WALKING BEHAVIOR MAPPING AND SPATIOTEMPORAL ANALYSIS USING MOBILE PHONE AND GEOAI

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ABSTRACT - Currently, there is an ongoing discussion regarding the role of urban planning and transport planning in the development of walkable cities. It argues for rethinking the technology-centric approach that combines urban/transport planning and technological domains, such as developing field called Geospatial Artificial Intelligence (GEOAI). This study addressed theoretical and practical challenges in walking behavior analysis. First, map pedestrian walking behavior. Second, quantifying spatiotemporal element's impact on walking behavior is challenging. The utilization of GEOAI in this field is still deficient. The methodology of this study employs GPS-enabled location-based services to capture walking behavior and street view, isovist factors, and space syntax to quantify the environment. This method maps walking behavior using GIS and k-means clustering, an unsupervised machine-learning model used for splitting data. Additionally, Extreme Gradient Boosting (XGBoost), a supervised machine learning, is employed to analyze how spatiotemporal factors influence walking behavior. The findings highlight a significant relationship between tree view, mean depth, choice, and walking behavior. This research provides transport and urban planners with crucial insights and a novel methodological framework to develop more walkable cities, optimize urban design, transport planning strategies, and enhance urban livability and sustainability.

Keywords: Waking Behavior; GEOAI; LBS; Machine Learning; Sustainable Urban Mobility Development

1. INTRODUCTION

Enhancing walking space is a key focus in urban planning studies for the development of effective traffic and transportation plans since it influences public well-being [1]. Understanding individuals' experiences in "seconds" and "meters" opens new avenues for research and strategic decision-making [2]. To reflect walking patterns, the map must include the environmental and individual features of numerous persons' inputs [3]. Based on the existing literature review, despite its significance, few research has mapped pedestrian walking behavior with an emphasis on temporal factors. Thus, the first step is to attempt to map. In Traffic Engineering, the factors that influence vehicular behavior are frequently easy to quantify and measure. Nevertheless, determining the key measurable factors influencing walking behavior is more complex due to the dynamic nature of pedestrian experiences. The interactions between pedestrians and their environment extend beyond the straightforward metrics. Pedestrians' decisions are influenced by diverse spatial factors [3]. The second necessity is to bridge this gap by using spatial data and expressing it quantitatively for micro-scale. Third, use machine learning to explore complex non-linear relationships [4].

2. MATERIALS AND METHODS

2.1 Mapping Pedestrian Walking Behavior

This work presents a technique for studying walking patterns by utilizing mobile phone data and applying the k-means unsupervised clustering algorithm. The data are plotted using GIS. Mainly the mobile mapping approach has been considered in this stage which is about the utilization of mobile devices that are outfitted with a range of sensors to gather geospatial data in real-time. This study examined the walking behavior of 60 university students at the University of Moratuwa, with a focus on experimental methods. Initially, direct the participants to utilize their mobile devices to document their walking speed, acceleration, and other attributes within the "sensor logger" mobile application. Walking behavior clustering is performed by considering the walking speed, walking direction, and time.

2.2 Identifies the Spatiotemporal Factors Influencing Changes in Walking

Three primary metrics have been utilized to determine the spatial factors. The first seven street view factors: sky view, building view, road view, people view, tree view, sight symbol view, and road view factors, were selected based on literature to identify the built environment or the ground-level features. Deep learning for semantic segmentation is used for image analysis. The case study evaluated 170 manually captured morning and evening images using semantic segmentation. Secondly, 7 isvost factors which refer to the visibility and geometry of the walking environment, were considered. These factors include isovist area and perimeter, compactness, vista, occlusuvity, choice, and drift. Finally, 4 space syntax parameters: have been used. Then using the XGBoost machine learning model Importance is used to prioritize the spatiotemporal factors. To better understand of non-linear pattern Partial Dependence (PD) plot was employed.

3. RESULTS AND DISCUSSION

3.1 Mapping Pedestrian Walking Behavior

K-means clustering techniques derived, a total of 622-speed clusters during both morning and evening. According to both the morning and evening hours, there is a significant increase in pedestrian traffic on Bandaranayake Mawatha and Molpe Road which are located adjacent to the front of the university. In those areas, there is a high concentration of slow pedestrians that can be observed. Conversely, Anandarama Road, Degasaw Mawatha, and De Soysa Road which are situated in other parts of the university, exhibit all have higher fast-speed concentrations throughout the morning and evening. It is also, found that individuals tend to walk slower in greener environments suggesting that the presence of greenery provides a more relaxed walking. Figure 1 shows the Pedestrian concentration of slow and normal-speed clusters.

