METRO CEBU, PHILIPPINES TRAFFIC INCIDENT EVALUATION AND ASSESSMENT USING 4-YEAR HISTORICAL DATA ANALYSIS

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Abstract:. The Philippines is losing ₱3.5 billion in daily losses by 2017 due to traffic incidents and damages. It also affects the economic status and the social welfare of the inhabitants of the country. To address this, a web-based traffic monitoring and information dissemination platform, The Floo Network, is developed to perform data analysis on 14,121 recorded traffic accident cases within the jurisdiction of the Cebu City Government between January 1, 2013 and September 30, 2017. It is found out that the most common type of damage inflicted during traffic incidents inside Cebu City is Property Damage, taking up to 93.4% of all recorded cases. Incidents resulting to Injuries have 6.5% and incidents resulting to Fatal Injuries have only 0.1%. Based on the classification of incidents according to their causes, the most common cause of traffic incidents in Cebu City is Human Error, measuring up 99.9% of all recorded incidents. Road Defect and Vehicle Defect collectively had the 0.01% of all recorded incidents. With road defect having only seven (7) recorded cases and vehicle defect having thirteen (13) recorded cases.The seven (7) traffic incidents that resulted from road defects are considered isolated and not connected to each other although there is a prominent similarity between these incidents. Six (6) of these incidents occurred in a type of intersection and all of these incidents are recorded to have happened in a very populous and dense area, with respect to the number of pedestrians and vehicles passing through the area.

Index terms: Traffic, Data Analytics, Traffic Accidents, Vehicles, Mapping, Smart City, Big Data

I. INTRODUCTION

1.1 Background of the Study

Metropolitan Cebu, or commonly known as Cebu City, is the main urban center of the province of Cebu in the Philippines. It is located along the central eastern portion of the Cebu Island which accounts for 20 percent of the land area and 61.5 percent of the population of the entire population of Cebu. (Philippine Statistics Office, 2015)

Metro Cebu's roads, streets and highways are among the country's busiest. The south-bound highway, Osmeña Boulevard, Colon Street and V. Rama are the city's major roads. The South Road Properties is also one of the frequently used highways consisting of a 12-kilometer, 4-lane highway that was aimed to improve the traffic condition of Cebu City.

In general the Philippines is losing billions of pesos everyday from lost productivity due to traffic jams caused by road accidents, particularly Metro Manila. The average travelling time of commuters in Cebu however, is roughly 3 hours. The most common causes of these traffic is the failure of the government to plan and execute the urban plan of the metropolis. Also another cause is the human error and behavior. (Lorenciana, 2018)

With these a number of losses are incurred by a commuters such as opportunity costs, direct losses such as fuel and electricity, lost labor hours and loss of life due to dangerous and poorly maintained traffic condition.

These losses can be prevented through the use of Data Analytics assessing on the current records harvested from traffic enforcement entities and governments. The fusion of urban data from increasingly complex networks of sensors allows for new ways to 'sense the city' and enhance transport capability and resilience. Predictive analytics provide a unified approach for extracting useful urban mobility information from networked infrastructure, connected vehicles and smartphones, for real-time estimation of traffic patterns, and deployment of management strategies (Mcclelland, 2016)

The amount of social data will increase in the upcoming years as the mobile devices and Internet begin serving a larger population. The Availability of the driver's location data from mobile devices feeds from micro-blogging sites play a key role in arriving at the solution. (Patel et. al).

1.2 Objectives of the Study

The primary objective of this study is to develop an application that shows a heatmap of all the traffic reports and incident that have been reported by the Cebu City Transportation Office (CCTO) within Metro Cebu from January 1, 2013 to

September 30, 2017. This study also specifically wants to:

- To classify the accidents according to the severity of the accident with the following categories: Fatal, Injury and Property Damage.
- To classify the accidents according to the cause of incidents with the following categories: Human Error, Road Defect and Vehicle Defect.
- To examine what could be improved off of the accident-prone areas specially if the root cause of the accident is a road defect.

