Development of Mobile Application for Geotagged Fault Lines in Southern Mindanao, Philippines using ArcGIS and Google Earth

Paterson P. Soroño[1], Karl Vincent F. Eran[1], Kit James R. Medina[1], Rodrigo S. Pangantihon Jr.[2]
[1,2]Computer Engineering Program, College of Engineering Education
University of Mindanao, Matina, Davao City, Philippines
[1]paterson783@gmail.com
[1]carlicexxx@gmail.com
[1]kenzmedina@gmail.com
[2]rodrigo_pangantihon@umindanao.edu.ph

ABSTRACT

An earthquake is considered as one of the most destructive natural disasters ever recorded. Fault lines exist by nature and all scattered around the world. Earthquakes occur on these faults, and the more active the fault, the higher chance of a shock. The study aimed to develop a mobile android application that will allow users to interact and monitor the location of fault lines, whether specific or listed, with the use of ArcGIS, Android Studio, Google Earth, and geotagging technologies. Fault lines data were gathered and the information on the occurrence of earthquake in a particular area. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) assisted in the validation of the information of the said earthquake and fault lines near it. Android Studio was used for the coding and functionality of the application. A User Acceptability Test was conducted and generated an overall result of highly acceptable. Government authorities and experts can use this app when geotagging new and emerging fault lines. The app is now available for download at Google Play Store.

Key words : ArcGIS, Earthquake, Fault line Map, Geotagging, Google Earth

1. INTRODUCTION

Many natural disasters are happening today around the world. A natural disaster is characterized as any hazard caused by geological forces, including earthquakes, floods, hurricanes, among others [1]. However, the most recent one in our region is the earthquake. Earthquake is a shaking of the ground, which causes massive destruction due to movements of two blocks of earth separated by a fault line. This kind of event creates many problems for all of us, especially to those who were affected. It is indeed hard if we are unable to predict when it will occur. In this case, for some people to be ready, the geotagging of fault lines can be applied. It helps find the location and gives specific data for a particular place where the fault line is located.

There are many destructive phenomena, and an earthquake is one of them. The energy that released suddenly on the earth causes shaking of ground known as earthquake [2] that results in the destruction of many infrastructures and can also trigger another natural disaster the tsunami. Since humans cannot alter natural disasters, people started preventing natural disasters by making use of technology that predicts earthquakes, storms, among others. Back Propagation (BP) neural network and an improvise Particle Swarm Optimization (PSO) algorithm is a strategy to predict the magnitude of an earthquake [3]. Through this method, people become more prepared and aware of an upcoming natural phenomenon. To prevent casualties and provide earthquake awareness fault line can be one of the significant leads in determining the possible area where earthquake occurs. To locate these particular fault lines easier is best to use geotagging.

Geotagging is the combination of geo-parsing and geocoding that has been applied to archival data in many projects. For improving geographical search and extracting information, digitizing archival records and automatic geotagging them may be applied [4]. Machine generated data such as videos and images can be tagged with coordinates, known as geotagging [5]. Geotagging was used to pinpoint the location stamp with precise coordinates, which helps the user to have better control over monitoring and collecting evidence for certain activities [6]. The use of location-based data processing methods is an integral part of entrepreneurial remarketing strategies [7]. One of the main elements of concern is the shared social media data of usres[8]. These data were also analyzed for both their content and location information; the results help to identify trends in the regions being researched [9]. The geotagging technique is currently being used by different organizations to have better on-field operations control. Geotag is also used to catch numerous

Feedback sessions conducted monthly for teams to share information, identify gaps, and reassess goals [10]. On the other hand, Mobile devices played an essential role in today's generation for their functions can be used as a substitute to a personal computer. Like a computer, mobile devices also have an Operating System (OS) in order for it to run, for mobile phones android is one of the popular OS developed and known for its user-friendly feature and many more [11]. The widespread availability and usage of media recording tools such as smartphones, cameras, and the growing proliferation of social networking and information sharing platforms online have resulted in a massive increase in user-generated content to news stories and real-world events. A key component of user-generated content is text, which for example, defines either the only component of a social media post, a tweet, or an annotation accompanying a multimedia item such as an Instagram image and YouTube video. Text annotations are also an essential aspect of digital user profiles, including a Twitter account's description field [12].

