Grasp the Amount and Service Level of Directionally Predominant Traffic

Using Hourly Population Distribution of Docomo's Mobile Spatial Statistics Data

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1. INTRODUCTION

In carrying out urban and regional activities, traffic that varies greatly in volume depending on the direction may be necessary. For example, in large cities, the number of residents is small compared to the amount of employment in the city center, so every morning a large amount commuting travels from suburban residential areas to the city center, and in the evening, homeward traffic occurs. Or in disaster affected area, damage to lifelines and accommodation facilities results that not all people engaged in recovery and reconstruction activities can stay in the area, so supporters travel into the disaster area every morning, and returns out in the evening. If natural disasters and abnormal weather conditions reduce the capacity of roads and public transportation services, making it impossible to realize the same directionally predominant traffic as in normal times, which leads to the decline in activity levels in cities and regions.

Not only the traffic volume but also the qualitative service level, such as vehicle speed could be grasped by pre-installed traffic censors. However, it is difficult to grasp changes in traffic volume and quality within a region using observation traffic data from a limited number of locations. In this study, we aim to develop a method to indirectly grasp traffic conditions from regional population distribution data by time, even though accuracy will be sacrificed.

In this study, we use Mobile Spatial Statistics Data (MSS) provided by Docomo Insight Marketing, co.ltd, (NTT Docomo, 2013, Terada, 2014). It included an hourly population estimate for approximately one million 500m meshes nationwide. This data can obtain also subdivided population of the residence municipalities based on information of mobile phone subscribers, but finer subcategorization results of larger percentage of conceals and missing values.

MSS Data is an estimate of the population locating each hour for each mesh, and does not itself represent traffic. Then we must develop a method to grasp the amount and service level for the traffic that varies greatly in volume depending on the direction, hereafter we call "directionally predominant traffic." In this presentation, we provide explanation of the proposed method as well as the result applied to the commuting traffic of supporters residing outside of the affected area of 2024 Noto Peninsula Earthquake.

2. METHODOROLOGY

2.1 Spatially consecutive zoning

Sawamura *et al* (2024) focused on the fact that spatial movement volume can be calculated from the increase or decrease in population distribution of spatially adjacent zones, and developed a method to quantitatively grasp one-dimensional movement volume within a metropolitan area using MSS. We follow their method to capture the amount of traffic and travel distance, with introduction of residential area aggregation process at first in order to avoid the problems due to concealing in rural region, where population is sparse. In order to capture the predominant flow can be captured as traffic between zones, we set a spatially consecutive zones aggregating the regional meshes.

2.2 Zonal cumulative diagram

A cumulative diagram is a diagram that plots the cumulative number of vehicles that have passed a certain point on a road where vehicles flow in one direction against time. If three are no access or egress in between the two points on the single road section, travel time is represented by the area between the cumulative curves at respective two points (Kuwahara, 2020).

Based on the consecutive zone system defined above, we can draw a zonal cumulative diagram, which plots the number of people located both in each zone and further beyond the zone against time. If we consider the traffic of predominant direction only, each curve must increase monotonically. Oppositely speaking, if we add correction to the original zonal diagram as monotonically increasing graph beginning from zero value, the result diagram can be considered as the diagram consisted of the traffic on dominant direction from outside of the target area.

2.3 Division of staying time

In a zonal cumulative diagram above, there are both vehicles that complete their travel, and vehicles continue to move without egress; as a result, total stay time after inflow into any zone, represented by area between two cumulative curves includes both stay time after arrival to destination in that zone, and the travel time of people traveling beyond that zone. Even though this division is not unique due to the vehicle order assumption, it may sit between the two cases shown in Figure 1 and 2.