II. REVIEW OF RELATED LITERATURE

2.1 Economy and Urbanization of Metro Cebu

Cebu City, the capital of the province of Cebu and is considered a significant center of commerce, trade and education in the Visayas region. Cebu City is a 1st class highly urbanized city in the island of Cebu in the Central Visayas Region of the Republic of the Philippines. According to the 2015 population census, it had 922,611 people living under its jurisdiction, making it the fifth most populated city in the country and the most populous in the Visayas. (PSA, 2015)

With Cebu being in the very center of the Philippine Archipelago, it is surrounded by many islands and is plotted with a myriad of beaches, hotel and resorts, diving locations and heritage sites which resulted to a high domestic and foreign tourist arrival thrusting its tourism industry. The island of Cebu can be accessed through air, land and sea transport, having its port second only to that of Manila,Philippines. (Zosa et al, 2014)

The city is a major hub for Business Process Outsourcing (BPO) industry in the Philippines. Cebu City ranked 8th in the "Top 100 BPO Destinations Report" by Tholons (SunStar Cebu, 2013) and in 2012, the IT-BPO revenues of the city grew 26.9 percent at $484 million and 18.2 percent at $13 billion nationally. Also Cebu is home to shipbuilding companies contributing up to 70,000 metric tons deadweight (DWT) and double-hulled fast craft as well which boosted the Philippines' shipbuilding industry to 4th largest in the whole world. (Manila Bulletin, 2013).

With a revenue growth of 18.8 percent in 2012, the fastest growing sector of cebu is real estate. Backed by strong economic indicators and top-bidding investors, condominium projects and hypermarkets are being established in the city at an accelerated rate. (SunStar, 2013)

2.2 Traffic Conditions and Existing Problems in the Philippines

According to Verzosa et. al (2016), Pedestrians are considered as one of the most vulnerable road users in less developed countries such as the Philippines. Yet, a lot of pedestrians remains poorly addressed in both urban and rural modes of transportation. Since car ownership in less developed countries face a rapid increase and with it, an increase in pedestrian-related injuries, it is highly necessary for intervention and providing guidance for injury prevention in such places.

Metro Manila, the capital of the Philippines, and its commuters and motorists spend an hour and more on average in traffic every day, placing the Philippines in the 3rd worst in traffic in Southeast Asia. This survey conducted by BCG indicated that traffic may worsen as 84 percent of Metro Manila respondents plan to buy a car in the next 5 years. (Rappler, 2017)

On the other hand, 37 percent of Metro Manila respondents would be highly willing to forgo purchasing a vehicle if ride sharing can meet their transport needs. Still, as expected in the current status of the country, travel time more than doubles during the rush hours in the morning and in the evening.(Rappler, 2017)

According to Japan International Cooperation Agency (JICA), the Philippines is now losing ₱3.5 billion a day due to traffic congestion even just in the Metro Manila. In its 2014 report, partnering with the National economic Development Authority (NEDA), the country suffered ₱2.4 billion in losses. The report then is projected at ₱3.5 billion in daily losses by 2017.

It is projected to become ₱5.4 billion a day by 2035 but with the currently implemented Build, Build, Build Program it is hopefully reduced to ₱3 billion a day, dragged down to ₱2.4 billion a day adding in the additional projects that will be implemented.(CNN Philippines, 2018)

2.3 Applied Data Analytics

The number of devices connected to the Internet of Things (IoT) by the year 2020 will be at its all time high at 75 billion. With it comes the huge demand for big data analytics to harness the multitudes of data generated by the Internet of Things (IoT). Though there are very few attempts in using Data Analytics to better the behavioral, organizational and business issues to understand its impact, it is highly necessary to incorporate the information that the data tell in order to serve constituents better. (Riggins et al., 2015)

Business Intelligence and Analytics (BI&A) became one of the most important area of study for both professionals and researchers, highly reflecting the magnitude of its impact especially towards data-related problems that could be solved by regular business organizations (Chen et al., 2012). On the other hand, Big Data Analytics and Deep Learning are areas of data science that are gaining focus. These fields became important as both private and public organizations have been collecting massive amounts of domain-specific information, which could hugely indicate potential problems such as errors in national intelligence, cyber security, fraud detection, marketing and medical informatics. (Najafabadi et al., 2015)

Companies in the likes of Google and Microsoft are mining and analyzing gigantic volumes of data for business analytics and decisions, impacting current and future technologies. Machine Learning algorithms extract high-level, complex abstractions as data representations through hierarchical learning process. (Najafabadi et al., 2015)

2.4 Data Analytics in Traffic Management

Knowledge of fundamental traffic flow properties such as speed, volume and density and associated analytical techniques are a very significant requirement in planning, design and operation of transportation, may it be on land sea and on air. Existing traffic flow models are commonly based on time headway, flow, time and space trajectory, speed, distance headway and density. These led to the development of a myriad of analytical strategies: demand and supply analysis, capacity and level of service analysis, traffic stream modelling, shockwave analysis, queueing analysis and simulation modelling. (Mohanet al., 2000)

