

Disaster Relief in Laguna: A Geographical Information System Through Crowdsourcing on Facebook

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Abstract—In the Philippines, disasters happen unexpectedly. A need for better and faster reporting to the government and to the people concerned is high. Social media makes information widespread by providing tools that lets people easily share information to the public. Statistics show that Filipinos use Facebook as their main social networking site. Given the problem and the technology, an application is created to fulfill the need for a coordinated system during disasters. The application combines the power of Google Maps, Facebook, and the concept of Crowdsourcing.

I. INTRODUCTION

A. Background of the study

The Philippines, an archipelago consisting of 7,100 islands, is considered to be a disaster-prone country because of its geographic location. Situated along the western part of the Pacific Ring of Fire, the country is surrounded by volcanoes and earthquake generators. Mount Pinatubo, a dormant volcano, shocked the country when it erupted in 1990 and caused a devastating state to the country. The Philippines also lies in the path of turbulent typhoons. Considering the archipelagic nature of the country and other problems in the country like deforestation, improper waste management, and other developmental factors, flooding is intensified and causes more trouble. Like when Ondoy struck the country last 2009, the storm dumped heavy rains which in turn caused landslide and sent floods and muds across Metro Manila and mostly parts of Luzon. Ondoy brought loss of millions of dollars in properties and affected the daily lives of Filipinos due to the unsettled floods which lasted for more than a month [?] [?] [?]. Aside from natural calamities, there are also human-initiated disasters like sudden fires in the city caused by careless individuals. Most of these fires happen among squatter areas where the houses are attached to each other, exaggerating the fire even more.

In the past, news about these disasters is spread out through television, newspaper, and radio. Since the evolution of internet, circulation of news is increased. Furthermore, the development of social media sites made information propagation widespread. In contrast to the regular media where we can only read a news story written on a newspaper, listen to a report aired on the radio, or watch an important event shown

on television, social media allows us to do all of that with added abilities to communicate, share, connect and interact. Antony Mayfield (2008) categorized social media into seven kinds, namely, *social networks*, *blogs*, *wikis*, *podcasts*, *forums*, *content communities*, and *microblogging* [?]. A list of top social networking sites in the Philippines for the year 2010 is ranked and Facebook got the first place [?].

According to Gao, Barbier, and Goolsby (2011), "Social media has recently played a critical role in natural disasters as an information propagator that can be leveraged for disaster relief." One example is after the Haiti earthquake where people posted their personal experiences of the earthquake via Twitter, Flickr, Facebook, and Youtube. This benefited Red Cross which received US\$8 million in donations [?].

B. Statement of the Problem

Although the manner of social media propagation through simple posting may bring a positive impression on the disaster, it does not provide a coordinated system for disaster relief. It is hard to visualize the whole disaster or its severity only through reading random status or post. To address these coordination issues, crisis-management applications were developed in other countries. These applications use crisis maps to better grasp the situation by visualizing the data they gathered from social media.

There is a need for that kind of system here in the Philippines to aid the country during times of disasters.

C. Significance of the Study

Basically, this study creates a Geographic Information System (GIS), which is defined by ESRI as an information system that integrates hardware, software, and data to capture, manage, display, and analyze geographic information [?]. By developing a GIS for the country, which makes use of the crowdsourcing power of social media and the mapping applicability of Google Maps, it would locate disasters on the map and also plot resources urgently needed. Based on the visualizations on the map, organizations and volunteers can easily determine which areas are most affected. Government and NGOs can focus on these areas while the public can avoid these areas. Facilitation and expedition of resource distribution process will also be efficient and effective as the map will show resources which are most needed and in which area.

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In addition to that, the map could be beneficial to schools and universities for authorized users can mark areas on the map where classes are cancelled. Usually, these areas where classes will be cancelled is characterized by multiple markers which signify higher degree of impact of the disaster on that area.

Also, storing the state of the map during disasters and making it available for future reference can be used for predicting what might happen on the same time and day the following year. This way, the system can be used as a reference for disaster prevention.

More importantly, the map is open to everyone so sharing and coordination among them is easier.