In several instances, text annotations created by the user indicate the place they originate from or refer to, either because they specifically mention specific geographical entities or because the text contains indications that implicitly signify particular areas. Often being able to perform geotagging is very useful for applications that track social media. For example, a journalist can identify and check where a breaking news item is located by corroborating numerous social media posts that have been automatically geotagged [13]. For another example, a market analyst may evaluate a specific brand's popularity across the globe by combining the locations that were automatically extracted from social media pages that reference the brand for their posts. To this end, the geotagging problem has gained tremendous attention in research, and a wide range of geotagging methods have been suggested to resolve it [14]. The popularity of smartphones has created several digital images with relevant data about geographic information, time information, and text description, called geotagged photo data set [15]. For the entire month of March 2018, 611,687 tweets were collected and confirmed to be geotagged only on an average of 0.11 percent tweets per day [16]. If tweets were geotagged, there is a known place where a specific article was written or a region it describes. Thus, by extracting geolocation data from such unstructured data and incorporating location information, it is possible to track the occurrence of a specific event and its location [17].

The purpose of this study is to design a mobile application that enables app users to find the exact location of fault lines in the Davao Region, Philippines, geotagged already by government authorities and experts. App users will be assisted to know where the exact location of the fault lines. Also, government authorities can use this app when geotagging new and emerging fault lines. The target of this study is to develop an android app readily downloadable from Google Play Store through mobile phones. In this way, it will be available to everyone that has access to the internet. Infographics and some learning materials about earthquakes are also installed in the app.

The significance of the study is about giving full awareness to all users and for them to be prepared and knowledgeable enough in terms of Earthquake and Fault lines. Users can also suggest if there is a potential Fault line near them by requesting a tag which is later to be validated by experts in the field. This application is also helpful in giving information as the application also featured infographics, historical data, and other learning materials related to earthquakes.

This study focused only on geotagging fault lines around Davao Region of the Philippines and limited its availability to mobile android users only.

2. MATERIALS AND METHODS

2.1 Conceptual Framework

In Figure 1, the inputs are the data of fault lines from PHIVOLCs, images, and datasets from the United States Geological Survey (USGS). Using these inputs, the whole process of geotagging commenced; the user captured an image of the area where the potential fault lines are located and upload the data taken to the server. If the data was proven correct, then geotagging of the fault line is successful. Aside from geotagging of faults, information about earthquakes, news, and website are also considered as the output of the study.
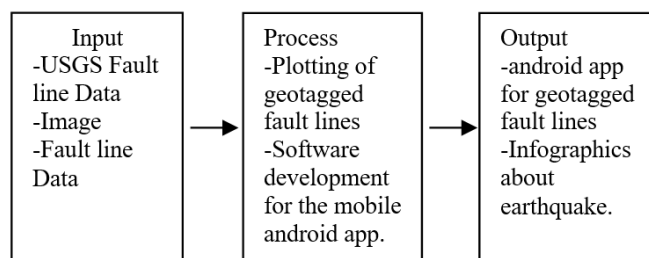
Input -USGS Fault line Data -Image -Fault line Data	Process -Plotting of geotagged fault lines -Software development for the mobile android app.	Output -android app for geotagged fault lines -Infographics about earthquake.

Figure 1: Conceptual Framework

In Figure 2, the use-case diagram illustrates how the user interacts with the system. Each action can be accessed by the user linearly. The map section contains two separate maps. One displays all the tagged locations by other users that are already approved by the developer. The user has a send-a-request option to add a tagged location on this map, and the user must provide all the necessary information in the request form and must wait for the developer's approval. The next map contains all the fault lines in Region XI and can be

filtered. A search bar can also be used to find specific locations and automatically zoom in the specified address. The Terrain View can be changed according to the user's preference and comfort. The dashboard serves as a monitoring section for earthquakes that have recently occurred; this was filtered weekly and displayed on a chart. The user can click on a specific earthquake occurrence to get more information. The Archive is a compilation of information that is relevant to fault lines and earthquake emergencies. The News section is sourced from a credible website. There is also a section of the app that provides a trusted website that gives more information and in-depth analysis on fault lines and earthquakes; the user is also given an option to open this website on an external browser.

