Black Spot Identification and Road Accident Mapping Using Deep Neural Network (DNN) Modeling in Jose Abad Santos Avenue (JASA), City of San Fernando, Pampanga

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Abstract:

The City of San Fernando is a first-class component city in the Pampanga province.The Jose Abad Santos Avenue has seen a rise in road accidents each year, leading to concerning numbers for road users. The research focused on identifying high-risk areas and mapping road accidents along Jose Abad Santos Avenue (JASA). The study used accident data from 2019 to 2023 to assess factors contributing to road accidents and employed Deep Neural Network modeling for black spot identification and accident mapping. This represents a significant advancement in transportation research with the potential to improve road safety. The researchers recommended solutions and suggestions to identify black spots on the road.

Keywords **—Black Spots, Deep Neural Network**

I. INTRODUCTION

In the early stages of transportation planning and road safety, the identification of black spots was primarily based on observational methods. Authorities relied on accident reports, often handwritten, and qualitative assessments to pinpoint areas with a high incidence of crashes.The term "black spot" refers to locations on roadways where a higherfrequency of accidents occurs, making their identification and mitigation crucial for enhancing overall road safety. The black spot identification through the years reflects the growing recognition of the need for targeted interventions to address specific risk- prone areas.Ensuring road safety is a priority worldwide, which has led to a collaborative effort to integrate advanced technologies into accident prevention strategies. This research aims to explore the potential of deep neural networks in identifying "black spots", which are locations where road accidents occur frequently. By implementing these neural networks, researchers can analyze historical road accident data more comprehensively, uncovering complex patterns and relationships between various contributing factors. This study focuses on developing a sophisticated model for black spot identification, using deep learning to create an approach to enhance road safety.The research specifically focuses on San Fernando, Pampanga, Philippines, a region that faces its unique traffic dynamics and challenges.By tailoring the methodology to the local context, researchers can better understand the factors that contribute to road accidents in this area. The anticipated outcomes of this study will not only contribute to the academic discourse on road safety

but also help develop targeted and effective safety interventions that address the specific considerations of San Fernando, Pampanga.

1.2 Study Area

The researcher aimed to understand the challenges posed by road accidents in Jose Abad Santos Avenue and identify black spots using historical road accident data. Therefore, the study was conducted in Jose Abad Santos Avenue in the City of San Fernando, Pampanga, due to the increasing frequency of road accidents every year.

II. METHODS

This chapter discusses the research method used by the researchers to determine Black Spot and map Road Accident along JASA in City of San Fernando, Pampanga.It coversthepresentation ofresearch design, data collection, and research instrument, and conclusion and recommendation.

2.1 Research Design

The researchers conducted this study utilizing a quantitative research method to identify black spots on Jose Abad Santos Avenue in the City of San Fernando, Pampanga. The researchers analyzed recent reports on road accidents collected from the City of San Fernando Police Station and the Pampanga Police Provincial Office. By calculating the frequency and percentage distribution of the data, the researchers located the black spots. To identify factors contributing to road accidents, the researchers analyzed the narrative reports from the gathered data. Based on the findings, the researchers recommended a solution to assess black spots along JASA.

2.2 Methodology

2.2.1 Data Collection

The researchers first identified the area of interest and then collected administrative data from the City of San Fernando Police Station and the Pampanga Police Provincial Office. The information and data collected pertained to road accidents that occurred on Jose Abad Santos Avenue in the City of SanFernando, Pampanga for a period of five years (from 2019 to 2023). This data served as the primary source for identifying the black spot, where the factors that cause road accidents were identified and analyzed.

2.3 Research Instrument

In the data collecting procedure, the study will use the following:

The researchers will collect the essential data for the study by conducting interviews with police officers at the Pampanga Police Provincial Office and San Fernando Police Station. Identifying black spots can be effectively processed through a deep neural network. The process involves organizing and formatting the raw data from PNP, which may include variables such as human factors, road conditions, vehicular conditions, and environmental factors. The data is preprocessed by tasks such as encoding categorical variables and handling missing values.

2.4 Modelling of Deep Neural Network

The process of identifying black spots using a Deep Neural Network method involves the following steps: First, the researchers collected road accident data along JASA. Second, categorize the road accident data in terms of time, location, date, narrative, factors and then use it to train the deep neural network model. After training, input recent historical road accident data into the trained model, which then generates real-time identification of black spots.After preprocessing, relevant features that could potentially contribute to identifying black spots are extracted. These features may include time, date, location, vehicles involved, causes of road accident as input variables for the deep neural network model.

