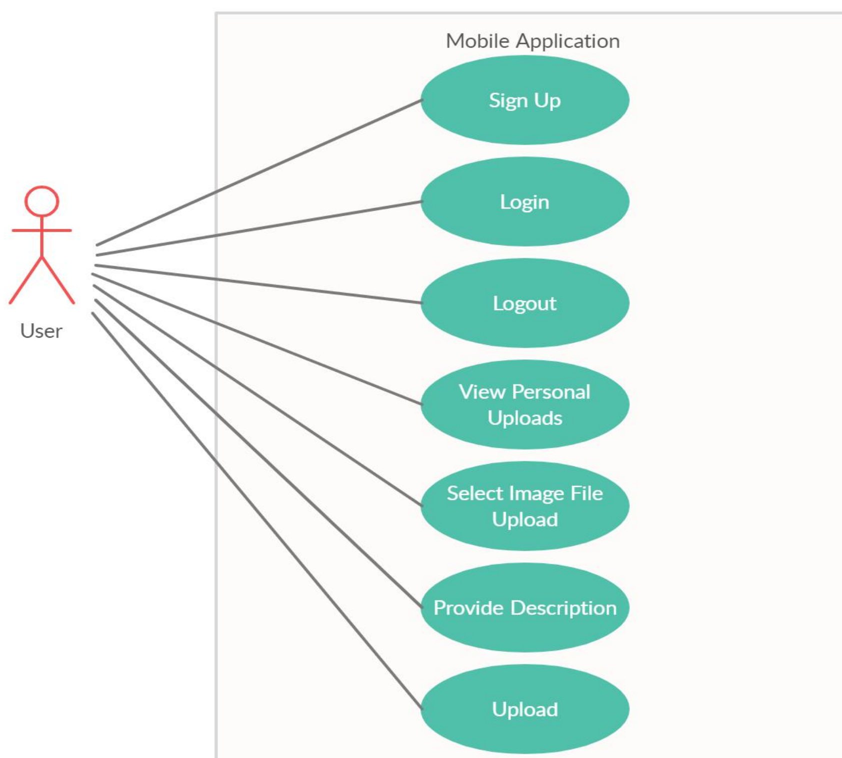


Fig. 1. Mobile App Use Case Diagram

## A. Mobile Application Development

Flutter by Google is a relatively new mobile application development platform that lets developers develop a single source code to be natively compiled as an android as well as iOS application. With the help of Android Studio, code writing and updating was done successfully, while Flutter's hot reload let the researcher see effects of code changes without recompiling and restarting the app. The researcher utilized the unique architecture of the said platform by creating widgets for the user interface of the mobile application, as well as importing Dart packages for utilities. The developer was able to include all necessary dependencies of the app such as device storage access, database communication and more, by including them in pubspec.yaml, a configuration file in a Flutter project which specifies asset requirements, all of which were utilized to create functionalities for user, as shown in figure 1. Figure 2 shows the pubspec file and the packages imported using it.

