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A DATA-DRIVEN APPROACH FOR SYSTEM FRAMEWORK DESIGN OF TRAFFIC AND VEHICLE ACCIDENTS

Maria Charmy A. Arispe, Rosemarie T. Bigueras, Jocelyn O. Torio and Daniel E. Maligat Jr.

[1]Faculty of Computer Studies Department,
Bicol University Polangui Campus, Polangui, Albay, 4506, Philippines.

[2,3,4]Faculty of Institute of Computer Studies,
Camarines Norte State College, Daet, Camarines Norte, 4600, Philippines.

Corresponding Author's Email: [1]cham.arispe@gmail.com

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ABSTRACT: The research was an attempt to propose a framework design by determining the process flow of emergency response and analyzing the traffic and vehicle accident profile. Quantitative data analysis was used to determine the accident data that depends on the distribution under Reckless Imprudence Resulting to Homicide (RIR-Homicide), Reckless Imprudence Resulting to Physical Injury (RIR-PI) and Reckless Imprudence Resulting to Damage to Property (RIR-DP). Then, the collected data were converted to technical design and system framework was developed to propose a mobile application emergency response system for road traffic and vehicle accidents. It also integrates the applications of spatial analysis in the proposed system framework design to specifically identify the area of the accident location. The validation of the proposed system framework design obtained a total weighted mean of 4.28, which is interpreted as moderately potential.

KEYWORDS: *System Framework; Emergency Response; Road Traffic & Vehicle Accidents; Traffic Incidents*

1.0 INTRODUCTION

Traffic accident is a sudden event that occurs without prior planning and usually leads to traffic accident damage between minor and heavy vehicles leading to death or permanent disability [1]. Road accident is usually due to automobile, pedestrian, or object collision that would lead to death, injury, or property damage [2]. It is any activity that distracts the normal course of moving vehicles, in a way that causes the vehicle's free flow to become unstable. The ever-increasing trend is a global tragedy. It is very common in big cities because there are narrow and overcrowded streets [3,

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4].

Road accidents are one of the leading causes of death in the world. Deaths caused by road crashes have increased in the Philippines. The Philippine Statistics Authority (PSA) recorded 6,869 in 2006 and since 2010, the number of road accident deaths has never fallen below 8,000. PSA recorded the largest number of road accident-related deaths with 10,012 people killed in the year 2015. This is 1.79% of the total deaths of 560,605, including non-road crashes [5]. From the 2018 PSA record, the number of road accidents in 2010 is 25,649; 18,637 in 2011; 15,186 in 2012; 17,348 in 2013; and 25,794 in 2014 [6, 7].

It is possible to prevent road traffic injuries. Governments need to take holistic action to address road safety. This requires involvement from multiple sectors such as transport, police, health, education, and road safety actions. Effective interventions include designing safer infrastructure and incorporating road safety features into land use and transport planning, improving vehicle safety features, improving after-crash care for road crashes victims, establishing and enforcing key risks legislation and raising public awareness [8].

Additionally, it is possible to identify accident-prone locations using Geographic Information System (GIS) along with road traffic and vehicle accidents by analyzing spatial characteristics of reported locations as well as the primary factors that cause accidents. Location identification is one of the most important aspects of using GIS, enabling users to connect information on roads and accidents, match data and locations, analyze data using fixed segment, slide and spot analysis [9, 10]. The application of GIS in data storage, manipulation and display makes accident management, more practical and case-specific incident prevention. GIS findings provide an idea of the current incident pattern status. GIS also enables police and others involved in accidents to understand and assess the spatial relationships between different levels of data, such as incidents and land use, and to predict and take precautions for future incidents because of their spatial operational capacity [11].

Emergency personnel or victims also need detailed information about the incident's current location. The emergency response units can be selected and routed to fixed emergency response locations using GIS. There is more to GIS than just applications. Individuals and methods are combined with geospatial software and tools to allow for spatial analysis, manage large datasets, and view map or graphical information. When the location is identified by GIS, it is possible to identify, route and deploy the closest emergency response units to an incident [12].