D. Scope of the Study

The scope of the geographic location only focuses on Laguna and is limited to *fire, flood, storms, and earthquakes* as the disasters. The public is only allowed to view the map, while authorized users, which can be government officials, are also permitted to edit the map.

II. REVIEW OF LITERATURE

GIS provides a way to display geographically dependent data in an easily understandable visual setup. It relates information in a spatial perspective to establish a relationship for efficient planning and better decision making. The technology is already implemented in various applications such as resource management, urban planning, criminology, marketing, statistical analysis, disease surveillance and other fields.

A. GIS and SVG

In the University of the Philippines Los Baos (UPLB), various special problems were Geographic Information System. Magsinoś (2005) study entitled Information on the Philippines: A GIS Approach uses survey data from NSO and visualizes this data in a map through the use of Scalable Vector Graphics (SVG). SVG is used to create a map of the Philippines. The map is divided into provinces. The GIS map relates information through color rendering. The higher the frequency of a variable (e.g., family size, food), the deeper the color of the province would be. The map can also be zoomed in and zoomed out once an area or province is clicked. This system can be a useful tool in analyzing the data gathered from NSO [?].

Another Geographic Information System for the Philippines was created as special problem in UPLB. In 2006, Regunay implemented GIS-Based Municipal Land Use Planning and Management System. His study focused on Pateros Land Government Unit. To create the system, he gathered thematic maps from the municipality and collected secondary information of socio-economic and environmental characteristics of the study area. The maps that have electronic copies were administrative/political boundaries map, tax maps, and zoning maps while the secondary information include demography, housing, employment and income, business services, and other information. The attribute data was associated with spatial data to implement the system [?].

Aside from easy data organization and urban planning, GIS could also be used for resource management. A special problem entitled Philippine Protected Areas: An Online GIS-Based Database System was created for this purpose. The Philippine map was created through the use of SVG and each region on the map has a designated color. Every protected area saved on the database was linked to the map. Clicking on an area shows all the protected areas in that region and once a protected area is chosen, the province where it is located is highlighted on the map. Alongside with SVG, PHP, HTML, and MySQL were used in implementing the system (Villamor, 2006) [?].

In searching for tourist destinations, geographical data is more helpful than textual data. GIS provided solution to that. In 2006, Launio and Flores created GISPansol: An Online Geographic Information System of Brgy. Pansol in Locating Resort. It served as their undergraduate special problem. It is a browser-based GIS application that creates a digital map for Pansol using SVG and locates resorts found in that barangay. It is created with HTML, PHP, JavaScript, and MySQL [?].

Maps are essential in GIS because it is where you put the geographically referenced information you collected and stored in a database. GIS map locations, quantities, densities, specific areas, and change in an area [?]. By mapping location, patterns can emerge through the distribution and concentration of features instead of just an individual feature. In mapping quantities, identifying where the most and least quantity is easy. In the past, SVG was used to create a map but it is limited since locations are only estimated. Google Maps, a web mapping application, emerged to solve this problem. Its API allows for embedding the map to any website, adding content to the map, and manipulating the map to accommodate different services like in real-estate research, environmental planning, or restaurant reservations. Google Maps is continually growing with over 150,000 websites already using it [?].

B. GIS and Google Maps

There are several undergraduate special problems in University of the Philippines Los Baos that used Google Maps as a platform. Campos (2008) developed an Online Interactive Map of Muntinlupa City. It showcases the cities establishments through the interactive map where it displays path between two establishments, allows for the search of establishments, and shows nearby establishments given a radius. MySQL is the database used for this study and implemented through PHP and AJAX [?].

In 2011, Fontanilla developed a GIS entitled A Collaborative User-Generated Geospatial Database for Socio-Economic Data Distribution Analysis using gathered census data and Google Maps. Instead of manually mapping socio-economic data distributions, this system speeds up the visualization on a geographical space using current web technologies. There are two users of the system, the encoders and the analysts. Encoders populated the database with socio-economic data, and based on that data; the system can then generate different data distribution visualizations (pins are marked on the map to show this distribution). Some of those generated distributions

pertains to distribution of residences which earn at least P300,000 per year, which has greater than or equal to five children members, or which breadwinners are fishermen with gross income greater than or equal to P100,000. In comparison with Magsino's system, Fontanilla's system is more reliable because it used current web technologies (e.g., Google Maps). Also, the system generates multiple data distribution visualization compared to Magsino's which relates only one variable at a time on the map [?] [?].