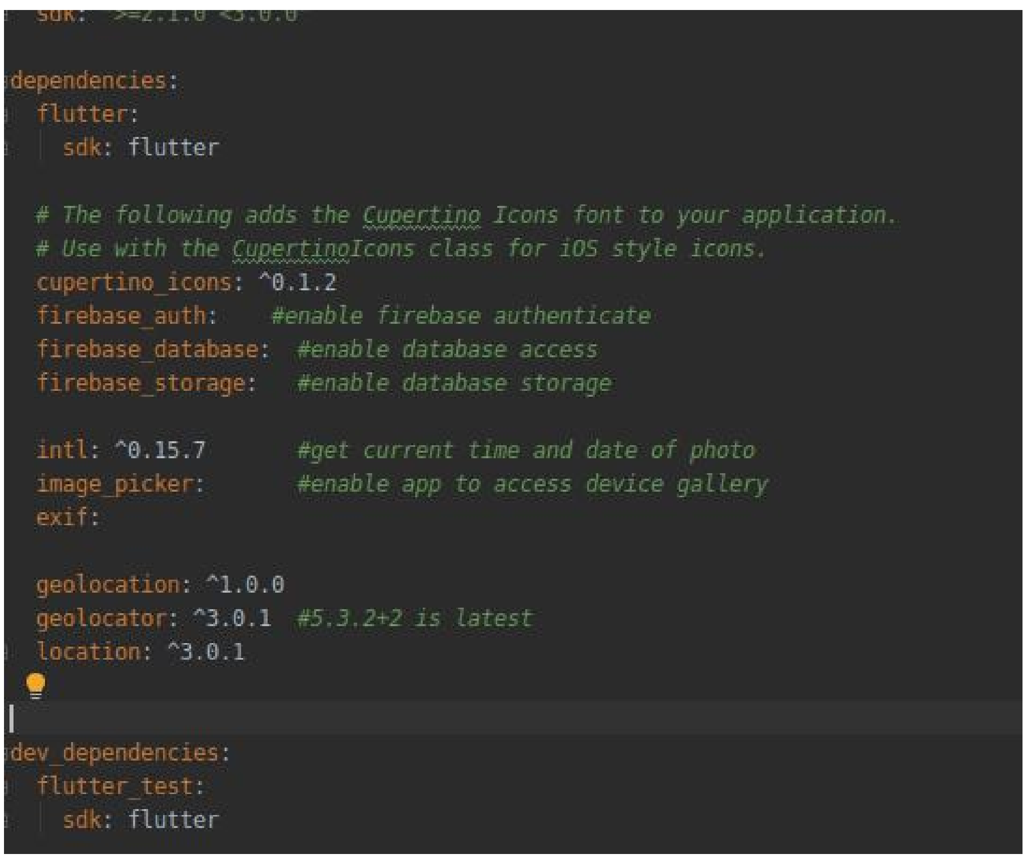


Fig. 2. Pubspec.yaml Contents

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## B. Database Setup

Google’s Firebase, a mobile and web development platform offers realtime database that supports Flutter-based application. This database uses the JSON format. The database can handle multiple users, and this functionality will be utilized for the purpose of this study. The database for the study is set up by signing in using a Gmail account, and choosing the “Realtime Database” variety as the database version using the Firebase console. The database rule for viewing is set to public in order for the web app to read the contents of the database. Database rule for writing and editing its contents is restricted only to authenticated users. These rules were updated by editing the database rules using the console mentioned earlier. Figure 2 shows the contents and structure of the database in use.

