Advancement of technology for understanding and analyzing human movement in urban areas

Policy development by Social Surveys and research **Reflection of results** movements MLIT Personal trip (PT) survey National survey of urban Diffusion of the Research on utilization measures Before transportation characteristics for urban traffic surveys (new Internet 1990 survey methods using GPS, etc.) Revitalization of [1997-1999] Widespread use Sophistication of personal downtown areas of cell phones trip surveys Improvement of PT -----surveys, etc. _____ Three urban development laws Reflected in the revision of Study on the utilization of Population peak, the Transportation Plan small-scale surveys (national Super-aging, Review Manual for Large-Act on Special Measures Declining PTs) in transportation Scale Development for Urban Renewal planning [2000-2002] birthrate Districts 2000s Protection of Nationwide urban Research on the improvement of Guidelines for personal information renewal PT surveys and utilization measures - panel survey on the Comprehensive Urban improvement of urban traffic Transportation System Widespread use Comprehensive urban survey methods (understanding Study (Draft) of smartphones transportation strategy changes over time) [2009-2011] [2007] Guidelines for Fact-Finding Research on personal trip Surveys and Analyses for surveys using the Web Studying Comprehensive [2014] Urban and Regional Population Urban structure Transportation Strategies and decline, Understanding flow by consolidation Rural decline utilizing big data Urban Transportation Plans for Compact + Network Specific Transportation Issues [2010] Research on the use of ICT in urban traffic surveys Site optimization plan [2011-2014] NTT DoCoMo, Inc. Mobile Spatial Statistics Reflected in the improvements COP21 Paris Low-carbon society Study on pedestrian traffic in in population statistics Agreement urban areas (image analysis, laser counters, etc.) 2010s [2014-2017] Guide to the Use of Big Productivity revolution Data in Comprehensive Urban Transportation Big data, Research on the analysis of System Surveys Reflected in [2018] ΑI wide-area flow using human location information (Utilization of mobile base Guidelines for Pedestrian Smart planning station data) Volume Surveys for [2015-2017] Measuring the Revitalization of the City Urban design [2018] Research on urban Walkable community development that responds to development diverse urban dwellers such Guide to Smart Planning Street design as tourists (Wi-Fi packet Practices sensors, GPS) [2018] [2016-2018] Study on a method for Street Design Guidelines The new normal grasping the walking flow in COVID-19 [2020] urban areas using new pandemic technology (Study on the 2020s DX combination of new technologies such as Wi-Fi Smart cities packet sensors and infrared Data-driven society counters) [2018-]

1. Outline of Studies and Activities

1) Background Events, Social Changes, etc.

Until now, the personal trip survey (hereinafter referred to as the "PT survey") has been the method used for grasping the traffic flow in cities. This method uses distributed questionnaires to conduct cross-sectional traffic surveys of pedestrians by counting the number of people, and it has contributed to the examination and evaluation of measures and plans for urban development in various situations. On the other hand, due to problems such as cost, labor, and heightened awareness of privacy, conventional traffic survey methods are becoming limited. It is also expected that urban development will increase the productivity of urban activities and the sustainability of cities by using smart planning methods that utilize transportation-related big data from the viewpoint of the need for more detailed urban development studies at the district level as well as the immediacy and comprehensiveness of the data, statistical reliability, and efficiency of acquisition.

2) R&D Agenda

For this reason, the National Institute for Land and Infrastructure Management (NILIM) is working on improving the questionnaire survey method itself, and is also working on new technologies such as image analysis, laser counters, and GPS, as well as researching methods for grasping and analyzing human movement using new technologies such as mobile phone base station data and Wi-Fi packet sensors. Combining these technologies could further our understanding and improve the analysis of human movement in cities (Figure-1).



Figure-1 Relationship between research on understanding and analyzing human movement and urban scale

3) Outline of Research and Activities

① Improvement of PT surveys, etc. (Questionnaire-type surveys)

- Increase of the reliability of PT surveys in urban areas by combining them with small-scale surveys such as the National Survey of Urban Traffic Characteristics (National PT) (2000-2012)
- (2) Enhancement of understanding changes over time through a common sample analysis of PT surveys in metropolitan areas, which are conducted approximately every 10 years (2009-2011)
- (3) Development of a personal trip questionnaire using a Web interface (2014)

Since the conventional personal trip survey by mail has a low response rate, errors, and omissions in responses, we have developed a questionnaire that can be easily filled out, even by the elderly, by utilizing a Web interface and makes it easy for the elderly to recall past behavior.

② Understanding the flow of people through the use of big data

- Improvement of population flow statistics generation method based on mobile phone base station information (Joint research with NTT DoCoMo, Inc., 2014-2017)
- Among traffic-related big data, we examined a method for grasping the traffic flow using mobile phone base station data.
- (2) Development of methods for grasping the pedestrian traffic volume using image analysis and laser counters (2014-)
- We examined a method for grasping the amount of pedestrian traffic using information and communication technology,

including image analysis and laser counters, etc.

(3) Development of technology for grasping pedestrian flow using Wi-Fi packet sensors (2016-) Among the new technologies such as mobile phone base station data and GPS data that can grasp the walking flow, we focused on Wi-Fi packet sensors, which can acquire data relatively easily and inexpensively, and we verified their usefulness.