In that same year, Pages implemented an Online Navigation of Philippine Real Estate Properties to be included in Philrealty-Showroom.com. This uses Google Maps search feature to search for real estate properties included in the sites database. Customized Markers were used, having unique markers for different properties. Also, there is System Administrator Control Center where the administrator can edit or add properties, or consider it Sold Out. A mini-feature was added in the Control Center, where administrators can drag the marker to the estimated location of a property, which automatically detects coordinates then stores it in the database. It was created using the Draggable Markers feature of Google Maps API [?].

C. Crowdsourcing

Information to be mapped for the GIS can be crowd sourced from social media sites. Crowdsourcing is simply gathering data from a broad community. This community is what you call the crowd, which in this case, is Facebook. Facebook Developers made available the entire core of Facebook Platform technologies by allowing the public to use their API. It also provided a way where applications can be integrated with Facebook [?].

One undergraduate special problem in UPLB made use of the Facebook Platform by integrating uplbstreetjazz website with Facebook. It used PHP SDK and JavaScript SDK to initialize the application which can be found in the Facebook Developers site (Baraquio, 2011) [?].

1) *GIS for Disaster Management*: GIS can be implemented to address different needs. One of that needs is disaster management, which are becoming prevalent because of various disasters that are happening. It is developed to lessen the costs of disasters, if not avoid. It can be used as a decision support system that will help in resource distribution and prioritize areas urgently needing these resources. Due to Hurricanes Katrina and Rita which hit the coasts of Louisiana, Mississippi, and Alabama in August 2005, Hurricane Information Maps (scipionus.com) was created. The site presents the map with status of specific locations affected by the hurricanes. People can contribute by adding new locations and their attribute information to update information on the map [?] [?].

Most of the GIS developed nowadays crowd source data from social media because it is the source of immediate information during disasters. Ushahidi (www.ushahidi.com) is an open source crisis map platform, created in 2007, which adopts crowdsourcing and integrates data from multiple sources such as Facebook and Twitter, to create a crisis map that is in turn available and of great use to relief organizations. There are

three advantages of crowdsourcing for disaster relief. First, it can collect data immediately after a disaster since people use social media to instantly update information regarding the disaster. Second, crowd sourced data can be analyzed to produce tag clouds which reflect most frequently requested resources (such as food, medicines, or shelter). Third, geo-tag information can be included in some platform such as twitter to accurately locate specific areas where help is need. More importantly, visualizing the data on a crisis map can help organizations easily assert the situations and coordinate with each other using information visualized on the map [?].

Here in the Philippines, a Geographic Information System for Disaster Management was created during Typhoon Ketsana (Ondoy). It documented road conditions, donation centers, situation map, and missing persons where markers are unique for each attribute. It included a form that anyone can fill out to report any incident and updates regarding the typhoon. The information is then placed on the map. The site uses Google Maps. By clicking on the specific (e.g., missing persons, road condition) pin on the map, information contained in that area will show [?].

Based on the related studies that were shown, it is possible to create a GIS for the Philippines that can help in disaster management in the country.

III. OBJECTIVES OF THE STUDY

The general objective of this study is to provide for easy coordination among relief organizations by visualizing data in a map gathered from social media. It specifically aims to:

- 1) Collect disaster information (e.g., location, description, name) from social media (Facebook) and save it to the database, only to include those within the scope of Laguna;
- 2) Post the disaster's information to the wall of the user;
- 3) Allow sharing of the application to user's friends;
- 4) Show recently added disasters within the time frame of two days;
- 5) Retrieve disaster information that happened on a certain day with a certain type (e.g., floods that happened during 09/25/10); and
- 6) Permit authorized users to drag or delete markers.