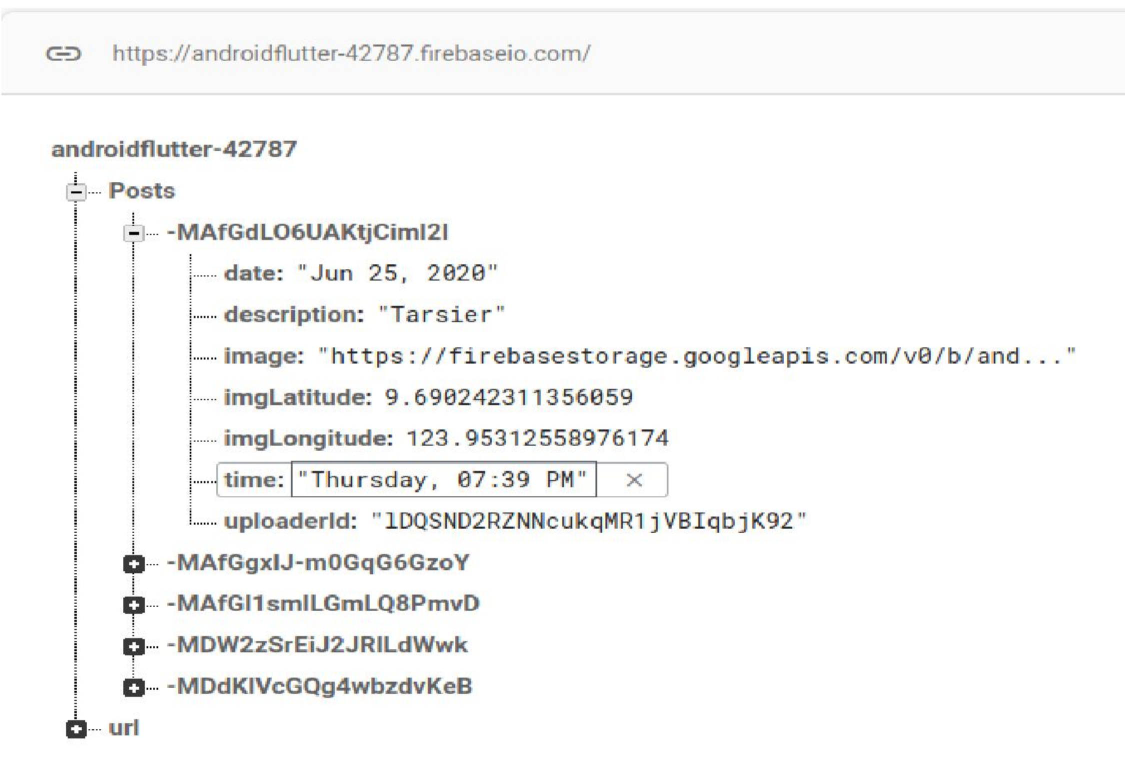


Fig. 3. Contents of the Database

User registration and login will also be handled by Firebase using its authentication service. This service is set by enabling authentication by email at the Firebase console, and importing Flutter's Firebase authentication package to the mobile app. The authentication activity diagram following UML modeling is shown on figure 3.

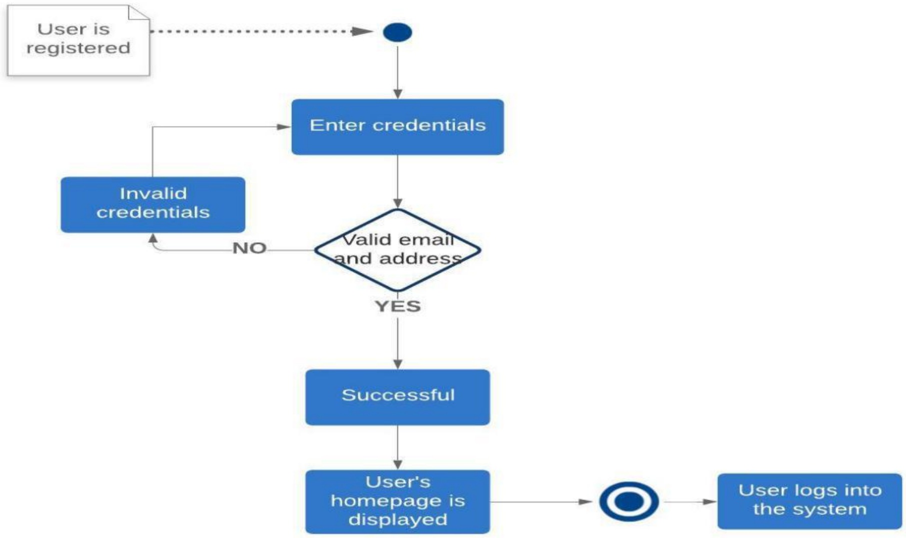


Fig. 4. Activity Diagram for Login

## C. Data Gathering

The mobile application lets the user choose a pre-captured animal or plant image and specify a brief description for the selected image. The mobile application processes the selected image upon being selected and reads its embedded metadata to find geolocation information. Extraction of the metadata is made possible by exif, one of Flutter's readily available Dart package which enables EXIF data from the image to be read and extracted. The flowchart for the mobile application's processes are mapped in figure 4, while its use case diagram is shown in figure 6.

