LEVERAGING GIS TECHNOLOGIES TO IMPROVE PASSENGER SAFETY ALONG MINIBUS TAXI TRANSIT FACILITIES IN SUB-SAHARAN AFRICA

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ABSTRACT

Geographic Information System (GIS) technologies are useful tools that can be leveraged by public transport operators and planners for improving public transport safety. Although having made a significant input on bus-based public transport systems, GIS has recently been adopted for improving informal minibus taxi services. GIS has been applied in modelling minibus taxi movement patterns and mapping vehicle safety. Little research exists on auto-passenger collisions in public transport (Wang and Cicchino, 2020) such as minibus taxis services. By leveraging the capabilities of GIS such as geocoding capabilities, Geographic Positioning System (GPS) data collection methods and Google Earth navigation tools passenger safety can be addressed by understanding the patterns such as auto-passenger collisions. In this essay, a methodology has been suggested for use in determining auto-passenger collisions at minibus taxi facilities and routes. Possible expected indicator includes auto-passenger collision frequency. The proposed method in this paper was amended from an existing methodology for hazardous bus stops identification developed by Pulugurtha and Vanapalli (2008). The amendment was done based on how an available GPS data for minibus taxis collected from Rustenburg Local Municipality can be used.

Keywords: Minibus taxi, Auto-passenger collision, Collision frequency.

1. INTRODUCTION

Upskilling and reskilling of public transport operators with Geographic Information System (GIS) knowledge is strategic to improving public transport passenger safety. Passenger safety plays a vital role in appraising quality of transit services and attracting ridership. Passenger safety is defined as reduction of risk factors that have the potential of causing injuries to passengers (Wang & Cicchino, 2020). Such injuries may arise from significant interaction resulting into collisions of passengers with transit facilities and other road users during a given trip. This essay focuses on GIS mapping of auto-passenger collisions along minibus taxi routes. Although detailed investigation was not conducted to verify, a methodology was proposed for evaluating passenger safety. GIS over the years has shown capabilities of mapping passenger safety information, facilitating quick decision making by planners and operators. At operational level, GIS was used by Pulugurtha and Vanapalli (2008) to evaluate passenger safety at bus stops which clustered the passenger collisions across bus network and obtained locations with dense collisions for safety improvement.

Auto-passenger collisions are collisions between automobiles and public transport passengers along public transport routes (Pulugurtha et al., 2007). Collisions can happen when passengers access transit services during boarding, and after alighting minibus taxis. Collisions can also happen during crossing and walking along the roads. From an accessibility point, passengers use walkways leading to the nearest stop or station; they interact with vehicles at pedestrian crossings and with other pedestrians on the walkways. Several approaches have been investigated to improving passenger safety related to accessibility and quality of services with measurable indices such as onboard security, freedom from crime, lighting, visible policing relevant for emergency responses (Wretstrand et al., 2014). Existing studies on pedestrian safety have mainly been focused on individual outputs of crash frequency, crash density, and crash rate, with minimal usage of GIS capabilities (Pulugurtha et al., 2007). In this essay, a proposed methodology was formulated to apply GIS technology in mapping and improving passenger safety.

2. WHY MINIBUS TAXIS?

Cognisant to their prevalent operation in most of the Sub-Saharan African cities (Giliomee et al., 2023; Behrens et al., 2015), minibus taxis have in recent years become a sector of scholarly interest among public transport researchers, academic institutions, and urban planners. Numerous research investments have been directed through institutions to address issues of their mobility, accessibility and informalized operations. Minibus taxis are known to operate in a flexible system with changes in routes and stops for passenger pick-ups and drop-offs. The pick-ups and drop-offs of passengers happen in various locations across the day, although over time, a pattern might develop. Auto-passenger interactions occur at minibus taxi ranks and at random stops. Figure 1 shows a random interaction of passengers at minibus taxi stops in AI generated pictures.

Figure 1: Artificial Intelligence (AI) generated pictures of depicting how passengers interact with among themselves and with other road users

Passenger interactions with other traffic such as vehicles and other pedestrians can have significant influence on their safety and leads to exposure to risk. According to the Department of Transport (2022), pedestrian crashes account for 40% of total road crashes in 2022. Insufficient research exists in measuring safety of passengers using minibus taxis. In a study conducted to evaluate the level of safety of passengers by Pulugurtha and Vanapalli (2008), pedestrian collisions were used to evaluate the performance of transit networks.

3. GIS TECHNOLOGY FOR IMPROVING SAFETY OF PASSENGERS

GIS technology uses geo-information in 2D and in 3D making it easier to draw patterns of events such as identifying minibus routes with possible stop locations as shown in the Tableau 2023.2 route map output in Figure 2. The raw data used for producing the heat map was obtained from Rustenburg Rapid Transit (RRT) through *https://lb.digitweb.co.za/login.php*. The red-hot paths show minibus routes with high speeds and dark spots show locations of low speeds in Rustenburg local municipality.