IV. METHODOLOGY

A. System Specifications

The system was integrated to Facebook and made to be a qualified Facebook application by obtaining a secure url (https). It was hosted by Oh Rainbow Hosting which uses cPanel. It runs on its own web server, cpsrvd 11.30.2.1, that supports MySQL client version 5.0.92, PHP 5.3.6, and phpMyAdmin 3.4.3.2. It used Core FTP LE version 2.2 to transfer files from localhost to the server. It was built using CodeIgniter framework [?]. HTML, JavaScript, JQuery, CSS, CSS3, and PHP were used in implementing the system.

B. System Design

Before the system was implemented, a simple system design helped to model the specifications of the system. An Entity Relationship Diagram (ERD) was created to show the entities and relationships between the entities within a database. It was used as a guide in creating the tables of the database.

Following that ERD, a database in localhost was created and was exported to the server. A form was designed to collect information from the user and any information supplied was validated using Form Validation class of CodeIgniter before successfully inserting the data into the database. Also, the location supplied was geocoded first by Google Maps API to make sure that the data entered by the user is valid.

The front-end design for the application is kept minimal so that users will not feel so foreign when visiting the application. A Wireframe was sketched using Cacao [?] to layout the whole site. It served as the blueprint or the basis during the coding stage of the design. Using wireframes, it was easier to determine the flow of the whole site as you can create various wireframes for different pages of the site.

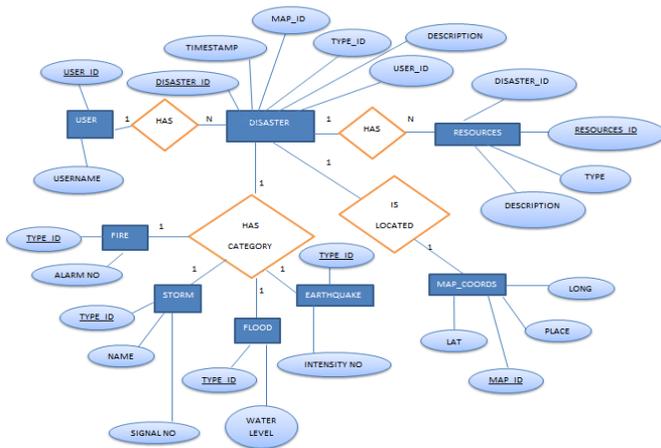


Fig. 1. The ERD for the reports to the system

C. Facebook Application

To gather data from Facebook users, a website was made which was integrated to Facebook. Facebook now imposes that your application uses a secure url (https) before letting users continue to your application, so a secure url was first acquired. The site was loaded in the context of Facebook or what they refer to as the Canvas Page, which is basically an iframe on the page. The application's canvas width was set to fixed width of 760px and height was set to a fluid value. `FB.Canvas.setAutoResize()` to dynamically resize the Canvas page to the contents of the site. Facebook improves their APIs and other developer tools over time so there are some migrations or altered settings that developers should take. One is the Enhanced Auth Dialog or the dialog that is shown to users for authentication. It was enabled for this application. Facebook offers a lot of development environment to choose from and among those, the Javascript SDK was used. It can access the Dialogs features of Facebook which displays

dialogs and requires interaction by the user. Core methods and Auth methods of Javascript SDK was used. First of all, the SDK was loaded. Right after that, a call to the `FB.init` method was made for initialization, where parameters are supplied. Any method should be called after `FB.init`. To check if the user already authenticated the application, `FB.getLoginStatus` was fired. Other method used was the `FB.ui` which was used to post as status the information entered by the user. Also, this method was used to let users share the application to their friends by giving out application requests.

D. Google Maps

The database was linked to Google Maps to generate visual distributions on the map. The Google Maps Javascript API V3 was used which is available in the Google Maps API family site. Google Maps provide very good documentation which are very straightforward and provides good examples. Also, there are lots of tutorials on the Web which are easy to understand and implement.