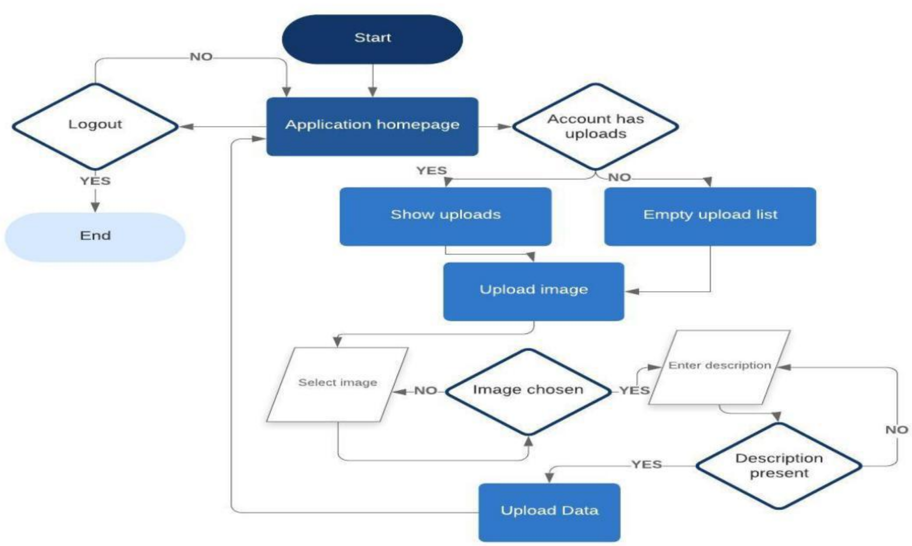


Fig. 5. Application Flowchart

## D. Data Analysis

The raw data collected by the application are formatted to follow the structure of the database. The mobile application sorts out various information from the user input such as the image file and description, and adds further data like date and time which serves as timestamp, image url, and user ID.

Since GPS devices provide coordinates in the form of Degrees, Minutes, and Seconds (DMS), in order for the GPS data to be simplified, the researcher implemented a DMS-to-latitude and longitude decimal conversion algorithm. An example of this geolocation tag in DMS format is shown in figure 5.

The DMS format:

$$[degrees°, minutes', seconds'']$$

Latitude *(S, E)* and longitude *(N, W)* signals are also present in DMS. These signals signify direction reference. Assigning variable names to decimal latitude and decimal longitude as *lat* and *long*, respectively, the main formula for the conversion algorithm is:

$$lat = [degrees° + (minutes'/60) + (seconds''/3600)]$$

$$long = [degrees° + (minutes'/60) + (seconds''/3600)]$$

If the latitude reference of a DMS latitude is equivalent to 'S':

$$lat = -1 * (lat)$$

If the longitude reference of a DMS longitude is equivalent to 'W':

$$long = -1 * (long)$$

Lastly, the values of *lat* and *long* will be stored to variables with data type of double to accommodate decimal values.