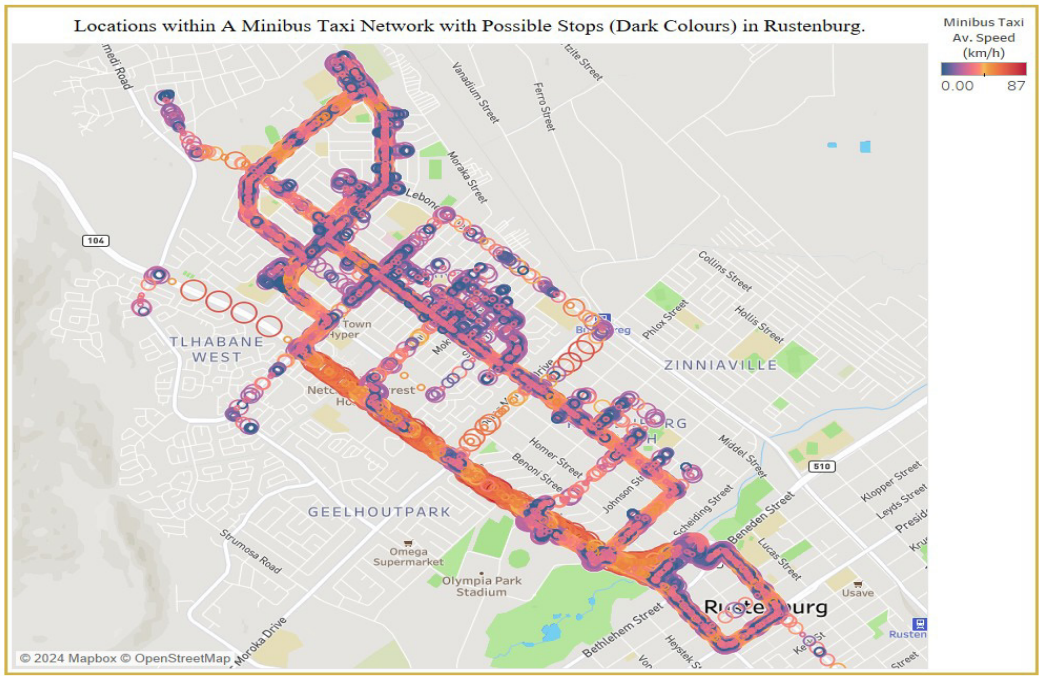

Figure 2: Minibus Taxi Network in Rustenburg local municipality

From the minibus taxi service network, possible vehicle stops for passenger boarding and alighting can be separated from mandatory stops at traffic signals by navigating the 3D interface of Google Earth. All non-traffic signal stops are filtered off. Auto-passenger collisions are investigated by undertaking collision data collection and analysis from police and hospitals for minibus taxi related crashes with their respective locations.

Auto-passenger collision information is then mapped to match the minibus taxi network using QGIS. Density maps can be used to visualize the mapped collisions as shown in Figure 3 proposed by Pulugurtha and Vanapalli (2008). Denser locations are identified for further investigation for adequacy of passenger facilities at the minibus taxi stops such as walkways, sufficient parking space for boarding and alighting passengers and the vehicle, pedestrian safety facilities for crossing mainstream traffic, etc (Rankavat & Tiwari, 2013).

Additional passenger boarding and alighting data is collected at the identified non signal stops by counting the number of passengers in each analysis period. Frequency of collisions are then determined by dividing the number of collisions in each period by the number of passengers within that period. The frequencies are superimposed on the minibus taxi network from which stops with high collision frequencies are mapped out for improvement by operating agencies. Summary of the proposed review methodology is shown in the framework in Figure 3 and possible outcomes from such an investigation in Figure 4.