1) Geocoding and Reverse Geocoding

It is assumed that the locations inputted by the user would not be the exact latitude and longitude coordinates of the place but the address of the place. However, to plot the place in the map, those coordinates are needed. Google Maps provided a way to convert the address string to geographic coordinates which is the latitude and longitude pair. That process of converting is called Geocoding. Using the Geocoding API, the address entered by the user was geocoded first before inserting into the database. It would be faster that way since coordinates need not be geocoded every time the user wants to view the map, but they are just retrieved from the database. In the Draggable markers, where the markers are dragged in the map, the values retrieved are coordinates so in that case, instead of Geocoding, Reverse Geocoding was used. It converts the LatLng coordinates to valid address and the result is saved in the database, as for the purpose of storing the place for reference and for users to easily comprehend.

2) Creating the Map - Initialize Map, Generate XML, Pin Markers

The first step done was the initialization of the map. It used a fix center (latitude, longitude coordinates) and it is where the map will first project. It is set to a fixed width and height. Also, specific map options are specified like the zoom value, and the map type. The information from the application was saved on the server's database. There are ways to plot this information to the map using plain PHP and JavaScript but using XML file can be more flexible to the application. The contents of the database was converted to XML format using PHP. To dynamically change the markers shown, the XML generated should also be dynamic. This is done by passing user request to a controller then querying the database, through a model, with that specific request. The results are then concatenated following an XML format which was echoed to a view. The data in the

view was parsed to generate the corresponding markers. Markers will be positioned using the retrieved coordinates and map bounds will be adjusted correspondingly.

3) Customizing the Markers and Info Windows

Every item in the XML equals one marker on the map. The XML could contain any or all of the information stored in the database regarding the disaster. These data were displayed in an InfoWindow (overlay that is like a speech bubble). These InfoWindows show whenever Events are fired. Events that are listened to by the markers in this application are click, dblclick, and mouseup. Generating only uniform type of markers are not that appealing so markers were customized to suite or differentiate the type of disaster and the type of markers (for disaster or for class suspension).

In general, the system gathers information from the Facebook application, save it to the servers database, integrate it to Google Maps, open the map to public, and allow them to easily visualize the disaster for better coordination of the action to be taken.

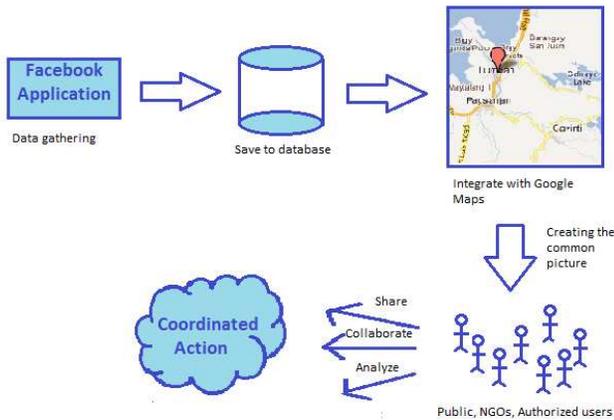


Fig. 2. Flow of the system

V. RESULTS AND DISCUSSION

The Facebook application can be accessed through <http://apps.facebook.com/lagunacrisismap>. The first stage that the first-time users will see is a Dialog asking for authentication as with all Facebook application. If the user choose to cancel it, it will just go back to Facebook homepage. Else, it will continue to the second part of the dialog which is asking for Extended Permissions. After that, the user will be brought to the application's homepage which is automatically the form where he/she will input the disaster. The information to be supplied are the type of disaster, the description, location (street, city, and province), resources needed (optional) and other information specific to a certain type of disaster (fire alarm, name of storm, water level, or intensity number). When the user clicks submit, there will be a Feed Dialog asking the user if he/she wants to post that information to his/her wall.

The navigation includes the Home, Timeline, Admin, and Share. The homepage is where the user reports disaster. In

the Timeline is where the user can view past disasters. The Admin requires login in which authorized users are allowed to make some changes to the map. Last is Share which invokes a Requests Dialog, giving the user the option to request for the User's friends to use the application. It also includes a special Latest button which shows recent disasters that were submitted and classes that were suspended.