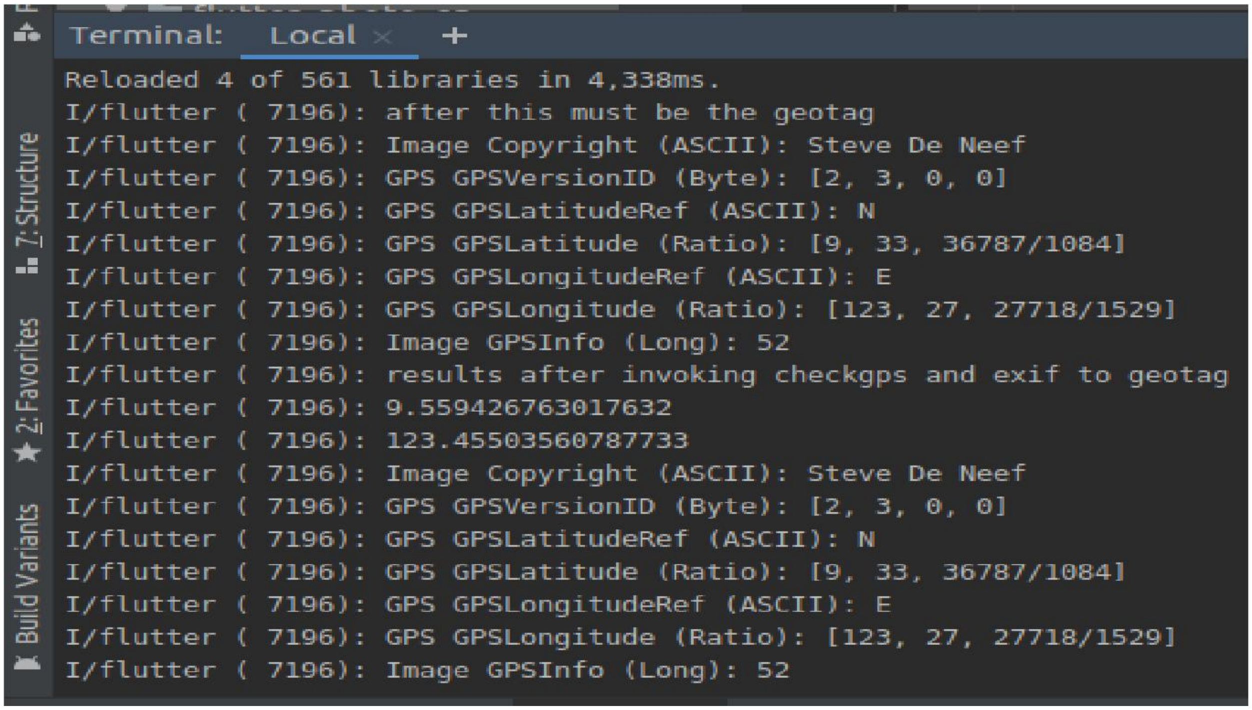


Fig. 6. Image Geolocation Tags

## E. Data Transformation on Mobile Application

The mobile app project was created using Android Studio, with Flutter as its UI development toolkit. The App has 3 main activities, the authentication, the homepage and the upload page. Firebase's library is used in order to easily store and retrieve data to and from the database. Authentication ensures each user is registered before utilizing the app.

The homepage lists all images the user has successfully uploaded, which are retrieved from the database, along with the corresponding description, date and time of upload. There is also the upload activity which which lets the app access device storage. On this activity, the the application enables user to select an image from the device storage before proceeding to upload. Any selected image will undergo exif detection and reading in order to find, convert to decimal coordinates, and store the geolocation data. Figure 6 shows description prompt on the upload activity.

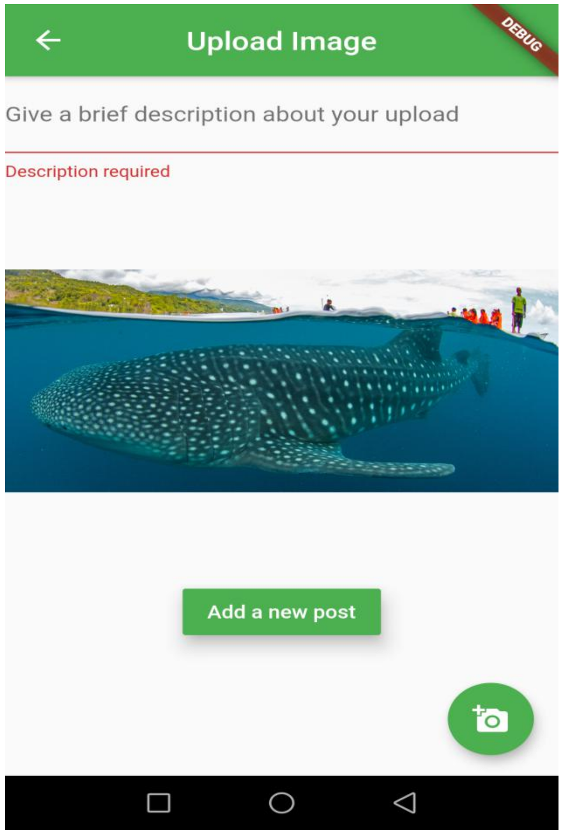


Figure 7. Image Selection and Description

After selection, the app requires a brief description for the chosen image before saving the photo to the database. During the upload process, the current date and time of the upload will be saved together with the image and its corresponding location coordinates.