2.5 Black Spot Identification Mapping System

In crafting a website for black spot identification and road accident mapping along Jose Abad Santos Avenue in the City of San Fernando, Pampanga, Leaflet.js emerges as a pivotal tool for effective spatial visualization and user interaction. Leveraging Leaflet's mapping capabilities, the website offers users an immersive experience, allowing them to explore and comprehend the distribution of road accidents along the designated avenue. Through seamless integration with geoJSON data representing accident locations, Leaflet dynamically renders interactive maps, enabling users to zoom in, pan, and click on

individual markers to access detailed information such as location, date, time, type of vehicle involved, factors that causes the road accident.

III. RESULTS AND DISCUSSIONS

3.1 Road Accident Data

This chapter presents data collected and organized according to the three phases of methodology: (1) Historical Road Accident Data; (2) Black Spot Identification.

3.1.1 Historical Road Accident Data

Thefollowingsection displays thedatathatwas collected andused as inputfor the Deep Neural Network (DNN). This data includes the date, time, location of accidents, type of vehicles involved, and factors that contribute to road accidents. Thegathereddatahasbeenuploadedtothewebsiteandc anbefoundunderthefile upload section.
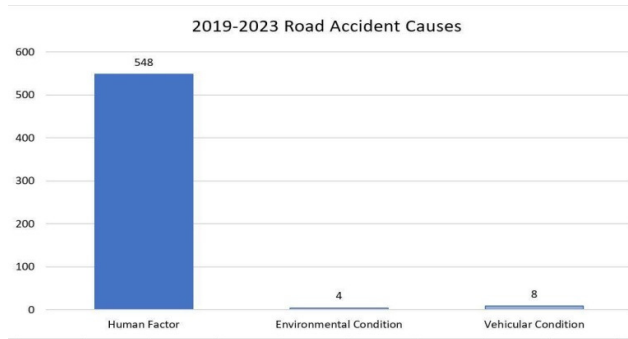
A. Road Accident Causes 2019-2023

Fig. 3.1Road Accident Causes 2019-2023

Fig. 3.1 shows that Human Factors as the main reason cause of road accidents in year 2019 to 2023 in Jose Abad Santos Avenue. Since there was a lot of traffic volume on the said avenue there were only few environmental conditions and vehicular conditions. It is important to note that road geometry was not included.

B. Number of Road Accidents 2019-2023
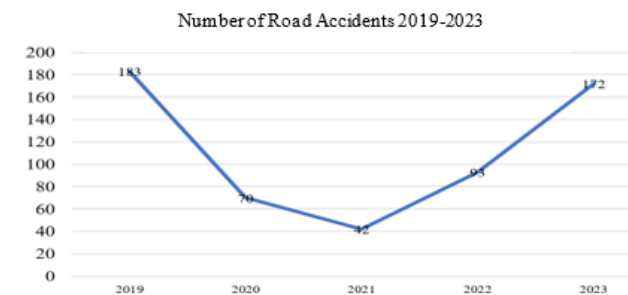

Number of Road Accidents 2019-2023

Fig. 3.2Number of Road Accidents 2019-2023

Fig. 3.2 shows that road accidents that occurred annually between 2019 and 2023. The year 2019 had the highest number of accidents, with 183 cases, while the year 2021 had the lowest frequency, with only 42 cases. It is important to note that the year 2020 to 2021 saw a decrease in the number of accidents due to the pandemic. Areas in Pampanga, specifically San Fernando, implemented Modified General Community Quarantine (MGCQ) guidelines strictly, resulting in a drop in traffic volume along Jose Abad Santos Avenue.
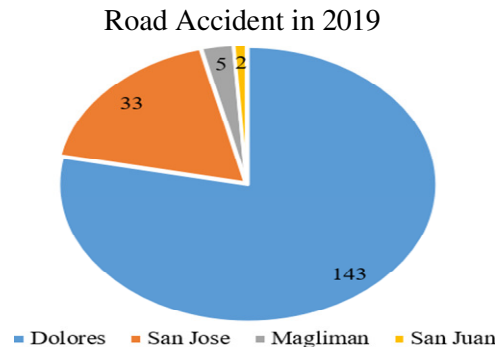