Figure 3: User request Data Flow Diagram (DFD)

2.2 Material and Resources

This study focused on the development of an android application. The actual application was made using Android Studio, including the templates and design. Graphical Information System (GIS) was designed to manipulate and analyze all types of graphical data [18], leading this study to use arcGIS.com as a working database. Also, the GIS framework consists of three main components: Database, Map, and Web servers. The cloud database acted as data processing and data storage. Map server offers maps based on requests from users on the server-side of the application, and the site server serves as a provider of web services to the user [19].

The data of the Fault lines in Region XI are sourced out from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) website in a Keyhole Markup Language (KML) format and viewed on Google Earth Pro as shown in Figure 4.

Figure 2: User interaction use-case diagram

Figure 3 illustrates the Data Flow Diagram for sending tag requests. The user will send a request through the app by filling out a Google Form. Once all the necessary data is provided, it will then be uploaded into the developer's cloud storage. Once received, the developers will review the request data and to be referred later to field experts. An email notification will be sent to the user for the result of the request, and the tagged locations map will be updated correspondingly.
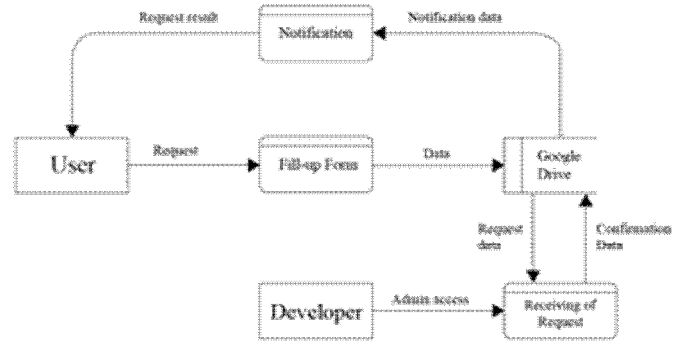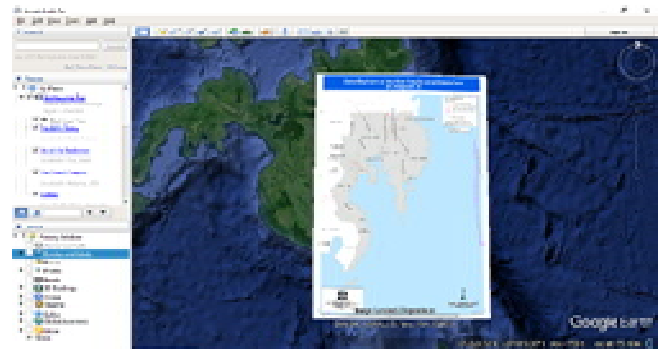

Figure 4: Distribution of Active Fault lines in Region XI

As shown in Figure 5, the tools used to trace the fault line was the ArcGIS software, together with the software's sub-feature, the Operations Dashboard for real-time earthquake monitoring. The different color scheme was used in every Barangay's perimeter to identify a specific Barangay that the user wants to see.
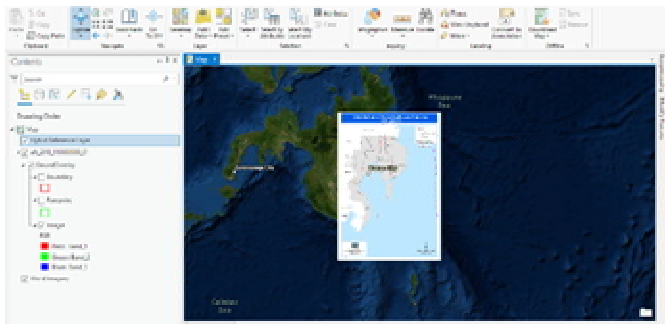
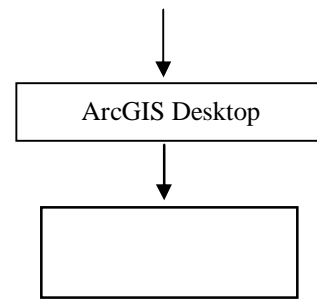**Figure 5**: ArcGIS Software Dashboard

