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Road Re-Routing System Framework Using Adaptive Systems For Mt. Mayon Danger Zones In Albay

Vince Angelo E. Naz [1], Thelma D. Palaoag [2], Guillermo Jr. V. Red [3]

1 Computer Studies Department Bicol University, Legazpi City, Philippines.
2 University of the Cordilleras, Baguio City, Philippines.
3 Computer Studies Department, Bicol University, Legazpi City, Philippines.
Email: vaenaz@bicol-u.edu.ph, tpalaoag@gmail.com, gjvred@bicol-u.edu.ph
Orchid Id number: 10009-0007-5105-9378, 20000-0002-5474-7260, 3 0000-0001-8060-5875
Corresponding Author: Vince Angelo E. Naz.*

Mt. Mayon, being an active volcano has histories in causing devastation and volcanic hazards in the roads of the province. This led to the indications of danger zones and areas of the province that vary depending on how close the area is to the volcano. These areas are towns and cities that are interconnected with numerous roads and highways to provide vehicular transportation. However, with the recent active activity of the volcano, vehicles travelling in the 6km danger zones are at risk in the dangers of volcanic hazards that can occur in the roads. The research aims to create a road rerouting system framework in assessing alternative routes in areas within the danger zone and the integration of adaptive systems for the framework to find the fastest and capable routes that depends on the capability and status of the vehicle. The development of the framework identified the map data of the danger zones, routes and the type of vehicles that are common for traveling. Mapping data roads is given by the integration of the google mapping API to provide the road routes. The framework used the model-view controller architecture and the adaptive system concept to create the model to evaluate and learn vehicle status and capability in identifying the best route for the vehicle to travel safely avoiding away from the danger zones in the Albay province. The designed framework presents a viable concept in assessing the best routes in safely traveling through danger zones while avoiding volcanic hazardous roads.

KEYWORDS: Adaptive System, Re-Routing, Road, Framework, Volcano, Danger Zones.

Introduction

Road mapping and routing is a system used by various devices and applications that provides map data of roads, paths, highways and routes. This system allows the integration of global positioning satellites to pinpoint the location of vehicles then show the available routes to the drivers. Routes are shown in various map types that can be used to further understand the distance, terrain, and traffic in the roads. These maps are ideal in creating frameworks and structures for the development of road plans and strategies in tackling problems in the road. In a study of Liu,Wang and Zhang, discusses the use of high definition mapping for the support of automated driving in which HD maps have a high potential in advancing this technology[3]. HD map structures provide a better detailed overview of roads providing more functionalities and accurate data. A detailed map data can provide clear terrain information on routes and routes present in the volcano's vicinity to which data on off roads, narrow paths, shortcuts and elevation are needed to be determined in the areas. Pertaining to this, another study conducted by Dotel, Shrestha, Bhusal Et al discussed deep learning techniques in assessing disasters on impacted regions [4]. Using satellite imagery, it can identify the affected areas and roads in a topographical imagery in which deep learning is used to identify specific areas to be assessed in case of disasters. With this, identification of affected roads is assessed effectively and accurately on maps. Identification of hazardous roads in form of mapping decreases the fatality and gives the predictability in avoiding such disasters as found on the study of Pachal and Shrivastava [5]. Preparing a hazardous area mapped area of the perimeter for the roads gives more planning and effective ways in approaching disasters with safer procedures. To overcome road disasters in a hazardous area, like for instance the 6kilometer danger zone of the Mayon volcano, map data of the vicinity and the integration of planned approaches are needed. Google maps is integrated to the system framework to assess the data collection of roads and paths in the province of Albay. A study conducted by Derrow-Pinion Et al demonstrated that with the use of graph neural networks through the web map services like google maps [6]. Integration of frameworks AI like graph neural networks can be applied and developed to google maps Api to further extent the use of the mapping feature of the system. Another study conducted by Abante determined risks hotspots and cold spots using google maps in the Albay province though hexagonal data binding [7]. These hotspots are defined as hazard areas in the province in which disasters are frequent in the area and are presented using google maps. Pertaining to this, the research gathered data on the danger-zone maps of the Albay province that is found in the vicinity of the Mayon Volcano using the integration of google map.