Road Accident in 2019

Figure 3.3 Number of Road Accidents in 2019

Figure 3.3 displays the number of road accidents in JASA during 2019. Barangay Dolores had the highest number of accidents at 143, while the lowest number of accidents at 2 in Barangay San Juan.
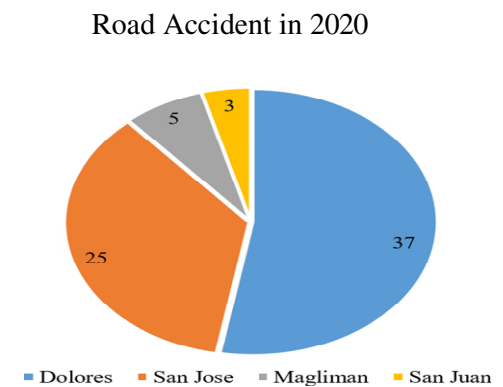

Road Accident in 2020

Figure 3.4 Road Accident along JASA in 2020

The Figure above, labeled as Figure 3.4, presents the number of accidents that occurred in JASA during 2020. The barangay with the highest number of accidents was Dolores, with 37

incidents.Following that, San Jose had the second-highest number of accidents, with a total of 25 incidents.
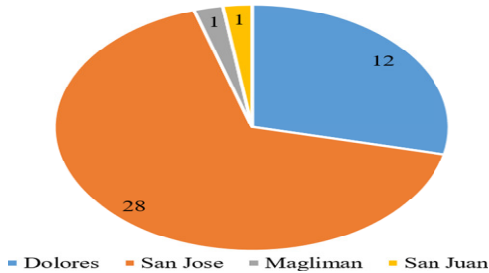
Road Accident in 2021

Figure 3.5 Road Accident along JASA in 2021

Figure 3.5 presents the data on the total number of accidents that occurred in JASA in the year 2021. According to the table, Barangay San Jose had the highest number of accidents at 28, while Barangays Magliman and San Juan had the same number of accidents at 1 each.
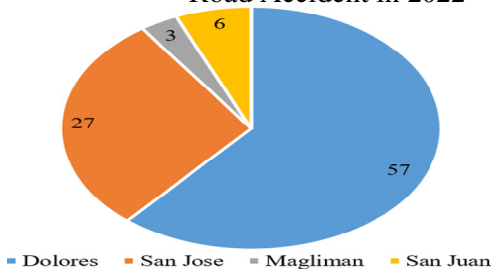
Road Accident in 2022

Figure 3.6 2022 Road Accident along JASA

The following is a report of the accidents that occurred in JASA during the year 2022. According to Figure 3.6, Barangay Dolores had the highest number of accidents with a total of 57 road accidents in JASA. On the other hand, barangay Magliman had the lowest number of accidents, with only 3 accidents reported.
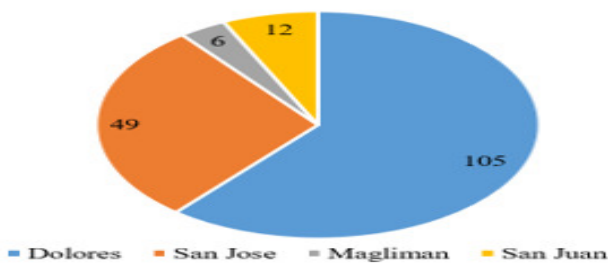

Figure 3.7 Road Accident along JASA in 2023

Figure 3.7 shows the number of accidents in JASA in Year 2023. The highest number of accidents is from Barangay Dolores with 105, while Barangay Magliman has the lowest number of accidents with 6 in the Year 2023.

3.2 Black Spot Identification

In India a Road Accident Black Spots on National Highways is defined as a stretch of about 500 meters in length where either 5 road accidents (resulting in fatalities or serious injuries) have occurred in the last 3 calendar years, or 10 fatalities have occurred within the same period.

The Department of Public Works and Highways Accident Black Spot Investigation Handbook aims to identify the most dangerous locations based on accident statistics. The handbook considers the number of major accidents per year for intersections and short mid-block sections (less than 500 meters), and for road sections longer than 500 meters, it uses the number of major accidents per year per kilometer. To be considered for inclusion in the Road Accident Reduction Program as a blackspot project, a site must have a high accident frequency. The criteria focus on major accidents because fatal and serious injury accidents have the greatest impact on the community in terms of economic and social costs.

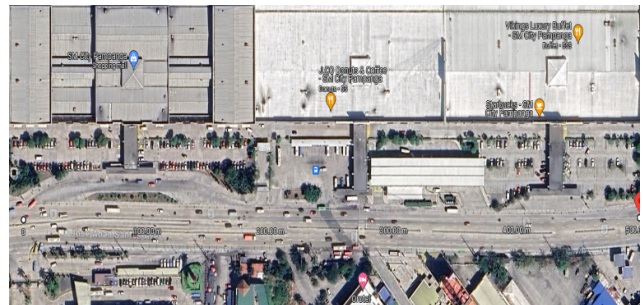### 3.2.1 Map of JASA per 500 mSection A to B

Figure 3.8 Map of JASA per 500 m using Google Maps Section A to B

In this figure, Section A to B starts with the exit gate of SM Pampanga and ends at the entrance gate of SM Pampanga along Jose Abad Santos Avenue with six road lanes.