## F. Data Transformation on Web Application

The web app is a single page web page that presents all the uploaded image of every user, as well as their corresponding location in a map, and has 3 activities, the map, image gallery, and information bar. It was created using Sublime source code editor, with HTML5 for markup language, Cascading Style Sheet (CSS) bootstrap for design template, and JavaScript as for backend implementation. The image gallery loads all image stored in Firebase Storage, with each image a clickable content. Upon clicking a specific image, its data gets presented to the information display, while its coarse location gets marked in the map activity.

The map activity plots every positional data stored on the database, and with the use of JavaScript, the researcher implemented an algorithm that hides the exact coordinates in a 500-meter radius to prevent the application from being used for wildlife trafficking.

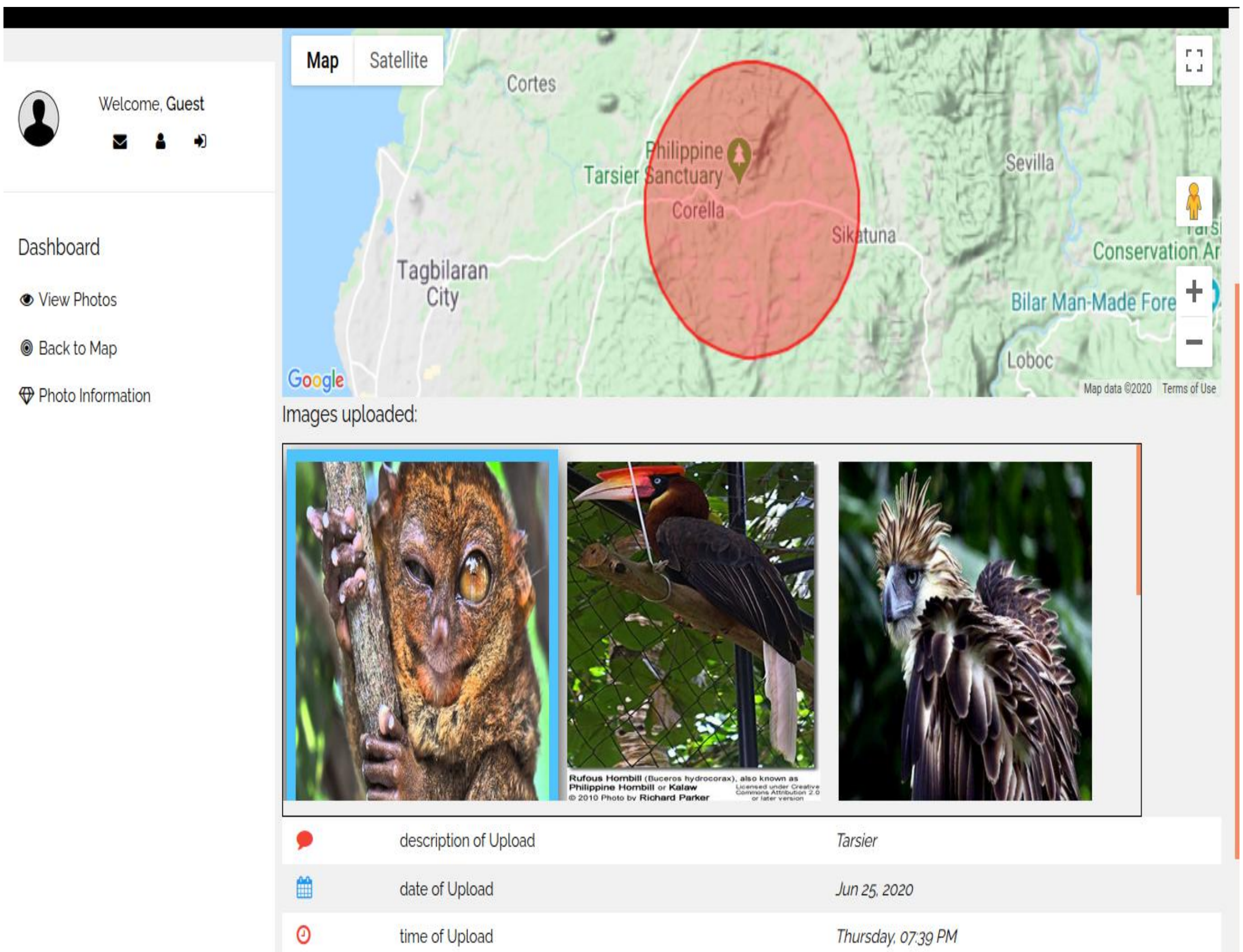


Fig 8. Web Application

# IV. Results and Discussion

When using the mobile application, the user needs to first register using an email and designate a password before being able to use all of its functionality. This is done in order for every data being collected to be associated with each unique account. Upon successful registration, the user may login using the registered email and password. The mobile device needs to be connected on the internet in order for it to successfully upload data, as well as fetch upload data of the user for homepage display.

Testing the system based on the data collected yielded proper corresponding results. The mobile application has been able to connect to the Firebase database, and authentication has been successfully made. The application successfully read all uploaded wildlife images of the particular user, and this has been made possible by the app's association of user ID per specific upload. Other than that, the application's upload function has succeeded in performing access on device storage for image selection, accepting description input from the user and uploading the selected image to the database, as well as adding the date and time of upload.

The utilization of Firebase service proved to be effective in storing various data, authenticating application users, and providing backend functionality. The blaze plan was opted in order to fully utilize simultaneous mobile and web support of the platform, but the cost of availing the said service for this application was free since Firebase offers 300 dollars worth of services free for first time users, and is consumable within 1 year. When opening the web page that will show the collected data, the browser accessing it needs to be connected to the internet in order to read every content of the database and load the bootstrap CSS. The web page doesn't need to be connected on the same network as the mobile application, the browser opening the web page just needs to be connected to the internet.