Moreover, to improve the operations of existing emergency response programmes, it is in need to accurately determine the human and material resources required for each particular accident to significantly reduce the number of victims and recognize the highly stochastic nature of traffic and incident management operations [13]. Road traffic injuries are one of the world's leading causes of deaths, handicaps and hospitalizations with severe socio-economic costs. Accident-prone sites can be identified using GIS by analyzing the spatial characteristics of identified sites and the

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underlying factors that cause accidents [14]. Efficient and effective response to emergencies relies on communication and coordination of the organization. This means that information technology must be designed to provide adequate decision-making support [15].

In this context, the researchers analyze the collected data and developed the system framework design that can be used for road traffic and vehicle accidents mobile application emergency response system.

2.0 METHODOLOGY

The researchers used quantitative data analysis [16, 17] to determine and analyze the statistics of traffic and vehicle accidents in Albay. Figure 1 describes the study's conceptual paradigm in which the primary data sources were gathered from the Albay Provincial Police Office (Albay PPO). The interview method was conducted to obtain first-hand information and meet with the Albay PPO Police Superintendent and other Provincial Investigation Detective Management Branch (PIDMB) Officers.

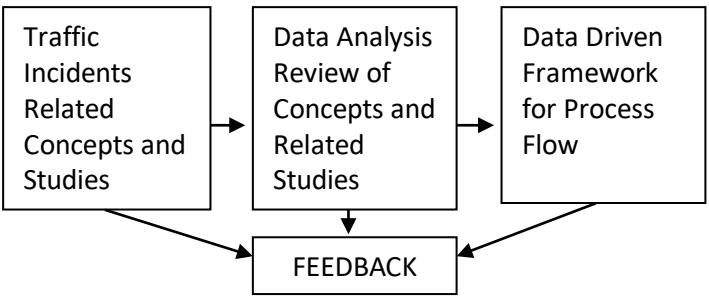

Figure 1: Conceptual Paradigm of the Study

The researchers efficiently collected accurate and relevant data about traffic and vehicle accidents. The collected data was converted into the technical design in order to validate and examine the user requirements and the specification of the different features of the study. The profile of traffic and vehicle accidents was categorized under Reckless Imprudence Resulting to Homicide (RIR-Homicide); Reckless Imprudence Resulting to Physical Injury (RIR-PI); and Reckless Imprudence Resulting to Damage to Property (RIR-DP). Swim lane diagram were also created to determine the PIDMB officers' response system ability and to show the traffic response procedures of the police stations.

3.0 RESULTS AND DISCUSSION

3.1 Process Flow of Emergency Response

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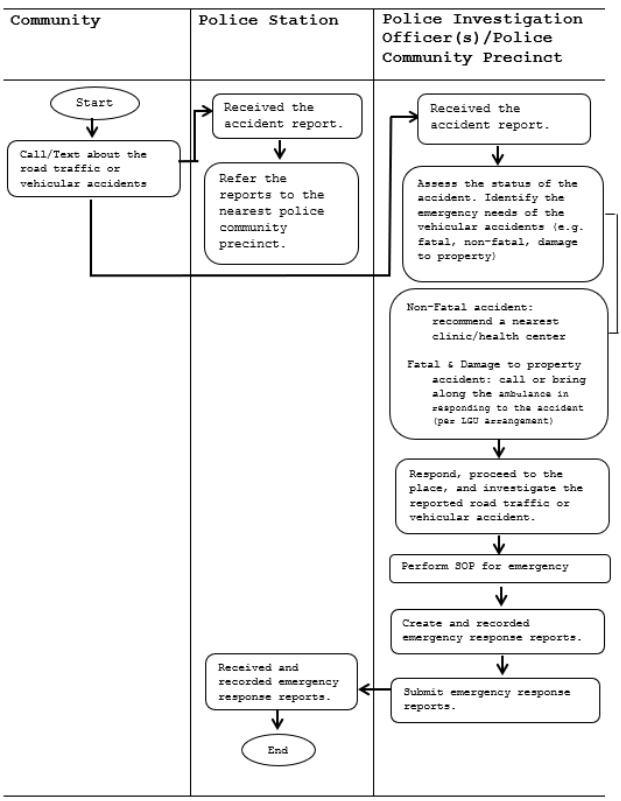

Figure 2: Swim lane diagram for traffic response procedures

Figure 2 shows the traffic incident response procedures of Albay PPO. The Police Investigation Officers responds to the road traffic incidents reported by community

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members by manually generating statistical reports such as number of incidents, gender of persons involved in the accidents, accident date and time, accident status, location of incidents, investigation reports, and others.