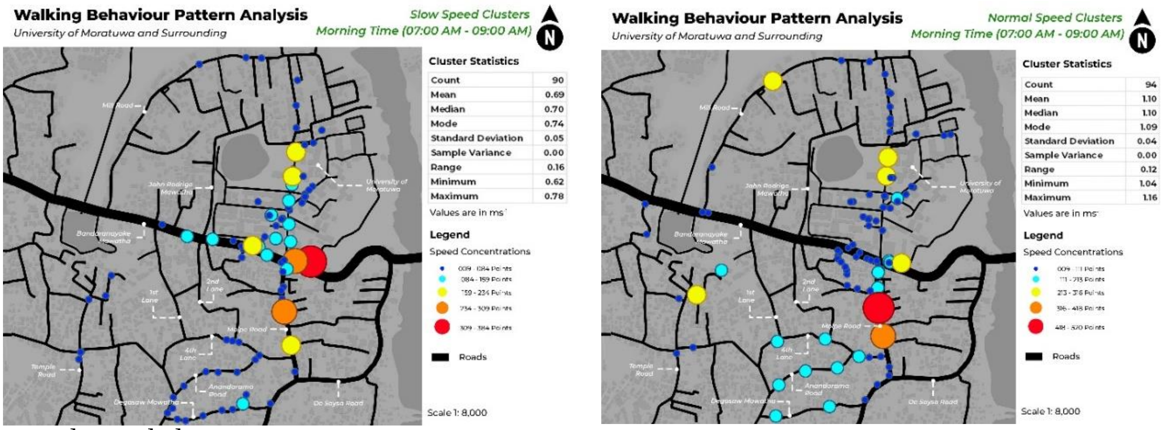

Figure 1. Pedestrian concentration of slow and normal different speed levels in morning hours

3.2 Identifies the Spatiotemporal Factors Influencing Changes in Walking

Based on important analysis the Tree View Factor is identified as the most significant factor. The overall accessibility of various areas is influenced by the mean depth, while the potential for movement through various paths is indicated by choice. These results indicate that pedestrian behavior is substantially affected by both the visual appeal and navigational complexity. In Figure 2, the first chart shows the

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most influential spatial factor affecting walking behavior, and the second PD chart shows how it varies with the actual values that need to be incorporated into the design solution.

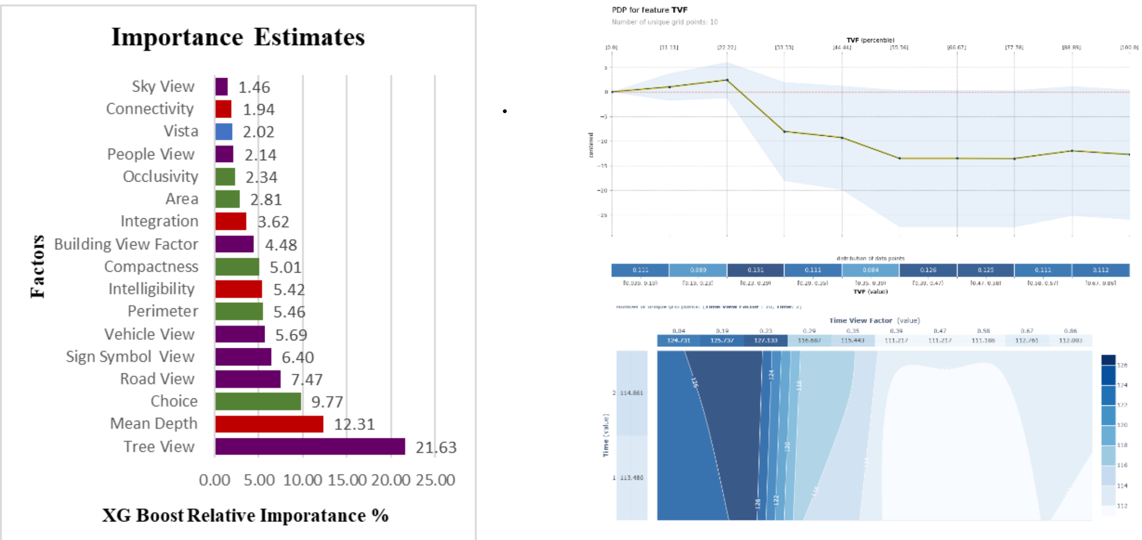

Figure 2. Result of XG Boost Importance and Partial Dependency of Tree View Factor

4. CONCLUSION

This study illustrated the efficacy of GEOAI in transportation planning, offering a novel method for enhancing the pedestrian network. By integrating real-time mobile data with advanced machine learning models, including k-means clustering and XGBoost, a comprehensive framework for evidence-based urban travel decisions was established. Significant insights into pedestrian behavior were obtained through the combination of accelerometer data, GPS-enabled services, street view image analysis, and spatial factors. Key findings, such as the impact of Tree View, mean depth, and choice metrics, are crucial for transport and urban planners to develop more walkable cities and improve urban design and transport planning strategies, ultimately enhancing urban livability and sustainability.

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