The rapid growth in the population density in most urbanized cities demand that establishments and services be provided to meet the demands of the city's inhabitants. This resulted to an increase of embedded devices, in the likes of sensors, actuators and smartphones, leading to an unprecedented business potential for the new era of Internet of Things (IoT) upon which multiple devices are able to communicate to each other over the internet. (Rathor et al., 2016)

On another study, Smart Connected Cities are envisioned to address the primary needs of preservation and cultivation of culture, the needs of the living in the status quo and the needs of planning for the future. Sun et. al. (2015) argues that the use of Internet of Things (IoT) has the potential to provide a ubiquitous network of connected devices and smart sensors in the development of Smart Connected Cities and big data analytics has the potential to enable the move from IoT to real-time control desired for Smart Controlled Cities. Some highlights would be mobile crowdsensing and cyber-physical cloud computing as two most important IoT technologies that could be powered by Data Analytics.

2.5 Related Studies

In Guo et al, (2011) an interactive visual analytics system has been developed, aptly named Triple Visual Trajectory Analytics (TripVista), used for exploring and analyzing complex traffic trajectory data. The users are fully equipped with a patented design interface to inspect data interactively from three perspectives: spacial, temporal and multi-dimensional views. Their study focused on the macro aspect of traffic flows, developing visualization methods to investigate and analyze microscopic patterns and abnormal behavior.

Using the Metro Manila Accident Reporting and Analysis System (MMARAS) data from 2008 to 20011, binomial regression analysis shows that traffic crashes that involve heavy and multiple vehicles , and an elderly pedestrian (60 years old and above), as well as those that happened during the evening and late at night have significantly higher odds of resulting to datal outcome; when crash involves a female pedestrian and given that the road surface is wet, the chances of a fatal outcome is lower. Moreover, by clearly examining the environment of national highways, most pedestrian fatalities are caused by high-speed, high traffic volume, multilane roadways that are surrounded by land uses that generate a problematic cocktail of heavy vehicular traffic.

The street level analysis also finds that fatal pedestrian crashes occur close to different types of transit stations. These results reflect a twofold challenge to pedestrian safety in rapidly urbanizing areas in countries such as the Philippines that are classified as lower-middle income: hey face some of the same pedestrian safety issues as more developed areas, but with a much larger number of pedestrians using the streets, and a built environment that was not planned for the high volume and speed of motor vehicle traffic on today's roadways. (Verzosa et. al, 2016)

III. METHODOLOGY

3.1 Research Design

This is a descriptive research done to determine the traffic conditions of Cebu City, Cebu, Philippines based on traffic incidents and reports that have been recorded by the Cebu City Transportation Office (CCTO) from January 1, 2013 to September 30, 2017. This study is also made to determine that economic and physical losses incurred by Cebu City with respect to these reports.

For the duration of 4 years and 9 months, all reports involving all land-based vehicles were used to

generate a heat map plotting all incidents within the jurisdiction of Cebu City, Philippines. Each instance was formatted such as the following:

Record ID - Date of Occurrence - Latitude - Longitude - Location in text - Weather Condition - Time of Day - Severity - Cause of Incident

The date of occurrence following the concatenated dd/mm/yy+hh:mm:ss format was used. The time was based on the 24-hour format. The latitude and longitude was used in plotting the incidents on the heat map while the text-form of the location was used for user clarity and experience. The weather condition was factored in as a possible factor for the cause of these incidents as well as the time of the day, whether it occurred during daytime, night, dusk or dawn.

The severity of the incident was classified between Fatal, Injury or Property damage. Fatal means death or dismemberment of body parts directly or indirectly resulted from the accident. Injury concerns scratches, bruises and other damage not resulting to immediate hospital care. Property involves damage to the vehicle or to any establishment during the accident.

The cause of incident was classified into Vehicle Defect, Road Defect and Human Error. Vehicle defect involves accidents caused by poorly maintained machine, broken equipment and apparatus necessary in running the vehicle. Road defect covers poorly managed streets, roads and highways that resulted to rough, rugged surfaces and harmful disturbances on the street.

3.2 The Floo Network

The Floo Network is a web-based application that allows imported CSV file containing data in the above-mentioned format to be read and analyzed by the system. It uses the longitude and latitude of an incident in order to plot point in the map, thus, generating a heat map of all incidents in Cebu City.

It uses Openstreetmap API to show a map-like interface upon which these points can be plotted. In the Floo Network, we can see the exact places incidents have had happened and the number of occurrences that places had an incident. It also allows satellite view which changes the screen into the actual top-view look of the location as seen from outer space. Also included are the zooming capabilities and shape-construction feature.

