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Visualizing minibus taxi availability in the City of Tshwane Metropolitan Municipality

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Abstract:

Commuting is an important daily activity for millions of South Africans. Unfortunately, commuting is not cheap. People rely on both public and private transportation systems, depending on affordability, accessibility, and availability. Statistics South Africa reported that the primary purpose for travelling in South Africa is to reach an educational institution. This was followed by trips to and from individuals' workplaces (Statistics South Africa, 2021). Furthermore, most individuals (17.4 million) travel by foot to reach their destinations. The second-highest mode of travel is taxis, or more generally referred to as minibus taxis in South Africa, (10.7 million people), followed by 6.2 million people driving a car or truck (Statistics South Africa, 2021). It was also noted that the number of household members who rely on bus services or trains as their preferred mode of transport decreased significantly over the last couple of years. The minibus taxi industry is a critical mode of public transport in South Africa, servicing mostly the informal economy. Typically, the capacity of a minibus taxi is around 12 to 16 passengers. Minibus taxis are the most affordable and available mode of transport in the country (Fobosi, 2013), and also the most dominant (du Preez and Venter, 2022). Routes are largely ad hoc without fixed schedules, designated stops nor standardised fares (de Beer et al., 2025). So, just how available and accessible are these taxis to people in South Africa?

This abstract presents the results of a study to spatially visualize highly available taxi routes in the City of Tshwane Metropolitan Municipality, South Africa, the administrative capital of the country. Minibus taxi movement data was obtained from iSAHA, who conducted a survey of taxi movement patterns in 2013 and 2014. For their survey, they selected a 5% sample of 4 000 licensed minibus taxis in the metro and captured daily movement patterns for each taxi over a period of seven days (iSAHA, 2015): 207 taxis were surveyed, totalling 8 997 trips. The location-based data comprises vector lines, each representing one trip. Unfortunately, on-board GPS technology sometimes captures inaccurate locations due to poor satellite visibility or multipath interference (Byun et al., 2002), causing spikes (irregular vertices), data gaps, or misalignment with the actual road network. The map in Figure 1 shows Pretoria Central in the City of Tshwane Metropolitan Municipality. The map was created in ArcGIS Pro. Each black line represents one of the 8 977 trips.

The challenge of this study was to identify a geospatial visualization technique that accurately accentuates taxi availability, while reducing or hiding noise caused by data outliers such as GPS spikes and misaligned line segments. Without any cleaning of the data, we experimented with various geospatial visualization techniques to assess their ability to accentuate availability (routes with high taxi volumes) and to obscure data outliers across the metropolitan area on different days of the week and for different time slots. Figure 2 shows one of the resulting maps that accentuate routes while obscuring data inaccuracies. The map was also created in ArcGIS Pro. The taxi volume visualization is a raster image categorized in different intervals ranging from yellow (low volume) to dark red (high taxi volume) based on derived pixel values.

The contributions from this study are two-fold. Firstly, minibus taxi movement patterns are analyzed and visually emphasised to identify spatial and temporal availability of routes. Secondly, various visualization techniques were assessed for their ability to accentuate the spatial patterns of high frequency routes while minimising visual noise caused by inaccuracies and outliers. For this, the visualization capabilities of both ArcGIS Pro and QGIS were utilised. The findings are useful to those who regularly commute via minibus taxis: identifying road segments with high minibus taxi frequencies on a given day helps with day-to-day planning and ultimately saves time and money. Although the

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minibus taxi movement dataset was captured between 2013 and 2014 and is considered outdated, the methods utilized to highlight minibus taxi volume could be applied and tested on more recent data with similar characteristics. Hence, these findings are also useful for those who need to analyze and visualize data with inaccuracies and outliers.

Figure 1. Minibus taxi trips in Pretoria Central – raw data

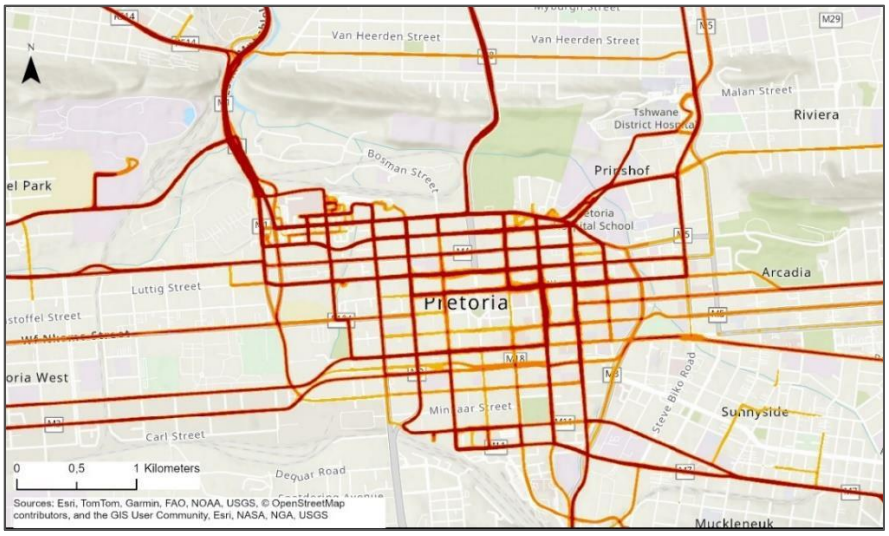

Figure 2. Minibus taxi trips in Pretoria Central – visualized to accentuate highly available routes and obscure data outliers

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