On Relationship between Pedestrian Movement and Walking Space

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１．Introduction

In Japan, there has been an increasing trend of migration to urban areas since the COVID-19 pandemic. People tend to concentrate in large cities such as Tokyo and Osaka. Therefore, people's behavior in urban spaces has various effects on their surroundings. Japanese sidewalk plans are based on standards for facilitating road traffic. The width of sidewalks is only set for two types of situations: high traffic volume and other situations. It is likely that traffic volume will fluctuate due to the concentration of people. It is unclear whether the existing roads are truly walkable.

In terms of disasters, the risk of earthquakes occurring in the future is increasing. During an evacuation, it is difficult to evacuate in an orderly manner in urban areas. Understanding people's behavior is important in order to improve evacuation route planning and the effectiveness of evacuation drills.

In addition, the percentage of bicycle accidents involving pedestrians has been on the rise in recent years. Sidewalks are most common at collision sites involving bicycles and pedestrians. Although bicycle lanes are gradually being developed on Japanese roads, they are still in the early stages of development. There are many places where bicycles and pedestrians mix, such as where bicycle lanes and sidewalks are adjacent to each other. These are important issues to consider when thinking about the safe coexistence of pedestrians and bicycles.

２．Purpose

The purpose of this study is to visualize the impact of human behavior on other forms of transportation as one of the factors to be considered when planning safe and comfortable spaces.

During rush hour and other times when public spaces are crowded, people sometimes behave differently than they do when they are alone, moving in tandem with the flow of the crowd. In this study, we refer to this as small-scale crowd flow. When public spaces become crowded, such behavior increases the risk of accidents. For example, when people gather in groups on sidewalks, their movements become more complex, which may lead them to enter dedicated lanes for bicycles and other vehicles.

３．Methods

３．１．Survey

We conducted first survey focusing on small-scale movement (small crowd movement).

For the survey, we took photos every second from the video. After that, we extracted the coordinates of people to create a ground plan, and we extracted the movements of walkers.

The survey results showed the relationship between density of people and shapes. Small crowd flows tended to form linear shapes when density was high, and then dispersed when density decreased. I concluded that density causes changes in shape.

３．２．Analysis

We believe that behavior changes depending on the density of fellow travelers as seen by the opponent, therefore we focus on density for quantitative evaluation. We performed multiple ring buffer and kernel density estimation analysis on our companions. Kernel density estimation was analyzed with a bandwidth of 90 cm. If the opponent was within the selected range, this information was added.

The analysis results showed that when passing each other, it is necessary to maintain a distance of 45 cm or more. At densities of 0.6 or higher, opponents were generally unable to walk, and walking behavior to avoid collisions was observed.

３．３．Calculation of Walkability Score

Next, we conducted second survey of walkability scores.

The survey site was the sidewalk around Hirakata Station in Osaka, Japan. We took photos between 1:00 p.m. and 2:00 p.m. We manually counted pedestrians, including those approaching from the opposite direction, in order to investigate actual pedestrian traffic volume.

People were treated as fluids with a diameter of 45 cm, and analysis was performed based on the survey results. People waiting at bus stops, lingering people, and plants were defined as obstacles. The effective walking width of the sidewalk was calculated based on the difference between the sidewalk and the obstacles. When there are many people traveling in the same direction as or opposite to the pedestrian, it is considered that walking speed may be reduced due to avoidance actions. Therefore, the occupancy rate was calculated based on the traffic volume of people traveling in the same direction and opposite to the pedestrian, and speed correction was performed. We assumed that traffic flow would differ between groups formed by friends and family and individuals, so we treated people as a fluid. In this study, we analyzed individuals as fluids of the same size.

First, the flow rate of human fluid was calculated. The total flow of pedestrians walking in the same direction and pedestrians walking in the opposite direction was calculated based on the maximum flow of people that can pass through the sidewalk and the actual number of pedestrians passing through the sidewalk. Walkability scores were calculated for each flow rate.

As a result, walkability scores were high for sidewalks with pedestrian bridges and back streets with restaurants. Walkability scores were low for streets lined with restaurants. Due to the low overall traffic volume, the differences in this analysis are considered to be relatively small. Public facilities such as bus stops and stations tend to have higher traffic volumes than other areas, resulting in lower walkability scores than the overall average. The survey site lacked sidewalks, and there were places where construction vehicles were parked on the road due to ongoing construction work. There is no human traffic there, so the score cannot be determined.

When considering traffic volume, even if the walkability score is high, it is possible that other external factors have not been taken into account. For instance, since it was noon and the weather was sunny and hot, we assumed that they were having lunch or moving around inside commercial facilities. It is also necessary to compare changes in traffic volume by time of day and weather conditions, such as commuting hours and return home times.

In this analysis, the interval length used to calculate density and occupancy rate was based on the length of the road links in the data. Therefore, as the interval length increases and the area becomes larger, the density and occupancy rate values decrease. As density and occupancy rate decrease, flow rate also decreases. It can be seen that the flow rate is low, so the score remains high. For this reason, we considered that it would be possible to derive a more detailed walkability score by dividing the range into sections based on obstacles and other factors, as this would clarify the density and occupancy rate calculated from the divided section lengths.

Future outlooks include defining the detailed values of each coefficient used in speed correction formulas and considering external factors. In addition, we will calculate walkability scores by dividing the route into sections and taking into account changes in traffic volume depending on the time of day and weather conditions. We will compare and verify the walkability score obtained this time with the walkability score that took various factors into consideration.

４． Reference

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