A. Types of Users

There are two types of user: the Reporter, and the Official (school or government official). Both can post status regarding a disaster and view the map. The Official can edit the map to add additional markers for class suspension or to delete markers which seems suspicious. The Official should login first before being able to do its functions. A problem that was encountered was how will posts be validated if it comes from a reliable source. A solution implemented was to grant this Verify function to the Official where he/she can delete markers which seems suspicious. Of course, verification is difficult when too much data needs to be filtered.

B. System Functions

1) View Map

The crisis map was embedded in the website so anyone who accesses the Facebook application will be able to see the map. The application has a Timeline feature which sorts data by type and date, and let the users select a type, year, month, and day from the drop-down lists and shows the map with markers based on the requested data. Every report submitted by the user is automatically added in the Timeline to provide users the ability to immediately see the disaster reported or view disasters added long time ago. Recent disasters are also prioritized so there is a specific page for that which shows markers within the time frame of 2 days. Along with the recent disasters is a tag cloud, which displays the resources needed and which varies in size according to which is needed the most. Also, the map can be viewed showing markers of places where classes are suspended.

2) Edit Map

The Official has two roles – to suspend or to verify. If the Official chose to suspend, he/she will be able to drag a marker to where classes will be cancelled. This was implemented by setting the draggable property of markers to true. These markers can also be deleted by the Official. When the official submits the map with markers positioned in no classes, those markers will change color and can not be dragged anymore. Also, if the Official placed the marker on a position where reverse geocoding was unsuccessful, a prompt will show telling the Official to position the marker again. This way, no invalid places will be added to the list of suspended areas.

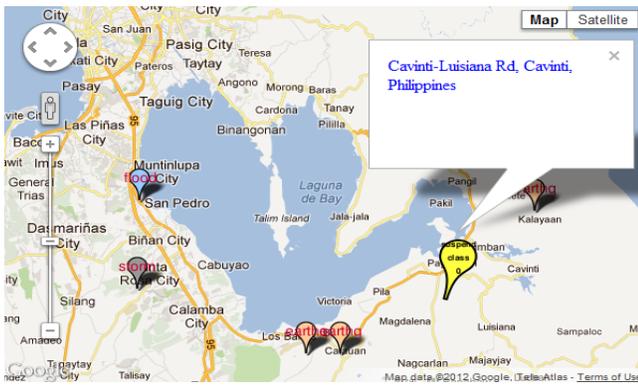


Fig. 3. Sample generated data distribution

me up, for extending a helping hand when I'm about to give up, and simply for always being there. To my bestfriend, who's ever willing to help me with my hosting needs. To my friends who have been with me through this roller coaster ride of college life, thank you people. Also thanks to my adviser, for giving out helpful tips, guiding us throughout the proposal until the final presentation, and being strict with deadlines.

VI. CONCLUSION

The application was successful in collecting disaster information from Facebook and for generating the map based on the disaster. It was able to provide different data distributions according to the Timeline, No Classes, and Recent disasters specification. Along with it, customized markers were used to effectively determine and distinguish the information presented on the map, and InfoWindows were created to show descriptions of disasters in each of the markers. Also, the map can be edited to cater more functions like the suspension of classes and verification of posts. Posting to user's wall and sharing the application to friends is a useful tool in Crowdsourcing, giving more publicity to the application and the chance to be used by many.

Crowdsourcing through social media is a useful tool in gathering data since almost everyone have access to the Internet and can supply information wherever they may be. Although it is hard to verify information if crowdsourcing is used in applications, having a greater number of people to provide for valid input compromises the fact that a single information might not be reliable.

VII. FUTURE WORKS

The application could be improved by providing a way to verify user's posts. It should also check if the place entered by the user is already in the database. Instead of pinning too many markers, the InfoWindow of the marker having the same location should accommodate the updates. Also, the app could be developed in Mobile (iOS or Android) to make the application more usable. This way, it will be easier for the users to access the app and also it can make use of GPS in mobile to automatically identify the location of the user.

VIII. ACKNOWLEDGMENT

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