Although with these studies, road mapping and routing still lacks the capability in determining and assessing the roads and routes in an area of volcanic activity. Mayon volcano is an active volcano and volcanic activity like eruptions is a sudden occurrence in the danger zone of the province where in even with the provision of maps, vehicles have difficulties in finding alternative roads that are suited their capability. These alternative roads vary from smooth terrain to offroad rugged or damaged road that may pose threats to safety. To resolve this, the research created a system framework with adaptability capability.

Adaptive systems can change their roles or entities to suit and adapt to the changes in the environment. These systems can apply adaptability to suit the needs of an entity. An example of this is a study conducted by Hartman in applying complex adaptive systems for tourist destinations to better understand the perspectives [8]. This gives the idea that adaptive systems can apply analysis in determining the ideal changes for the system in different levels. This includes the capability in determining climate changes and disasters that happen in a location and predict and apply a change in the system to help in the assessment. Another study by Wang Et al suggested that climate change has been a frequent phenomenon in which transportation operations and infrastructure is vulnerable to risks [9]. To resolve these problems, planning reviews and adaptation strategies are performed to mitigate the risks. This concept is integrated to the adaptability of the research to plan out safer routes in occurrences of changes in the environment in the danger zones. This applies by determining strategical routes that can be faster and capable for most vehicles. These strategies also include adaptation of traffic rerouting to stabilize the flow of the vehicles that goes through. Risks also include in a situation where disaster arises, evacuation routes and roads are crowded with vehicles. The traffic creates problems of evacuation of vehicles in the danger zone. In a study of Tseng and Ferng, real-time traffic information provides a solution in minimizing traffic in areas [10]. This creates strategies for determining traffic on real-time perspective and efficient alternative roads and routes. Another study discussed by Ho Et al pertains to traffic rerouting by selection of vehicles in specific roads and routes to minimize traffics [11]. This concept provides a dynamic vehicle selection to classify and select vehicles to specific roads that are capable of travel and separates them from vehicles with different specifications. To apply this concept, the research used google maps API to provide the real time traffic flow of roads that is present in the Albay province. This also provides the system framework with the capability to determine the road maps, alternative, traffics and the type of road status for classifying vehicles that can pass through depending on their vehicle specification.

The use of this is to integrate the adaptive system into the research framework to determine the changes in the vicinity of the Mayon volcano danger zone and apply assessment in road routings to escape the 6-kilometer area. This assessment implies the identification of the vehicle ‘capability to approach roads that can easier and capable to the vehicle’s specification.

This research is to design a framework that gatherers map data and the road routes on the area of vicinity of the danger zone of the Mayon Volcano and integrate an intelligent adaptive system module to recommend passable roads and routes with safety and assurance of the vehicles capability to past though and evacuate in case volcanic disasters. The concept of the adaptive system in the framework is to provide the overview of the identification of roads and the terrain information around the 6-kilometer danger zone of Mt Mayon needed to determine the passable roads and paths in the area on certain conditions of the environment of the Mayon volcano. With the use of this framework the system provides the drivers with the capability to identify alternative routes suited for the vehicle to pass through and evacuate quickly in the 6-killometer danger-zone area of the Mayon Volcano. The research used an integration of google map API to provide the map data of the identified 6-killometer danger zone of the volcano.

Methodology

The research conducted interviews and surveys in determining and compiling the collected data samples needed to create the framework. These data consist of the map routing, danger zones heat maps and radius, volcanic road hazards and types of vehicles used to travel in the danger areas of the Albay province. Different factors are determined to identify the needs of the development of the framework and the structure of the adaptive intelligence module of the research.

The data collected results to this major 3 factors:

A. Danger Zone Area

The first factor concerned by the research is the areas with roads and highways that are within the affected range of the volcano. These areas are identified as danger-zone level locations where volcanic activities are present and pose danger in the vicinity.