Another feature of the Floo Network is through the use of filters which enables users to tailor the points plotted based on the date constraints, the severity, the reporting agency and the cause of the incident. With this feature, users can easily look into a particular case with relative ease. A graph was also generated to determine the number of accidents that have occured in a day.

3.3 Heatmap Construction and Analysis

Using the longitude and latitude, points are plotted where accidents have happened. However, there will also be a recorded text format of the actual venue of the accident so that users can understand and read the information.

When the location was already prepared, the points were drawn in the map, thus generating a heat map. When points are plotted exactly on the location of an accident, we can determine the probable cause such as the presence of an intersection or at some extent, even the presence of road disturbance or an establishment generating huge crowds that may hinder traffic from flowing freely.

Using the plotted location, we can visit the exact site and determine what would be the probable cause, exempt the human error or vehicle defect, it could be a road defect and thus could be reported to authorities of the city for immediate assistance and repair.

Should the cause of the accident be either human error or vehicle defect, this data could also be used in order to provide signages and warnings as to what the common

IV. RESULTS AND DISCUSSION

4.1 Generated Heat Map from the Floo Network

After the development of the Floo Network, we have incurred 14,121 recorded incidents coming from the Cebu City Transportation Office and the Cebu City Local Traffic Unit. These data have been fed to the database and was analyzed, generating 14,121 points within the Cebu City jurisdiction. These incidents have been in record for 4 years and 9 months starting from January 1, 2013.
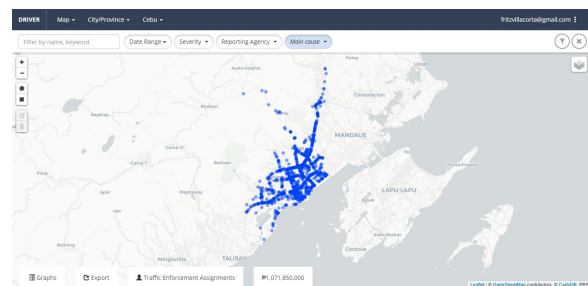

Fig.1 The Map view of the Floo Network

Though the Floo Network has been used to monitor the traffic conditions of the Cebu City area only, it can also be expanded to any location within the planet, given that there are access roads, streets, and highways plotted within the virtual map courtesy of the OpenStreetMap API. Though considering the situation of Cebu City, traffic-related incidents are concentrated within the downtown area with a

splattering of reports from the northeast, north and southwest regions.

4.2 Classification of Incidents based on Severity

Included in the Floo Network is the *Severity* Filter which categorizes all 14,121 incidents into three (3) severity categories namely Fatal, Injury or Property Damage. Below is the actual comparisons of cases between the three categories.
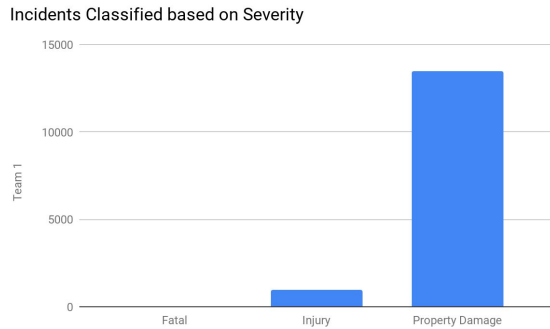
Incidents Classified based on Severity

Table 1. Incidents Classified based on Severity.

Looking at the 14,121 data analyzed by the Floo Network, Cebu City has incurred 19 (0.1%) Fatal Injuries and 940 (6.5%) Injuries. Considering this is the accumulated data for 4 years and 9 months only, the damages are relatively low in reference to the 480,981 of car owners driving the streets of Cebu City this 2018.

However, there are 13, 488 (93.4%) recorded cases of Property Damage which is a lot higher than that of the Injury cases for the specified period. Property Damage includes car crashes that resulted to no injury but incurred damages to the vehicle itself, another vehicle/s, establishments and damages to infrastructure such as the road barriers.