2. Main Research Results

Development of personal trip questionnaire using a Web interface (2014)

In order to improve the PT survey method, we developed a "destination pre-input type" questionnaire based on an existing
questionnaire and an "entry-type" questionnaire in which the input method was rearranged to make it easier to recall the
respondent's behavior on the target day (Figure-2). In both formats, messages are displayed in the case of inconsistencies

and omissions in the input content related to the context of time, etc., to reduce the number of invalid responses, and the location information can be specified on a map as well as by entering text, making it easier for the respondent to visualize the place.

 In the personal trip survey and other surveys currently being conducted, efforts are being made to utilize not only mailed questionnaires but also Web-based questionnaires.

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Figure-2 Personal trip questionnaire using a Web interface

◆Improvement of "Mobile Spatial Dynamics" generation method based on mobile phone base station information (Joint research with NTT DoCoMo, Inc., 2014-2017)

 Toward the advancement of the method for understanding human flow, we organized the properties of the "Population Distribution Statistics" data, which represent the population distributed at a specific time in an arbitrary area such as a mesh or administrative district of the NTT Docomo Mobile Spatial Statistics, and the properties of the "Mobile Spatial Dynamics" data, which represent the population moving between arbitrary areas (Figure-3 and 4). We compared them with existing statistics and verified the validity of the data.



Figure-3 Trips generated from cellular base station data



Figure-4 Population distribution statistics and mobile spatial dynamics

- We compared the average number of passengers at stations, as published by railway operators, with the population distribution statistics and the transportation sharing rate of the PT survey, and confirmed the general validity.
- In addition, when comparing the Mobile Spatial Dynamics data on the Tokyo metropolitan area with the data from the PT survey on 20 Tokyo metropolitan areas, the Mobile Spatial Dynamics and the OD traffic volume of the PT survey matched to a certain extent on the intermunicipal scale (Figure-5). On the other hand, in the case of short-distance trips, such as private trips, the correlation between the Mobile Spatial Dynamics data and the PT survey data was low, and it was necessary to link with other data on a small scale.
- It is reflected in the MLIT City Bureau's "Guide to the Use of Big Data in Comprehensive Urban



Figure-5 Comparison of OD traffic volume between metropolitan area PT survey data and mobile phone base station data

Transportation System Surveys" and "Guide to Smart Planning Practice" as a method for grasping traffic flow using mobile base station data.

- ◆Development of methods for grasping pedestrian traffic volume using image analysis and laser counters (2014-)
- The estimated values using the image analysis technology and the visual count survey were compared, and the values of the image analysis and visual values of the total values during the observation time were almost identical (Figure-6).
- However, when comparing the measured values of the laser counter with the visual count survey, the road width was 4 m or less and the traffic volume was less than 400 people / 10 minutes.
- It is reflected in the MLIT City Bureau's "Guidelines for Pedestrian Volume Survey to Measure the Revitalization of Towns" and "Guide to Smart Planning Practice" as a



Figure-6 Comparison of the number of visual counts and the estimated values by image analysis

method for grasping the pedestrian traffic volume using image analysis and laser counters.

Development of technology for grasping pedestrian flow using Wi-Fi packet sensors (2016-)

Comparing the measurements from the Wi-Fi packet sensor observations and the visual count survey (Figure-7), the trend in the variation by time was generally the same. However, the ratio of measured values tended to vary by installation location.

- The pedestrian flow data showed a trend consistent with the general trend of commuters (moving toward the city center in the morning and toward the suburbs in the afternoon).
- Furthermore, the data can be observed separately for aboveand below-ground areas, and the observed values for belowground areas increase during rainy weather, etc., qualitatively confirming the movement of people.
- The MLIT City Bureau's "Guidelines for Pedestrian Volume Surveys to Measure Urban Revitalization" and



Figure-7 Image of observation survey by Wi-Fi packet sensors

"Practical Guide to Smart Planning" reflect the use of Wi-Fi packet sensors as a method for understanding pedestrian flow.

3. List of Related Reports and Technical Documents

- 1) NILIM Annual Report 2015, pp. 145, "Research on Web-based personal trip surveys" http://www.nilim.go.jp/lab/bcg/siryou/2015report/ar2015hp123.pdf
- 2) NILIM Technical Note No. 1015 (May 2018), "Cooperative research on the application of statistics information about people's movement obtained based on operational data from mobile terminal networks to transportation planning, etc." http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1015.htm
- Proceedings of the 60th JSCE Conference on Civil Engineering Planning (2019), s13-No.17, "Verification of Observation Conditions for Pedestrian Traffic Observation Using Laser Counters" https://jsce-ip.org/biannual-conference/
- Paper at the Urban Infrastructure Technology Promotion Conference (UIT) (2020), B03, "Research on gait flow observation using Wi-Fi packet sensor"

https://www.uit.gr.jp/tech_research/presentation/result.html

4. Future Outlook

There are limitations to the data that can be obtained by individual methods alone, and further improvement and upgrading of these methods is needed to increase the accuracy and usefulness of the acquired data. We will continue to conduct research to establish a method that can efficiently and effectively capture human movements while keeping the cost down, by accurately linking big data such as cell phone base station data, and combining the new method with the advantages of conventional methods. It is expected that the results of these studies will be utilized in the planning and design of urban development for the formation of sustainable cities.