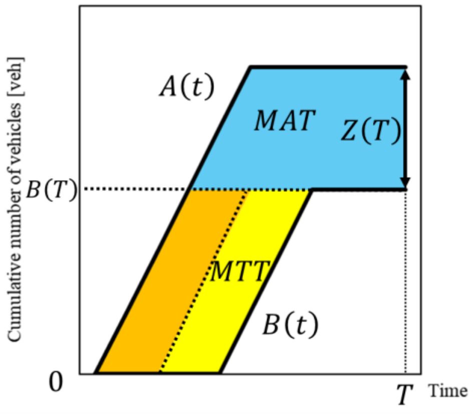

Figure 1 – *Minimum division to the time after arrival: when vehicles heading further arrive earlier.*

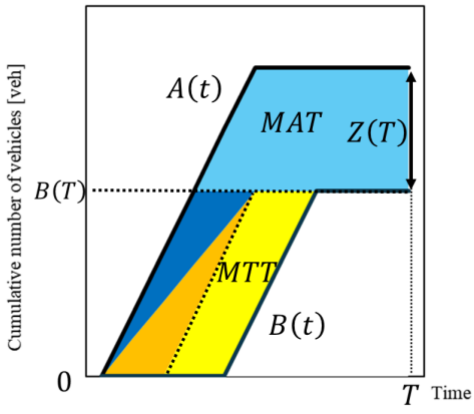

Figure 2 – *Maximum division to the time after arrival: when arrival rate to any zone is constant along time.*

2.4 Calculation of travel speed

After getting the total travel time by summarizing the travel time in all zones, average travel speed can be calculated division by the total travel distance. Seeing the changes in the average speed, we can understand the change of service level along time.

3. OUTSIDE VOLUNTEERS' TRAFFIC OF 2024 NOTO PENINSURA EARTHQUAKE

3.1 2024 Noto Peninsula Earthquake and poor access problem

Noto Earthquake occurred at 16:10 on January 1st, 2024, which caused severe damage in the Oku-Noto region, the poor road network was cut off, making it difficult for outside volunteers to move around and making it difficult to accept them, and it was also called the "too quiet disaster area."

3.2 Zone division and target traffic

The 500m meshes in the target area are aggregated into zones every 2km, from Kanazawa Station, considered to be the upstream side of the subjects' movement. The target period is from Monday, January 8, 2024 to Wednesday, July 31, 2024, and the weekly average values on weekdays are shown. From that, we prepared zonal cumulative diagrams for the morning, and the evening.

3.3 Quantitative estimation: traffic amount and average travel distance

The change in the weekly average of the total daily movement amount on weekdays is shown in Figure 3. From the second week to the fourth week of January, shortly after the disaster, it remained at around 16,000 people, but from the fifth week of January it exceeded 18,000 people, and by the third week of March it had increased to about 21,800 people. However, the number of people began to decrease around mid-April, and remained at around 19,000 people until July.

Next, we show the change in the average daily movement distance, which is calculated by dividing the total daily movement distance by the total daily movement volume. Figure 4 shows the change in the weekly average of the average daily movement distance on weekdays.