4.3 Classification of Incidents based on the Cause of Incident

Included in the Floo Network is the *Main Cause* Filter that measures the number of incidents that resulted from three (3) general causes. Namely Human Error, Road Defect and Vehicle Error. Below is the graphical representation of the incidents sorted among these causes.
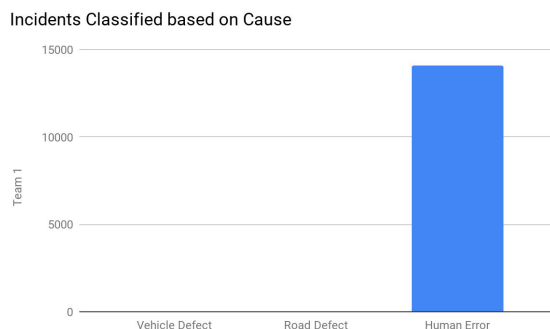
Incidents Classified based on Cause

Table 2. Incidents based on the Cause

Basing on the Table 2, it is evident that the most prominent cause of reported traffic incidents are Human Error, accumulating up to 99.9% of all the recorded incidents. Human Error includes drunk driving, texting while driving, drivers that are under the influence of drugs and other narcotics, speeding, inexperienced driving and drivers who lack enough sleep.

The other two factors, namely Road Defect and Vehicle Defect collectively take up the remaining 0.01% of all the recorded incidents. Vehicle Defect having thirteen (13) recorded cases and Road Defect having seven (7) recorded cases. Though these causes happen quite rare given the span of time of this study, improvements can still be extracted from these results.

4.4 Identification of Probable Cause of Road Defect-caused Incidents

There are seven (7) recorded traffic incidents that are caused by road defects in Cebu City between January 1, 2013 and September 30, 2017. Road Defects includes, but not limited to, rough and stony roads, poorly maintained roads, slippery roads, roads without traffic lights or traffic enforcers, roads without proper pedestrian lanes and signages and roads that leads to intersections.

Location	Type
Cebu Century Hotel, Pelaez, Sun Valley Subdivision, Cebu City, Cebu, Central Visayas, 6000, Philippines	Side swipe
Motortrade, Cebu South Road, La Paloma Village, Cebu City, Cebu, Central Visayas, 6000, Philippines	Side swipe
Asian College of Technology - ACT, P. del Rosario Street, Sun Valley Subdivision, Cebu City, Cebu, Central Visayas, 6000, Philippines	Rear end
San Jose Bakeshop, General Maxilom Avenue Extension, Mercado Compound, Doña Rita Village, Cebu City, Cebu, Central Visayas, 6000, Philippines	Rear end
Technical Education and Skills Development Authority, Salinas Drive, Gonzales Compound, Doña Rita Village, Cebu City, Cebu, Central Visayas, 6000, Philippines	Rear end
Progress Commercial, R. Duterte, Happy Valley Subdivision, Cebu City, Cebu, Central Visayas, 6000, Philippines	Right angle
Cut Lahug 2, Gorordo Avenue, Gonzales Compound, Doña Rita Village, Cebu City, Cebu, Central Visayas, 6000, Philippines	Rear end

Table 3. Location of Road Defect Traffic Incidents

Examining these locations closely, these seven (7) traffic incidents are caused from two (2) cases occurring on a T-junction intersection, three (3)

cases from a four-way intersection, one (1) incident occurring from a pedestrian crosswalk and one (1) incident occurring from a fork intersection. Without a prominent type of intersection, it is considered that these are isolated cases.

These incidents occurred on different dates within the allotted research period which can then be concluded that these incidents have no connections to each other. However, these incidents all occur on highly populated areas with dense volumes of pedestrians passing by and also the high volume of vehicles passing through these streets on any given time of the day.

V. CONCLUSION

5.1 Conclusion

The web-based traffic monitoring and information dissemination platform, The Floo Network, was found to be able to perform data analysis on 14,121 recorded cases within the jurisdiction of the Cebu City Government between January 1, 2013 and September 30, 2017. Also it has been proven that participation from the Cebu City Transportation Office (CCTO), the Philippine National Police (PNP) and the local government units (LGUs) can be both beneficial for proper and efficient traffic monitoring practices.

This study also found out that the most common type of damage inflicted during traffic incidents inside Cebu City is Property Damage, taking up to 93.4% of all recorded cases. Following far behind are incidents resulting to Injuries with 6.5% and incidents resulting to Fatal Injuries having only 0.1%.

Based on the classification of incidents according to their causes, the most common cause of traffic incidents in Cebu City is Human Error, garnering up to 99.9% of all recorded incidents. This then can be used as evidence that accidents that have occurred during this study was almost always caused by human error. Road Defect and Vehicle Defect collectively had the 0.01% of all recorded incidents. With road defect having only seven (7) recorded cases and vehicle defect having thirteen (13) recorded cases.

Finally, the seven (7) traffic incidents that resulted from road defects are considered isolated and not connected to each other although there is a prominent similarity between these incidents. Six (6) of these incidents occurred in a type of intersection and all of these incidents are recorded to have happened in a very populous and dense area, with respect to the number of pedestrians and vehicles passing through the area.

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