Collecting data on road traffic and vehicle accidents is the responsibility of the nearest Police Community Precint. The incidents recorded must be reported and submitted to Albay PPO within 24 hours. It is recorded in accordance with the Standard Operating Procedure (SOP) No. 2012-001 of the Philippine National Police (PNP) [18, 19] where the road traffic reports and vehicle accidents are treated as an event or activity. The PNP maintains a handwritten document called the Police Blotter which documents all aspects of organizational and administrative operations using the basic report writing criteria.

A record entry in the police blotter is not to be made directly to the police blotter book with respect to incident reporting. In the Incident Record Form (IRF) [20] the details and data of a blotter entry must first be registered. In order to report incident reporting mechanisms, concerned citizens need to contact the local or cell phone numbers of the nearest police community precint within the area or other response units, such as hospital or fire station in order to address the incidents. The dissemination of information between police stations and external fields can be achieved by using cell phones to enable police officers to know where the various emergency incidents are currently located. Police officers investigate the incident on the road traffic and vehicle incidents scene, collect data and make a decision on the fault of the scene.

3.2 Profile of Traffic Incidents

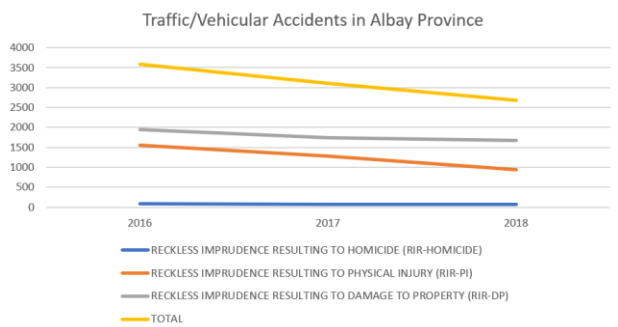

Figure 3: 2016-2018 Traffic Incidents in Albay Province

The road traffic and vehicle accident profile in Figure 3 illustrate the traffic incident condition from year 2016 to 2018. Albay PPO have recorded 3,577 vehicle accident cases in 2016; 3,109 in 2017; and 2,682 in 2018. The highest number of road accidents recorded in Albay was between 7:00a.m. to 8:00a.m. and from 4:30p.m. to 7:00p.m.,

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considered to be the day's rush hours. It was also noted that the Legazpi City area has the highest number of vehicle accidents recorded by Albay PPO.

With regard to the gender of persons involved in traffic and vehicle accidents, the RIR-Homicide has a minimal number of gender of persons involved in year 2016 to 2018, male has only 8 persons per year, respectively, whereas, for female, it has five, three and one only. The total number of gender of persons involved in RIR-Homicide is 13 on 2016, 11 on 2017 and nine on 2018. For the gender of persons involved in RIR-PI, it has 389 males in 2016, 348 in 2017 and 234 in 2018. For females, there were 96 in 2016, 119 in 2017 and 114 in 2018. For RIR-DP it has 888 accidents in year 2016, 789 were male and 99 were female. In 2017, it has 831 male and 166 females, with a total of 997. In 2018, a total of 1,165 incidents were recorded which involved 999 male and 166 females.

3.3. System Framework Design

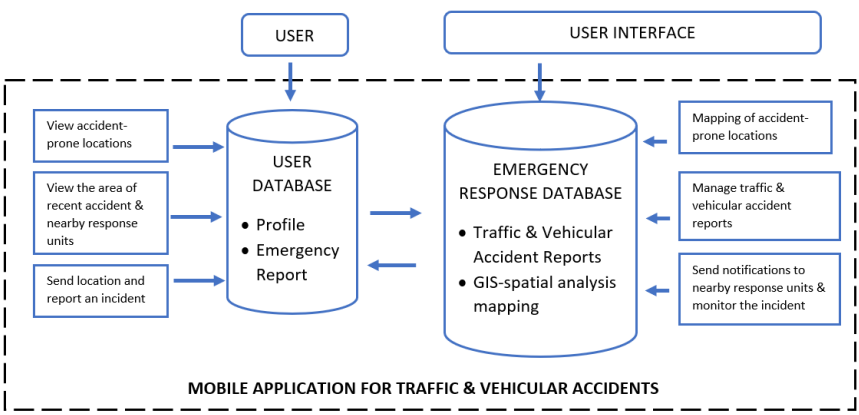

Figure 4: Proposed System Framework Design

Figure 4 presents the proposed system framework design for traffic and vehicle accidents. The proposed system framework design model is applicable to a user-friendly mobile application that can submit traffic accident data. The user or concerned community can send a report of the incidents and submit a notification of the location of the incident to the nearby response unit or police precint station concerned. It would