The Province of Albay consists of 15 different municipalities/towns and cities. These areas are divided into sectors that surround the Mt Mayon volcano. With concern to the volcanic presence, the area around the volcano has been imposed with a 6km radius declared as the 6km danger zone that poses threats occurring within the range of the circle as seen on Fig 1. Situated in this 6km radius identifies 8 municipalities and cities that are within the range of the danger zone marker. The danger zone marker consists of 4 alert levels in which the higher the alert level of the area the nearer the area is to the volcano. Although this is declared as a disaster-prone perimeter it is still inhabited by people that thrive with businesses and structures. Municipalities identified in this area are namely Legazpi City, Daraga, Camalig, Sto Domingo, Guinobatan, Ligao, Tabaco and Malilipot.

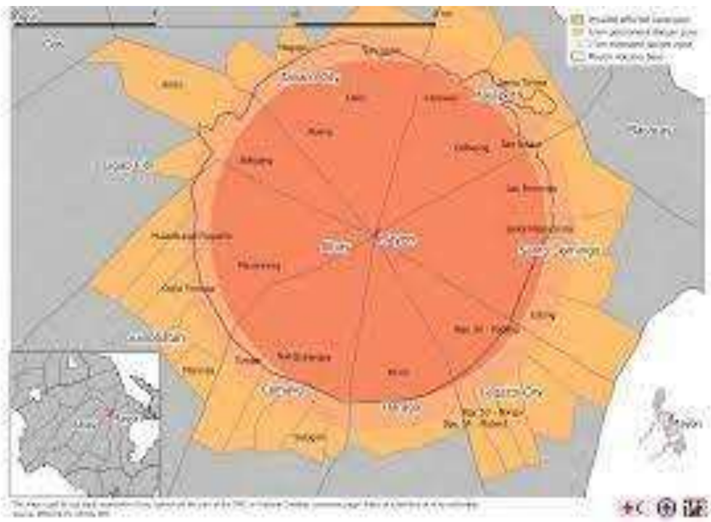

Fig. 1. 6-killometer danger zone of Mt Mayon
Source: Adapted from [12]

The municipalities identified consist of roads, routes and highways that are interconnected to travel between places but are also vulnerable to the hazards imposed by volcanic threats as this is situated on the 6-kilometer danger zone of Mt Mayon. These hazards are encountered by most drivers and vehicles which impose problems in traveling and safety. Based on the gathered data on figure 2, the municipality of Camalig has the most encountered road hazards. In this area, road hazards are a challenge to vehicles traveling as it has the most roads used that are within the danger zone interconnected to different municipalities in the Albay province. According to a study by Buot and Cardenas, the municipality of Camalig has one of the highest affected communities in the province. The area of Camalig is one of the places located close to the crater and almost entirely inside the 6-kilometer danger zone of the volcano's vicinity. Communities living in the area experienced numerous hazards from the volcano's climate and eruption. Hazards include lahar flows, floods, drought, ash falls and debris that are brought by the volcano, yet communities can continue to thrive. The hazards also cause problems on the roads and passageways that are used to travel in the area. The roads of Camalig interconnect to most municipalities that surround the volcano. According to the survey on figure 2, these hazards are the cause of the problems and risks in safety of drivers travelling in the danger zone where it focuses on the 8 municipalities. The intensity of road hazards where most drivers experience is around the Camalig municipality where the roads are within the 6kilometer danger zone and are commonly affected by the volcano's activity. The research focuses on these 8 municipalities' roads and routes where road intensity is frequently experienced.

Fig. 2. Road hazard intensity on the danger-zone of Albay

B. Vehicle Targets

The second factor consists of the data gathered on the concerned type vehicles that are being used to travel on the roads within the danger zones. As seen on Fig 3, 3 vehicles namely private vehicles, public vehicles and heavy machinery vehicles are identified. 49 percent of survey found that most of the vehicles commonly used are public transportation. These public transportation vehicles are identified as vehicles of the masses in which most of the people in the province use to travel in between municipalities. Public transportation road vehicles consist of buses, jeepneys, tricycles and cabs/ taxis that are found in the danger zone area to satisfy customer masses needs for travelling. Although this is common in the area, the specifications of each public vehicle must be to the standards proposed by the government and provide declared routes to ensure the safety of the passengers. This poses limited routes for rerouting due to the constraints of the standards imposed.