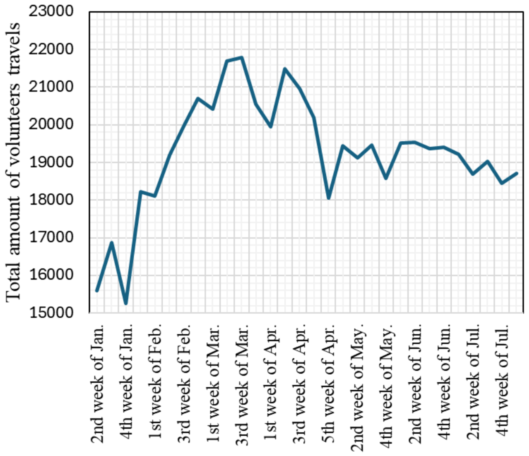

Figure 3 – *Weekly changes of weekday total amount of volunteers travels*

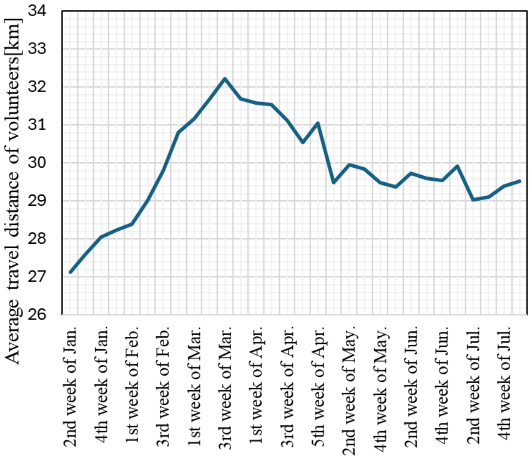

Figure 4 – *Weekly changes of weekday average travel distance of volunteers*

3.4 Qualitative estimation: average travel time and average speed

We show the trends in average travel time, obtained by dividing the total travel time by the total daily travel distance, and average travel speed, obtained by dividing the total daily travel distance by the total travel time. The results for each are shown for the morning. Figure 5 shows the trends in the weekly average of the maximum and minimum values of the average travel time on weekdays in the morning. Both the maximum and minimum values decreased significantly from the second week of January to the first week of March, and then decreased gradually until July.

Figure 6 shows the trends in the weekly averages of the maximum and minimum values of the average travel speed on weekdays in the morning. Both the maximum and minimum values rose significantly from the second week of January to the first week of March. There were no major changes thereafter, remaining almost constant until July.

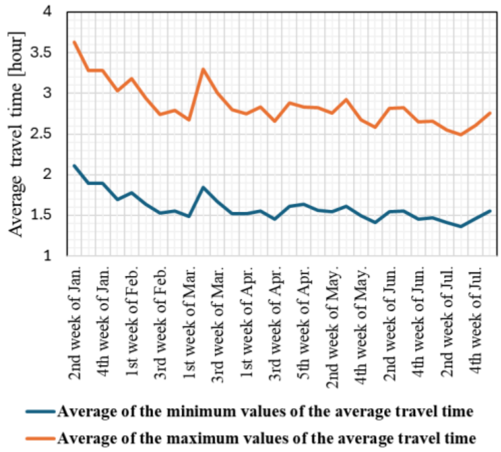

Figure 5 – *Weekly changes of weekday average travel time of volunteers*

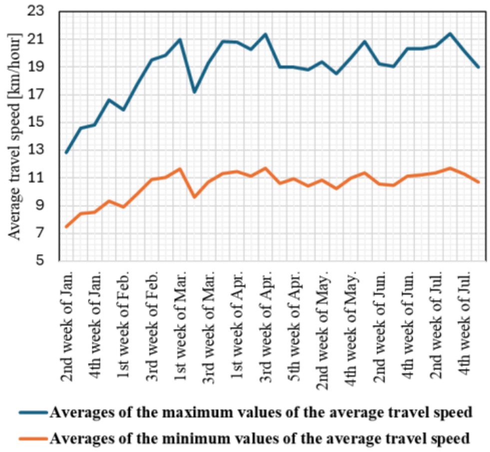

Figure 6 – *Weekly changes of weekday average travel speed of volunteers*

4. CONCLUSION

We proposed a method to calculate travel time based on the Docomo's MSS data, through zonal cumulative diagram and made it possible to calculate travel time and average travel speed in addition to quantitative indicators such as the number of people moving, travel distance. That method had applied to calculate quantitative indicators of the movement of non-disaster residents in the disaster area after the 2024 Noto Peninsula Earthquake. Future issues include proposing a method to grasp the traffic service level and changes in traffic bottlenecks for each section. The zone accumulation diagram itself represents the number of people present in each section, travel time, and flow rate. Furthermore, if the traffic density at each time point can be calculated, it will be possible to draw a Macroscopic Fundamental Diagram, which is a congestion index that captures the traffic situation.

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