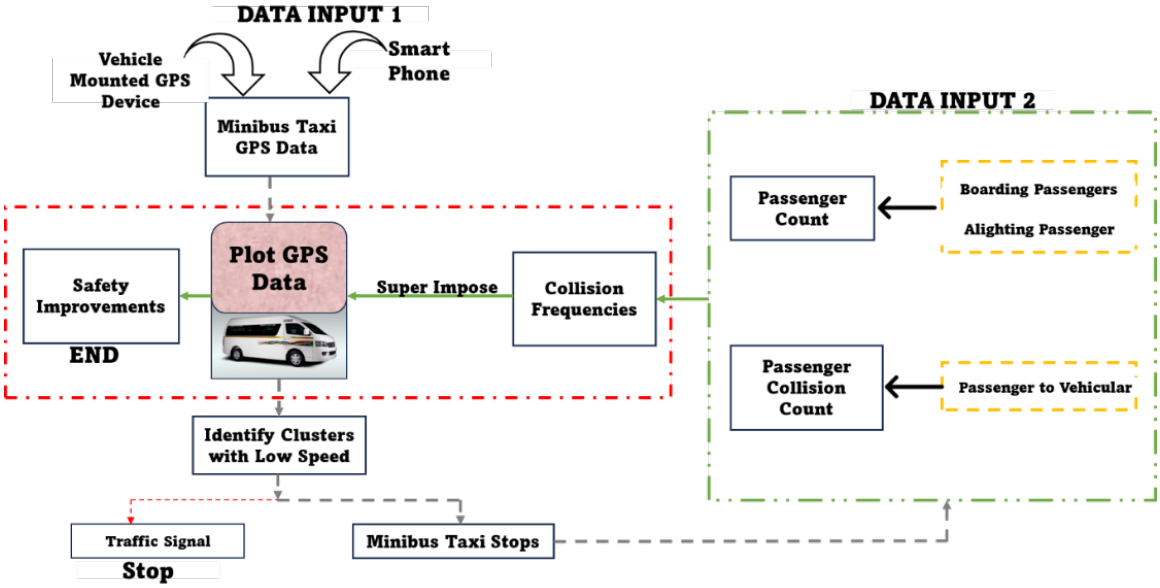

Figure 3: Proposed Passenger Safety Investigation Framework for Minibus Taxis Using GIS

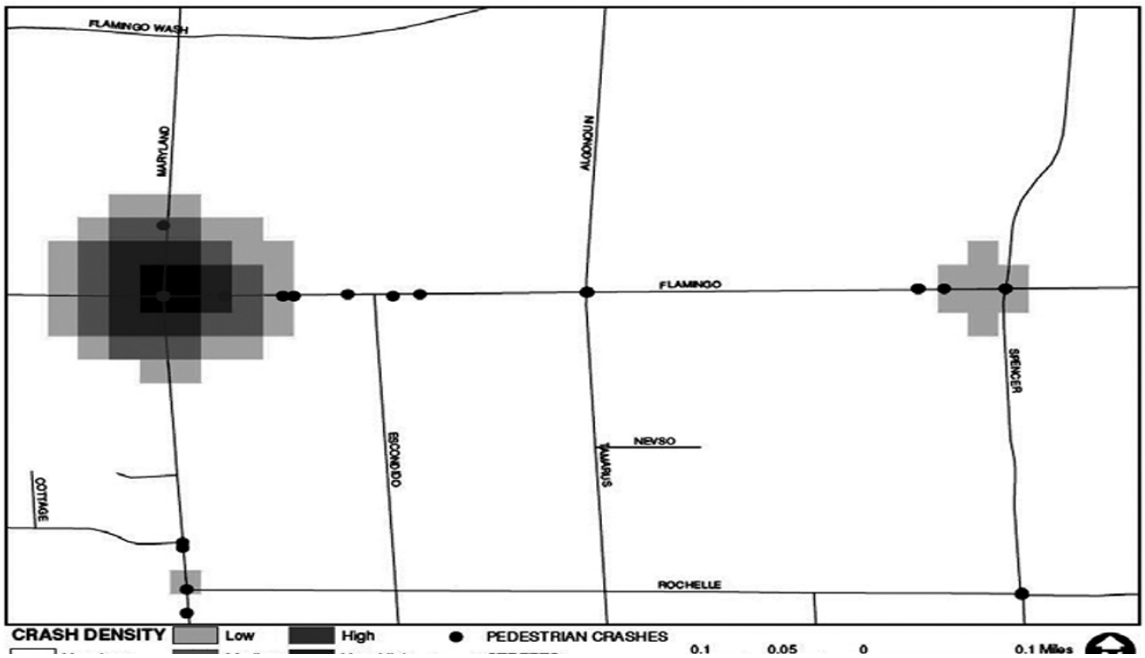

Figure 4: Passenger Collision along a Public Bus Network (Pulugurtha & Vanapalli, 2008)

4. CONCLUSION

GIS provides enormous opportunities for improving minibus taxi services. Sufficient auto-passenger collision data obtained from sources such as the South Africa Police Services (SAPS) and health facilities can be geo-mapped and synchronised with minibus taxi networks. Although the essay only focused on how possible the methodology can be customized to suit the needs of minibus taxi services, it needs to be tested for validity.

GIS geocoding capabilities to model these scenarios can efficiently influence decision making for improving minibus taxi passenger safety (Steiner et al. 2003). Little has been known about the capabilities of geocoding in improving minibus taxi passenger safety.

Therefore, urban transport planners can leverage the capabilities of GIS to improve the services of the ever-growing safety concerns in minibus taxi industry in Sub-Saharan Africa.

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