Figure 6: Procedure of modelling Application Map

2.3 Methods and Procedures

In developing the application, a trade-off analysis was conducted wherein two designs were proposed with different features. With the use of Pugh Matrix technique, the design to be implemented was determined [20]. Collecting profiles of all fault lines in Southern Mindanao and gathering data about the information of the occurrence of earthquakes in a particular area with the help of the PHIVOLCS and USGS was conducted.

Taking pictures was one of the major requirements; it must be carefully planned to where and what type of picture has to be taken. Mapping important information such as longitude, latitude, and the address where the potential fault line is located must have been conducted beforehand.

After gathering all the necessary data and information on fault lines in Region XI, these will be stored in the database in order for the user to access those data. For the final output of the study, an android application for mobile phones was created.

In creating the software, Global Positioning System (GPS) is one of the things to be considered. GPS can save a tracklog, such as Garmin Eterex (compact GPS device), along with software like Google's free GPicSync (software used to download a geocode pictures from your camera and a GPS tracklog) which can combine the tracklog and photo timestamps to create the geotags automatically. Geotag software is an open-source that can be modified.

All created maps on ArcGIS Desktop were saved in a web portal, which can be viewed using ArcGIS Online, enhancements, and animations of the map will be executed. Once the creation of the map is done, it will be available once the map is published online. The process is shown in Figure 6.

Google Earth Map

Through the mobile application, the user can access the information uploaded in the database. Users would need a GPS enabled phone and internet connection for them to tag the specific location of the fault.

3. RESULTS AND DISCUSSIONS

3.1 Android Application

In Figure 7, the main menu is the first page that the users will see. It is crucial to keep it minimal and intuitive. The user should know how to use the application without any manuals or guides; thus, the main menu will be a vital part of the experience. Bright colors with a dark background are used on this page. Minimal icon design and text give the user enough information to understand what each button does without creating distractions and confusion. Each page was assigned a color that corresponds to a button in the main menu, a technique done to create continuity and familiarity on each page transition. All the resources are modeled with a 1920 x 1080 resolution and exported with a .PNG extension for android studio layout.
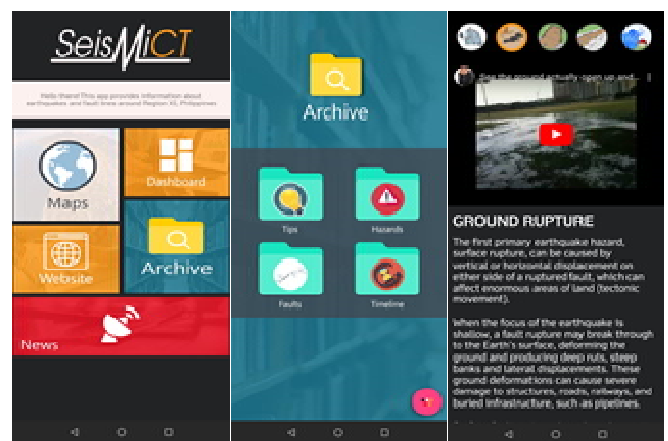

Figure 7: Main Menu, Archive and Hazard

All the exported images are then saved in the drawable folder in the project directory. At the same time, the icons are saved in the mipmap folder. The layout from the Adobe XD will then be redone in the android studio; this time, it is hardcoded. The layout is done first to make the testing and coding of the functions much more comfortable. Java language was used to code the functions, and two to three

pages are coded at the same time to check the right interactions and outputs. Pages are tested every time a segment is done. Multiple function tests are conducted before proceeding to the next segment of the page. When everything was coded, and tests are successful, the app will now proceed in the building process. This is done to test it further with other devices with different resolutions. Then the app is finally built for release, and a signature key is provided to follow the guidelines of the Google Play Store.