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try to improve the ability of the response system so that the police and traffic officers reach the site easily. The various details provided in the proposed model would be useful in providing a database of accidental data, and the GIS spatial analysis may be useful in making decisions and analyzing incidents where police stations can provide assistance for accident prevention. It would also limit the time needed to report an accident and more accurately determine its location.

To report an incident after successful access, the user may report an incident, determine the location of the incident on the map and take photos of the incident. Upon receiving report coming from the concerned community, the Albay PPO would be alerted and the personnel in-charge should check and validate the report along with the photos and location submitted by the user and immediately forward to the respective response units that may have a concern with the incident. Aside from that, the personnel can check also if a system enhancement is available and install the upgrade as well as updating and controlling the access level of the users. Moreover, the response team consisting of police officers, medical staff and/or fire station personnel must have access to their respective accounts with the concerned community and Albay PPO. After accessing the account, the respective units will be able to check and return to the incident report that the Albay PPO has reviewed and verified for the incident reported. And finally, for proper documentation, submit the created report.

3.4 Validation of the Proposed System Framework Design

The evaluation was carried out through a plenary presentation using the Architecture Tradeoff Analysis Method (ATAM) [21,22] to assess the potential level of the proposed system framework design for emergency response.

ATAM has nine phases that are grouped into four categories [23,24], such as presentation, investigation and analysis, testing and reporting. For presentation, the proposed system framework design was introduced and discussed to the selected evaluators, such as 12 PIDMB officers or Albay PPO personnel and 28 randomly selected community members. For investigation and analysis, the researchers present the design to the evaluators and discuss the advantages of using a mobile application with spatial analysis integration in emergency response. For testing, the evaluators mapped the possible emergency response scenarios in the proposed system framework. In developing the emergency response system, they provide and mention emergency response situations and express their concerns when responding to traffic and vehicle accidents. For reporting, positive questions were asked by the evaluators to assess whether the proposed model meets the requirements and their effect on other emergency response scenarios. Comments and feedback have been properly documented.

Table 1. ATAM Validation of Proposed System Framework Design

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Group	Activities	Weighted Mean	Interpretation
(A) Presentation	Presenting ATAM. Presenting business drivers. Presenting architecture	4.70	Highly Potential
(B) Investigation and Analysis	Identifying architectural approaches. Generating the quality attributes. Analyzing the architectural approaches	4.20	Moderately Potential
(C) Testing	Brainstorm and prioritizing scenarios. Analyzing the architectural approaches	4.30	Moderately Potential
(D) Reporting	Present Results	3.90	Moderately Potential
	Total Weighted Mean	4.28	Moderately Potential

The ATAM validation of the proposed system framework design of emergency response to traffic and vehicle accidents was carried out and shown in Table 1. The evaluation is based on metrics (five-point Likert scale of 4.51-5.00: highly potential; 3.51-4.50: moderately potential; 2.51-3.50: potential; 1.51-2.50: less potential; 1.50-Below: non-potential). A total weighted mean of 4.28 was obtained, which is interpreted as moderately potential.

4.0 CONCLUSION

The research study developed a system framework design for traffic and vehicle accidents by determining the existing process flow in responding to emergency and analyzing the traffic incident profile. The collected data from Albay PPO was classified under RIR-DP, RIR-Homicide and RIR-PI. The framework has an integration of GIS spatial analysis and is applicable to mobile applications. This also aimed to enhance the response system capability of PIDMB officers, to reduce the number of accidents and to increase overall road safety. In addition, validation of the proposed model was conducted to determine its validity and to identify the number of possible thresholds for the improvement of the study. It obtained a 4.28 total weighted mean or perceived as moderately potential. Nonetheless, the traffic incident situation should be recognized as an urgent matter and action should to be taken to reduce the number of incidents and improve overall road safety.

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