Private vehicles on the other hand are composed of privately owned vehicles that are issued to a registered individual. These vehicles specifications can be customized and upgraded by the owner to their own liking. Most of these vehicles can be driven onto any roads and routes in which they are versatile to any terrain in the danger zone regardless of the vehicles specifications to suit the terrain.

Heavy machinery are vehicles that have tough specifications which can mostly handle difficult terrain but are also limited to only specified roads and highways to be driven. These vehicles are mostly trucks and tractors carrying heavy things for construction and transportation of materials. With the sheer size and weight of this vehicles they mostly are vulnerable in case of volcanic activities on the danger zone due to their size and slow speed this poses difficulty in finding alternative routes that can suit the vehicles specification to evacuate the danger zone perimeter.

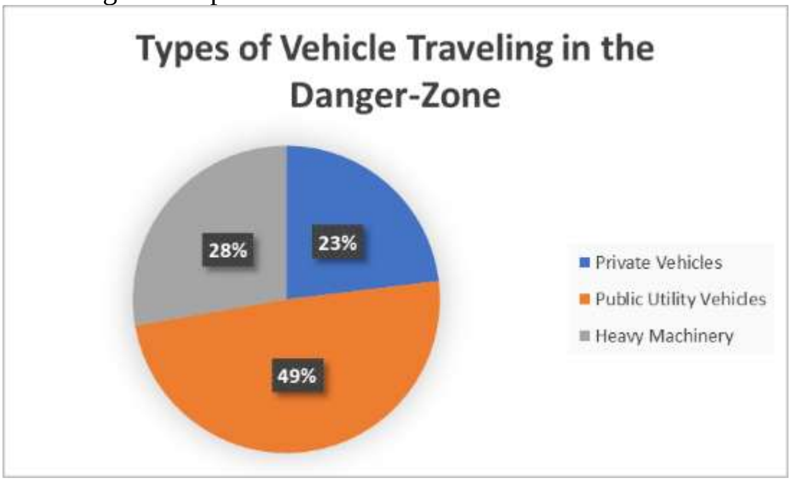

Fig. 3. Types of vehicles travelling in the danger-zone of Mt Mayon

C. Terrain Area

The third factor to consider is the terrain of the danger zone perimeter of Mt Mayon. Using google maps features the collected data on figure 4 shows the actual satellite map imagery of the terrain. The map data presents the main highway that surrounds the volcano and as well as pinned places within the area that are accessible by road transportation. This highlighted road identifies as the Asian highway in which it is used as the main road that interconnects the municipalities. The highway also consists of alternative roads and routes that can go into the inner perimeter of the Mayon volcano. Based on the terrain data of figure 4, most roads in the inner perimeter consist of high elevated lands that challenge vehicles to climb into hills and mountains to reach destinations in the inner areas of the volcano. Off-roads are also identified in the terrain map data, the green colored floor in the map indicates the forested area in the vicinity and the brown and black colored floors indicates rugged terrains that suggestively can accommodate off road suited vehicles to use these road routes.

Although even with the tough road terrain that are identified, numerous vehicles still use this route as they provide alternatives in escaping traffic, collecting and transporting materials, tourism traveling and exploring, civilian transportation etc.

Fig. 4. Terrain map data of the Mayon Volcano

In summary of the results, 3 factors should be considered for the requirements of framework architecture are: the danger zone area in the vicinity of the 6-kilometer hazard area of the volcano, the target vehicles that are commonly present and used on the roads and routes of the said danger zone, and lastly the road terrain map data that shows the type of roads that are present and used by vehicles.

The roads and routes within the danger zone places a vital role in the development of the province of Albay such that it provides the necessities in vehicular transportation in between municipalities even though they can pose risks and hazards to the vehicle and the safety of the drivers and the passengers. When volcanic activities happen, these roads in the danger zones are used to evacuate people away from the 6-kilometer perimeter. The need to identify alternative routes and by adapting to these volcanic activities can help vehicles navigate away from the 6-kilometer danger zone and evading hazardous roads to reduce the risks for the safety of travelling.