3.2.2 Map of JASA per 500 mSection B to C

Figure 3.9 Map of JASA per 500 m using Google Maps Section B to C

In this figure, Section B to C starts with the entrance gate of SM Pampanga and ends at the end of the bridge near NLEX road along Jose Abad Santos Avenue with eight road lanes.
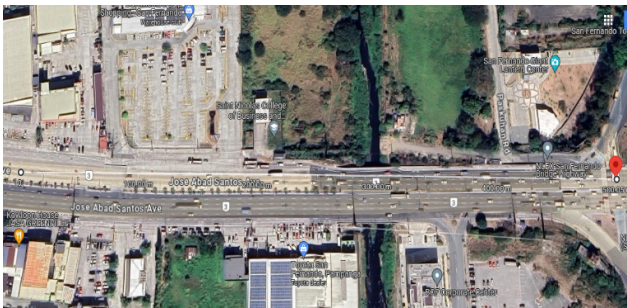
3.2.3 Map of JASA per 500 mSection C to D

Figure 3.10 Map of JASA per 500 m using Google MapsSection C to D

In this figure, Section C to D starts with the end of the bridge near NLEX road and ends in front of S&R building along Jose Abad Santos Avenue with seven road lanes.

3.2.4 Map of JASA per 500 m Section D to E

Figure 3.11 Map of JASA per 500 m using Google MapsSection D to E

In this figure, Section D to E starts in front of S&R building and ends in front of the LandBank Pampanga building along Jose Abad Santos Avenue with ten road lanes.

3.2.5 Map of JASA per 500 mSection E to F

Figure 3.12 Map of JASA per 500 m using Google Maps Section E to F

In this figure, Section E to F starts in front of the LandBank Pampanga building and ends in front of MC Home Depot Pampanga building along Jose Abad Santos Avenue with ten road lanes.

3.2.6 Map of JASA per 500 mSection F to G

Figure 3.13 Map of JASA per 500 m using Google MapsSection F to G

In this figure, Section F to G starts in front of MC Home Depot Pampanga building and ends after the overpass intersecting Dolores along Jose Abad Santos Avenue with four road lanes.

3.2.7 Map of JASA per 500 m Section G to H

Figure 3.14 Map of JASA per 500 m using Google Maps Section G to H

In this figure, Section G to H starts after the overpass intersecting Dolores and ends near Sun Star Pampanga along Jose Abad Santos Avenue with four road lanes.

3.2.8 Map of JASA per 500 m Section H to I

Figure 3.15 Map of JASA per 500 m using Google Maps Section H to I

In this figure, Section H to I starts near Sun Star Pampanga and ends in front of Casa Nueve Residences at the end of Lazatin flyover along Jose Abad Santos Avenue with four road lanes.

3.2.9 Map of JASA per 500 m Section I to J

Figure 3.16 Map of JASA per 500 m using Google MapsSection I to J

In this figure, Section I to J starts in front of Casa Nueve Residences at the end of Lazatin flyover and ends in front of Autokid Truck Dealer near Nobleminds Montessori along Jose Abad Santos Avenue with four road lanes.

3.2.10 Map of JASA per 500 m Section J to K

Figure 3.17 Map of JASA per 500 m using Google MapsSection J to K

In this figure, Section I to J starts in front of Autokid Truck Dealer near Nobleminds Montessori and ends in front of Sun Star Pampanga, Publishing

Inc. near Magliman in Jose Abad Santos Avenue with four road lanes.
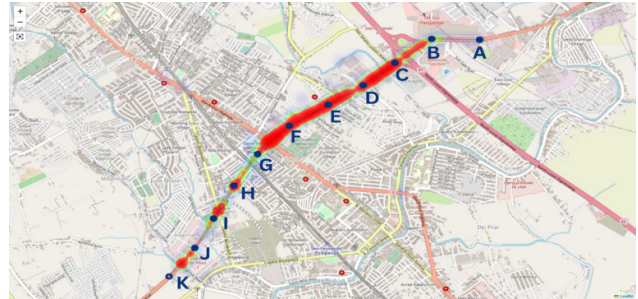
3.2.11 Road Accident Density of JASA per 500 m

Figure 3.18 Road Accident Density of Section A to K in JASA per 500 m

Figure 3.18, shows a graphical representation of the division of Jose Abad Santos Avenue into ten sections, each 500 meters long, labeled A to K. The number of road lanes in each section is as follows: A to B has six lanes, B to C has eight lanes, C to D has seven lanes, D to E and E to F both have 10 lanes, and F to K has four lanes.