Testing the web app based on the data from the database yielded correct results. The Javascript developed for the backend has been able to access the Firebase realtime database and perform data reading. The page's mapping algorithm has also succeeded in plotting every coordinate yielded from the exif data of all images, with each position randomly enclosed in a radius marker, reducing accuracy as a precaution to deter application misuse.

# V. Conclusion and Future Work

In this paper, mapping out various existing wildlife using location-based information derived from images has been made faster, low cost, and non-invasive through the use of mobile application, compared to using conventional methods that require multiple devices and significant budget to maintain. Firebase as a backend and database platform provided solid utilities for the mobile app and low-cost service due to its generous free trial promotion. Prolonged usage of this system beyond the trial period however, may incur significant cost depending on the app's extent of use to the said service.

The Flutter UI development kit proved its ease of usability, customizability, and maintainability in creating this mobile application. Presentation of recorded data has been tailored to be simple yet insightful. Information storage through the use of a cloud database proved beneficial in ensuring data accessibility, integrity and safety. Specific measures to deter application abuse are present and functioning.

When implemented on a larger scale, this system can be used on wildlife parks, rural and urban areas, environmental regions that need portable and non-invasive means of procuring data for mapping out wildlife presence. If utilized on a large-scale implementation, this system is significantly a cost efficient investment.

The presence of stable internet connection is limited on certain areas. The implementation of offline data synchronization system that may be done using Flutter's *flutter offline* package or any package with similar function, which helps save app activity while offline.

The versatility of mobile applications in handling various kinds of tasks is a big advantage to multiple scientific domains. Flutter as a mobile application development tool further enhances app development with its simpler approach on creating UI using widgets, as well as its vast free-to-use packages that are easy to use and integrate. Continuously advancing technology reaches more and more fields of study, we expect further breakthroughs as we explore more possibilities of integrating mobile applications in various disciplines.

## REFERENCES


[1] A. El-Rabbany, “Introduction to gps: The global positioning system,”2002. p. 2-3, March 2002.

[2] Y. Huang, Q. He, Y. Wang, Z. Xie, and T. Wang, “Research on global positioning system in mobile communication equipment based on android platform,” April 2014.

[3] B.(Thomas) Robertson, J. Holland, and E. Minot, “Wildlife tracking technology options and cost considerations,”Wildlife Research, vol. 38,pp. 653–663, 01 2012.