FRAMEWORK

The research used the model-view-controller architecture framework to integrate the data gathered factors. The architecture framework as seen on figure 5 organizes the factors into 3 parts namely the model which contains the database, the view where inputs and the interface of the system application, and lastly the controller that houses the algorithms and the intelligence module of the framework. According to the study of Syahputra, the model view controller architecture is effective in creating applications for mobile like web platforms [14]. This framework is used for websites mobile platforms that can be efficient in gathering data and creates interfaces that can be accessed through mobile devices via networks. Mobile devices allow the capability of accessing applications anywhere which is effective in applications that use GPS and API integrated systems. Another study conducted by Yin et al, used a framework that integrates autonomous navigation controller for agricultural vehicles. The concept of autonomous navigation from the study discusses a framework that can work with network integrated applications to help in gathering data for navigation of agricultural vehicles. In the development of the model view controller, their concept is applicable in which the model view controller framework is designed to be portable and usable for a mobile application platform in which it integrates data provision of drivers and their vehicles and provides road routing information around the danger zone of the Mt Mayon Volcano.

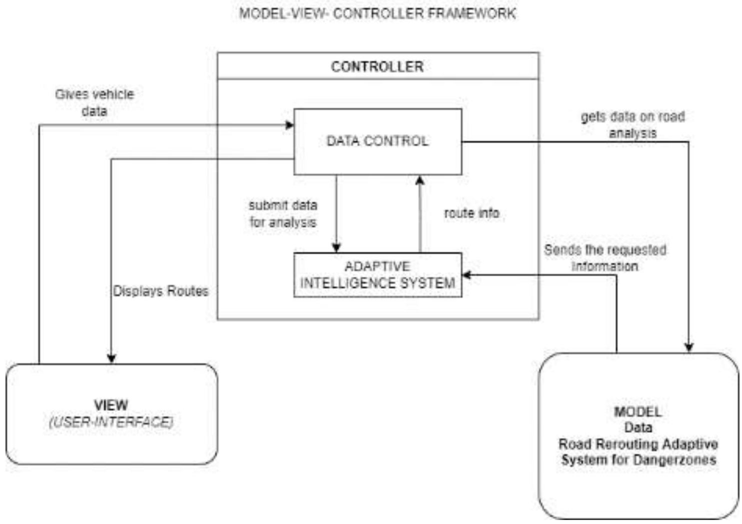

Fig. 5. MVC Framework for Road Damage awareness with adaptive system

MVC frame consists of the 3 parts where as indicated, the view consists of the user interface, the controller consists of the control of data and the adaptive system intelligence to integrate the intelligence of the framework, and lastly the model where the database of the road rerouting is integrated. Description of the parts as follows:

A. The View

The view is the interface of the MVC framework. This interface is presented to the users of the system where the data needed for the system is gathered then process the outputs for viewing and reports. The input consists of the location of the driver, vehicle specifications, and the current situations of the environment where the vehicle is present in the danger zone area of the volcano. Data gathering can be accomplished using mobile devices to transmit information automatically or manually by the drivers. The drivers can also input their preferred destinations for the system to analyze road routes and alternatives to help in navigating roads terrains to get out on the danger-zone area of the volcano.

B. The Model

The model defines the database and the storage of information gathered from the inputs of the view to be processed for outputs. This data stored consists of road data on routes, climate, terrain, volcanic status, drivers' information and vehicle status. Google Map API is integrated to the framework to provide the needed roads, pathways, routes and terrain in the danger zone area of the volcano. According to the study of Derrow-Pinion et al, the google map API can be used for the neural network intelligence in which this intelligence system is effective in travel time prediction on transportation [16]. Furthermore, in their study, the efficiency of the provision of google map API on mapping roads and routes is effective in the way of integrating neural network. The API can be used to efficiently gather map data on the roads and routes with can be stored in the model part of the framework. Using the API's capabilities the framework can gather and store the available road and routes with the terrain details on the implied danger zone area of the volcano. As the driver places the GPS location of the vehicle requests the system, the availability of the roads around the danger zone is collected in the database and is displayed to the view.