3.2.12 Total Number of Accidents along JASA per 500m
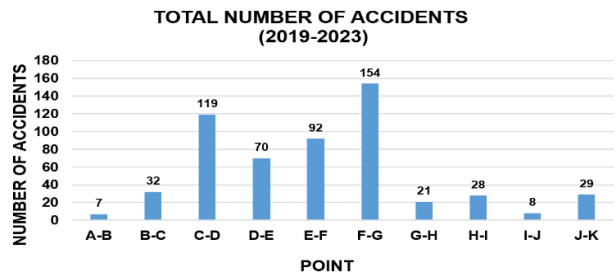
Figure 3.19 Total Number of Accident JASA (2019-2023)

This Figure reveals the graphical representation of the total number of accidents per 500-meter in JASA during the year 2019-2023. The highest number of accidents that occurred along JASA is in section F-G with 159 road accidents since from four road lanes merge into two road lanes wherein a flyover exists, while the lowest number of road accidents can be seen in section A-B with seven road accidents.

IV. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary of Findings

This study aimed to identify black spots (areas with high accident rates) and create a heat map to visualize road accident density along Jose Abad Santos Avenue in San Fernando, Pampanga. The researchers uploaded the raw data in .xlsx format to the system and the system automatically generated the heat map showing the Black Spot concentrations and Road Accient Density. Based on the results, analysis of traffic accident data for Jose Abad Santos Avenue in San Fernando, Pampanga, from 2019 to 2023 revealed black spot locations and accident density.

These high-risk sections, particularly segments B to I and J to K, exhibit a statistically significant concentration of accidents. Analysis of accident data from 2019 to 2023 confirmed a higher risk of road accidents in certain areas along Jose Abad Santos Avenue. Human factors were the leading cause of accidents during the study period, accounting for 548 incidents, while environmental conditions were the least contributing factor, with only 4 recorded cases.

The findings of the research point towards a higher risk of road accidents in certain specific areas on the road. This highlights the need for safety interventions and better management strategies that are targeted towards these areas. The identification of these Black Spots is an important contribution towards improving road safety. By identifying these 'black spot' areas, it becomes possible to focus on specific sections of the road that need improvement. This increased accuracy of the data provides actionable insights for the different government organizations to implement targeted initiatives for road improvement.

4.2 Conclusions

Based on the results of the study, the following conclusion can be drawn:

• It shows that in the year 2019 to 2023 the highest road accident causes is Human Factors while Environmental Condition has the lowest.

• The highest frequency of accidents is in the year 2019 during the pre- pandemic phase.

• Based on the calculated results per year, Barangay Dolores has been the highest percentage in terms of number of road accidents from year 2019- 2023 since it is the main intersection of vehicles starting from public transportations such as buses, public utility vehicles (PUV), trucks, and private owned cars.

• Barangay San Jose surpassed Barangay Dolores with the greatest number of accidents from that year with the implementation of Pandemic Quarantine Guidelines.

• Section F-G has the highest concentration of road accidents with 159 road accidents along JASA because it is an overpass intersection located in Dolores with high number of vehicle traffic.

• The analysis revealed that segment B to I with 519 road accidents while segment J to K with 29 road accidents have statistically significant concentrations of accidents, making them high-risk areas or black spots.

• This finding provides valuable data for road safety efforts by allowing for targeted interventions on specific road sections.

• Using DNN modeling can help identify black spots, but it should be backed up by another method or comparative analysis.

4.3 Recommendations

After completing the study, the researchers suggest potential areas of improvement for future studies.

• The researchers recommend that the City of San Fernando's traffic management department prioritize safety measures in the identified black spots (segments B to I and J to K). This could involve increased signage, improved road markings, speed limit adjustments, or even infrastructural changes like median barriers or dedicated turning lanes.

• Include Road Safety Audit checklist to identify the factors affecting road safety.

• The developed DNN model must be improved in terms of accuracy.

• This study can serve as a starting point for further research. By adding data sources to the existing format such as traffic volume and road geometry can be explored to improve the model for more accurate black spot identification.

• Additionally, investigate the feasibility of implementing a real-time accident reporting system to update the model continuously.

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