3.2 Maps of Fault lines

The application, template, and design of the Graphical User Interface (GUI) were made using Android Studio, an application that best suits upon creating an android application. The actual mapping of fault lines was made using Google earth and improved its design using arcgis.com. With the help of the Philippine Institute of Volcanology and Seismology (PHIVOLCS), this paper can track the exact location of fault lines in the Region XI.

Figure 8 shows the actual image of the fault lines being displayed in the android application. Arcgis.com was the working database were the filtered map was fetched. From the database, the map was embedded in the application, to easily track any possible errors.
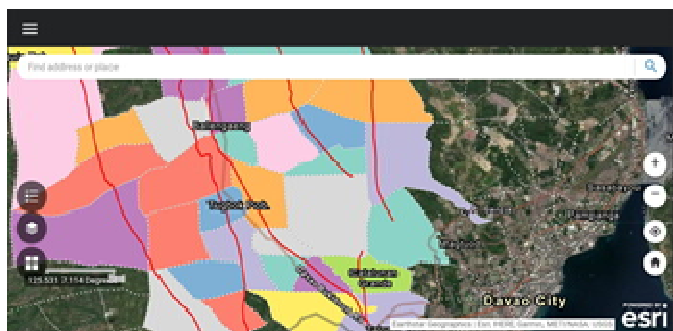

Figure 8: Mapping of Fault lines and Barangays affected

This study used Google earth and the data given by PHIVOLCS to identify the barangays that lies on the Fault line in Region XI, shown in Figure 9. Coordinates gathered in each Barangay were processed by converting the KML file created through Google Earth Pro Desktop to Geojson file. The fault line coordinates of 14 out of 205 affected barangays in Davao Region is shown in Table 1.
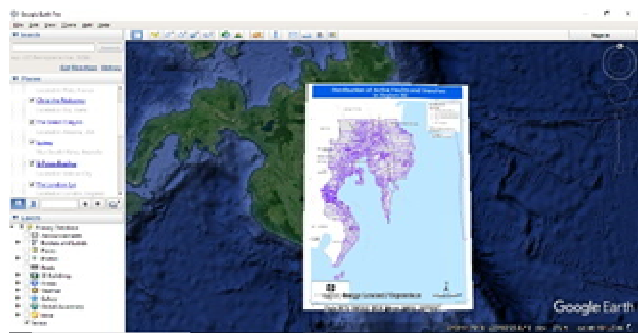

Figure 9: Shape file of Barangays in Region 11

TABLE 1: Sample Barangays affected with fault lines

Barangay	Longitude	Latitude
San Isidro	125.242459	6.470282256
San Pedro	125.4447016	6.441721875
Buca	125.4873957	6.449127439
Kinilidan	125.4658075	6.431830201
Pinalpalan	125.4965658	6.423778658
Demoloc	125.3371872	6.367092508
Dahican	126.2771065	6.936135727
Waan	125.5557774	7.123285197
Tamugan	125.3130221	7.215791799
Riverside	125.4669094	7.169553054
Las Arenas	126.1577257	7.217195391
Araibo	126.2336537	7.263611888
Mapawa	126.1832473	7.31608766
Bahi	126.2596559	7.317346788

3.3 SeismiCT Real-time Dashboard

The name of the mobile app is SeismiCT, as this relates to the frequency of earthquakes occurring in a particular place. Recent earthquakes were captured using the SeismiCT application and filtered, so that only felt earthquakes would appear in the dashboard. An example of an earthquake felt last February 20, 2020, which was also broadcasted via SMS, is shown in Figure 10.
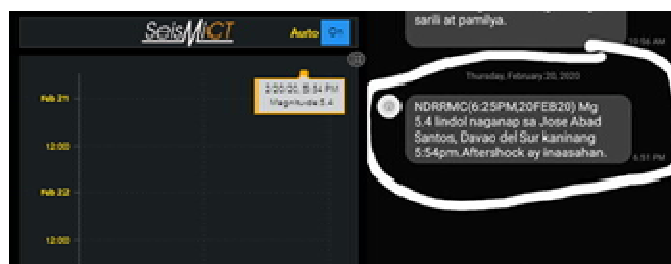

Figure 10: SeismiCT dashboard and NDRRMC alert SMS

3.4 Infographics

This paper aimed to give awareness to people about fault lines and earthquakes. The application indicated all the necessary information users need to know. The application also allows the user to become more updated to the earthquake for its news feature. News about an earthquake in the entire Philippines was fetched from different news sites and was embedded in the application. Features like the types of hazards, the timeline of Philippine earthquake history, and the names of the earthquake were also compiled to raise earthquake awareness among the app users. The said information is shown in Figure 11.