[4] C. Vincenot, A. Collazo, K. Wallmo, and L. Koyama, “Public awareness and perceptual factors in the conservation of elusive species: The case of the endangered ryukyu flying fox,”Global Ecology and Conservation,vol. 3, pp. 526 – 540, 2015.

[5] M. A. Zemanova, “Towards more compassionate wildlife research through the 3Rs principles: moving from invasive to non-invasive methods,”Wildlife Biology, vol. 2020, no. 1, 2020. [Online]. Available:https://doi.org/10.2981/wlb.00607

[6] R. Kays, M.C. Crofoot, W. Jetz, and M. Wikelski, “Terrestrial animal tracking as an eye on life and planet,” Science, vol.348, no.6240, 2015. [Online]. Available: https://science.sciencemag.org/content/348/6240/aaa2478

[7] S. J. Cooke, V. M. Nguyen, S. T. Kessel, N. E. Hussey,N. Young, and A. T. Ford, “Troubling issues at the frontier of animal tracking for conservation and management,” Conservation Biology, vol. 31, no. 5, pp. 1205–1207, 2017. [Online].Available:https://conbio.onlinelibrary.wiley.com/doi/abs/10.1111/cobi.12895

[8] H. Caswell, “Matrix population models: construction,” August 2020.

[9] R. A. Powell and M. S. Mitchell, “What is a home range?”Journal of Mammalogy, vol. 93, no. 4, pp. 948–958, 09 2012. [Online]. Available:https://doi.org/10.1644/11-MAMM-S-177.1

[10] S. R. DE Solla, R. Bonduriansky, and R. J. Brooks, “Eliminating autocorrelation reduces biological relevance of home range estimates,” Journal of Animal Ecology, vol. 68, no. 2, pp. 221–234, 1999. [Online]. Available: https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2656.1999.00279.xn using machine learning techniques,” p. 6, August 2005.

[11] L. Mech and S. Barber-Meyer, “A critique of wildlife radio-tracking andits use in national parks,”U.S. National Park Service Report, pp. 1–78, January 2002.

[12] S. M. Tomkiewicz, M. R. Fuller, J. G. Kie, and K. K. Bates, “Global positioning system and associated technologies in animal behaviour and ecological research,” Philosophical Transactions of the Royal Society B:Biological Sciences, vol. 365, no. 1550, pp. 2163–2176, 2010.

[13] P. Krogh. (2015,sep) Exif. [Online]. Available:https://www.dpbestflow.org/metadata/exif

[14] (n.d)What is an exif file?[Online]. Available: https://docs.fileformat.com/image/exif/

[15] (2020) Exif data explained. [Online].
Available:https://photographylife.com/what-is-exif-data
[16] C. Khawas and P. Shah, "Application of firebase in android app development-a study," International Journal of Computer Applications,vol. 179, pp. 49–53, June 2018.
[17] M. Napoli,Introducing Flutter and Getting Started, 09 2019, pp. 1–23
[18] S. Biswas. (2019, dec) Why android developers should pay attention to flutter in 2020. [Online]. Available: https://blog.codemagic.io/why-android-developers-should-pay-attention-to-flutter-in-2020/
[19] D. Stevenson. (2018, sep) What is firebase? the complete story, abridged.[Online]. Available: https://medium.com/firebase-developers/what-is-firebase-the-complete-story-abridged-bcc730c5f2c0
[20] M. Napoli,Adding the Firebase and Firestore Backend, 09 2019, pp.375–410.
[21] Pricing plans. [Online]. Available: https://firebase.google.com/pricing
[22] S. Stapleton, M. LaRue, N. Lecomte, S. Atkinson, D. Garshelis, C. Porter, and T. Atwood, "Polar bears from space: Assessing satellite imagery as a tool to track arctic wildlife,"PloS one, vol. 9, p. e101513, July 2014.
[23] A. Vatresia, J. Sadler, R. Rais, and E. Imandeka, "The development ofmobile application for conservation activity and wildlife in indonesia,"10 2016, pp. 203–208.