C. The Controller

The controller is the part of the MVC framework that controls the dataflow and process of the view and the model. This is the part of the framework where the data provision to the system has the intelligence to retrieve and process the data needed to be displayed to the users. As seen on figure 5 of the MVC framework, the controller is in between the view where the interface and inputs of the system is displayed and the model where the sources of stored data is found. The controller also houses the adaptive intelligence system module where the integration of the adaptive system controls the request of the drivers to locate their location on the area of the danger zone then processes to give the routes and alternative roads that can suit their vehicle to travel safely away in the danger zone.

D. Adaptive System Intelligence

Adaptive Systems defines as systems that adapts to changes that it encounters. The framework uses adaptive system concepts to integrate the capability to analyze and assess vehicular capability to be able to provide road routes capable for the vehicle to travel quickly and safely escaping the indicated danger zone areas in the volcano. The vehicular conditions consist of the performance, location and status that the system gathers. The adaptive system intelligence used the google mapping API to gather routes, traffic and terrain data needed for the framework to analyze the best routes suited for the vehicle condition. As seen on figure 6 show the activity diagram of the process of the adaptive system module. The adaptive system module consists of the danger zone status, vehicle module and the map routing system. The danger zone status provides the alert level status of the volcanic activity of the Mayon volcano. The danger zone map is analyzed and the module estimates the predicted affected areas. These areas are considered as hazardous areas where it notifies the drivers warnings and evacuation suggestion to avoid or leave the possible affected areas. The vehicle module then requests the vehicle specifications and status that includes its GPS location to analyze the condition of travelling of the vehicle. The module analyzes the capability of the vehicle based on its specification for travel. Using the Google maps integration, the GPS locates the vehicle and the availability of the roads and routes in the danger zone area. The system adapts to the situation of the volcanic alert level and prompts the driver road and route alternatives. The suggested roads adapt to the current specification of the vehicle that can be capable in the type of terrain of the road. The generated road and route suggestions of the system provides the drivers safe alternatives that can suit the vehicles specifications in order to travel in the danger zones avoiding hazardous areas that can be caused by volcanic activities.

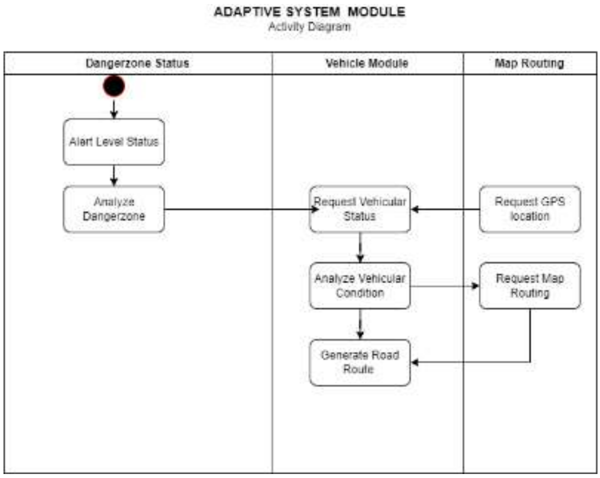

Fig. 6. Activity Diagram of the Adaptive System Intelligence Module

The adaptive system intelligence module capability in generating road alternatives combines the 3 factors of the research. These factors are present and guides the module in gathering the required information for the module to analyze and the best course in travelling into the danger zones of the volcano.

CONCLUSION

The development of the framework identified the map data of the danger zones, routes and the type of vehicles that are common for traveling. Mapping data roads is given by the integration of the google mapping API to provide the road routes. The framework used the model-view controller architecture and the adaptive system concept to create the model to evaluate and learn vehicle status and capability in identifying the best route for the vehicle to travel safely avoiding away from the danger zones in the Albay province. The designed framework presents a viable concept in assessing the best routes in safely traveling through danger zones while avoiding volcanic hazardous roads.

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