Figure 11: Earthquake and Fault lines infographics

3.4 Adding a Fault line tags

Adding a tag is the key to make the application interactive to the user. A feature like this allows the study to maximize its usage. Users with concern can add tags to a specific location with a potential fault line, but that does not mean tags will automatically display; instead, the user will use its Google account as a way to request a tag. The requested tag will be reviewed accordingly and, if proven, will allow displaying the newly added fault line.

Procedures are being displayed upon using the interactive feature of the application to avoid confusion. Observing from Figure 12, users are only allowed to add tags with their Google account only. Pictures must already be saved to Google Drive. By doing so, requesting a potential fault line tag comes directly into place. The system admin will verify the requested tags by referring it to the government authorities who are experts on this matter.
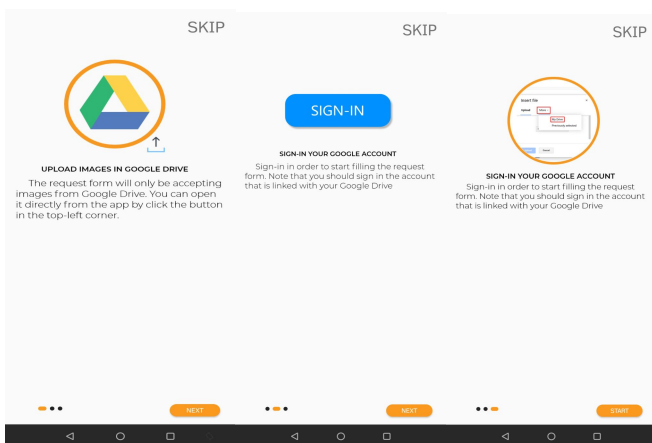

Figure 12: Procedure to request an add tag

3.4 User Acceptability Test Results

The developed mobile application was tested and evaluated for user acceptance using google form. As reflected in Table 2, the overall outcome of the usability testing resulted in a remark of highly acceptable.

TABLE 2: User Acceptability Survey

Criteria	Mean	Remarks
The navigation system is easy to use	4.44	Highly acceptable
User-friendly and intuitive.	4.56	Highly acceptable
Interesting and appealing.	4.38	Highly acceptable
The animation had appropriate lengths	4.56	Highly acceptable
The animated sections are entertaining.	4.38	Highly acceptable
The content is easy to understand without the help of the developer.	4.44	Highly acceptable
There is no feeling of lack of information	4.06	Highly acceptable
The pace in which the content of the application was delivered was adequate	4.13	Highly acceptable

4. CONCLUSIONS

With the use of ArcGIS, Google Earth Map, and geotagging technologies, a mobile android application called SeismiCT was developed. Datasets from PHIVOLCS and USGS were used to arrive at accurate geotagging of fault lines. A User Acceptability Test was conducted and generated a 'highly acceptable' result. The developed android app is now available and downloadable in the Google Play Store.

REFERENCES

1. Hansun, S. (2020). **Natural disaster risk prediction in Indonesia: H-WEMA approach**. *International Journal of Advanced Trends in Computer Science and Engineering*, 9(2), 1526-1530. doi:10.30534/ijatcse/2020/94922020.
2. R. Edelani, A. R. Barakbah, T. Harsono and A. Sudarsono, "**Association analysis of earthquake distribution in Indonesia for spatial risk mapping,**" 2017 International Electronics Symposium on Knowledge Creation and Intelligent Computing (IES-KCIC), Surabaya, 2017, pp. 231-238.
3. C. Li and X. Liu, "**An improved PSO-BP neural network and its application to earthquake prediction,**" 2016 Chinese Control and Decision Conference (CCDC), Yinchuan, 2016, pp. 3434-3438.
4. Leetaru, K. H., **Fulltext Geocoding Versus Spatial Metadata for Large Text Archives: Towards a Geographically Enriched Wikipedia**. D-Lib Magazine, (2014).

5. Abhijeet S (2016) **Geotag and its applications in driving public health programme performance**. J,ournal of Health Educcation Research & Development 4: 46.

6. **DA-PRDP introduces geotagging for project monitoring to CSOs**. (2015, October 5). Retrieved from https://prdp.da.gov.ph/da-prdp-introduces-geotagging-for-project-monitoring-to-csos/

7. Sinha, Abhijeet P & Syed, Sarfaraz. (2016). **The Use of Mobile Geotag Technology in Driving Project Performance at Scale**. Journal of Health Education Research & Development. 04. 10.4172/2380-5439.1000197.

8. Kevin Hufnagle, **Designing and Developing a Travel-Based Android** Application (2014).

9. J. Choi and X. Li, "**The 2014 ICSI/TU Delft Location Estimation System.**" (2014).

10. Da.gov.ph. (2015, June 25). **Geotagging recognized as an effective transparency tool for government projects**. Retrieved from https://digitalcommons.wpi.edu/cgi/viewcontent.cgi?article=2274&context=mqp-all

11. Sayal, R., Subbalakhmi, C., & Saini, H. (2020). **Mobile app accessibility for visually impaired**. *International Journal of Advanced Trends in Computer Science and Engineering*, 9(1), 182-185. doi:10.30534/ijatcse/2020/27912020

12. Kordopatis-Zilos, Giorgos & Papadopoulos, Symeon & Kompatsiaris, Ioannis. (2016). **In-depth Exploration of Geotagging Performance using Sampling Strategies on YFCC100M**. 3-10. 10.1145/2983554.2983558.

13. Cao, Jiewei & Huang, Zi & Yang, Yang. (2015). **Spatial-aware Multimodal Location Estimation for Social Images**. 119-128. 10.1145/2733373.2806249.

14. Kordopatis-Zilos, Giorgos & Papadopoulos, Symeon & Kompatsiaris, Ioannis. (2017). **Geotagging Text Content With Language Models and Feature Mining**. Proceedings of the IEEE. PP. 1-16. 10.1109/JPROC.2017.2688799.

15. Liu, G. Q., Zhang, Y. J., Fu, Y. M., & Liu, Y. (2014). **Behavior identification based on geotagged photo data set**. TheScientificWorldJournal, 2014, 616030. doi:10.1155/2014/616030

16. Kyunghyun Min, Jungseok Lee, Kiyun Yu, Jiyoung Kim, **Geotagging Location Information Extracted from Unstructured Data** (2018).

17. K. Oku, K. Ueno and F. Hattori, "**Mapping Geotagged Tweets to Tourist Spots for Recommender Systems**," 2014 IIAI 3rd International Conference on Advanced Applied Informatics, Kitakyushu, 2014, pp. 789-794.

18. E. J. G. Galupino, L. E. O. Garciano, M. C. R. Paringit and J. R. Dungca, "**Location based prioritization of surigao municipalities using Probabilistic Seismic Hazard Analysis (PSHA) and Geographic Information Systems (GIS),**" 2017IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), Manila, 2017, pp. 1-7.

19. Alado, D. B., Plata, I. T., & Bartolome, B. B. (2019). **The development of the geographical information system (gis)-based mapping of infectious diseases using spatial data analysis**. *International Journal of Advanced Trends in Computer Science and Engineering*, 8(6), 3577-3583. doi:10.30534/ijatcse/2019/140862019

20. Robert D. Arcayena, Alessis D. Ballarta, Kendall N. Claros, and Rodrigo S. Pangantihon. 2019. **Development of Arduino Microcontroller-based Safety Monitoring Prototype in the Hard Hat**. *In Proceedings of the 2019 6th International Conference on Bioinformatics Research and Applications (ICBRA '19).* Association for Computing Machinery, New York, NY, USA, 119–124. DOI:https://doi.org/10.1145/3383783.3383790