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Availability of a newly developed social survey method on noise using the Internet and the geographic information system (GIS)

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ABSTRACT

The brief overview of a newly developed social survey method and its availability are reported. This research system consists of the web-based questionnaire survey about the annoyance caused by traffic noises and the estimation of the noise exposure level at the respondents' residences based on the geographic information system (GIS). By using the web-based replying system, vast amounts of response data can be obtained from extensive regions with relative ease, which has been difficult to acquire such data for traditional survey methods. Not only the dose-response relationship but also the population distribution exposed for different noise levels is possible to estimate by combining the population census data with the GIS. The availability of the newly developed method is confirmed by comparing the dose-response relationships with those obtained by the traditional methods.

1 INTRODUCTION

To promote the national noise policy effectively, it is important to understand the relationships between the noise exposure and the residents' annoyance, so-called dose-response relationships. Up to now, two social survey methods have been mainly used to make clear the adverse effect of noise in Japan. One is a face-to-face interview by investigators who visit every household and the other is an indirect questionnaire survey via mails. Additionally, the noise exposure levels of respondents have been estimated based on the data obtained by field measurements. Needless to say, these methods are not sufficient to collect a vast survey data from much wider areas.

In this research, assuming the questionnaire survey over the Internet, we have built a new survey system which consists of the recruitment and the selection of applicants for survey, the collection of survey results and respondents' location information, the management of the collected data, and so on. On the other hand, we have built another system to estimate the respondents' noise exposure level from the predicted noise level and respondents' location information using the GIS database. By building the population census data into this system, we can easily estimate the population distributions of each sound source corresponding to different noise levels as well as the individual respondent's noise exposure level. Though the

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social survey method has not been completed yet, the systems developed so far are summarized in this paper.

2 RESEARCH OUTLINE

This research system consists of a questionnaire survey on annoyance through the Internet and an estimation of noise exposure level using the geographic information system (GIS) as shown in Figure 1.

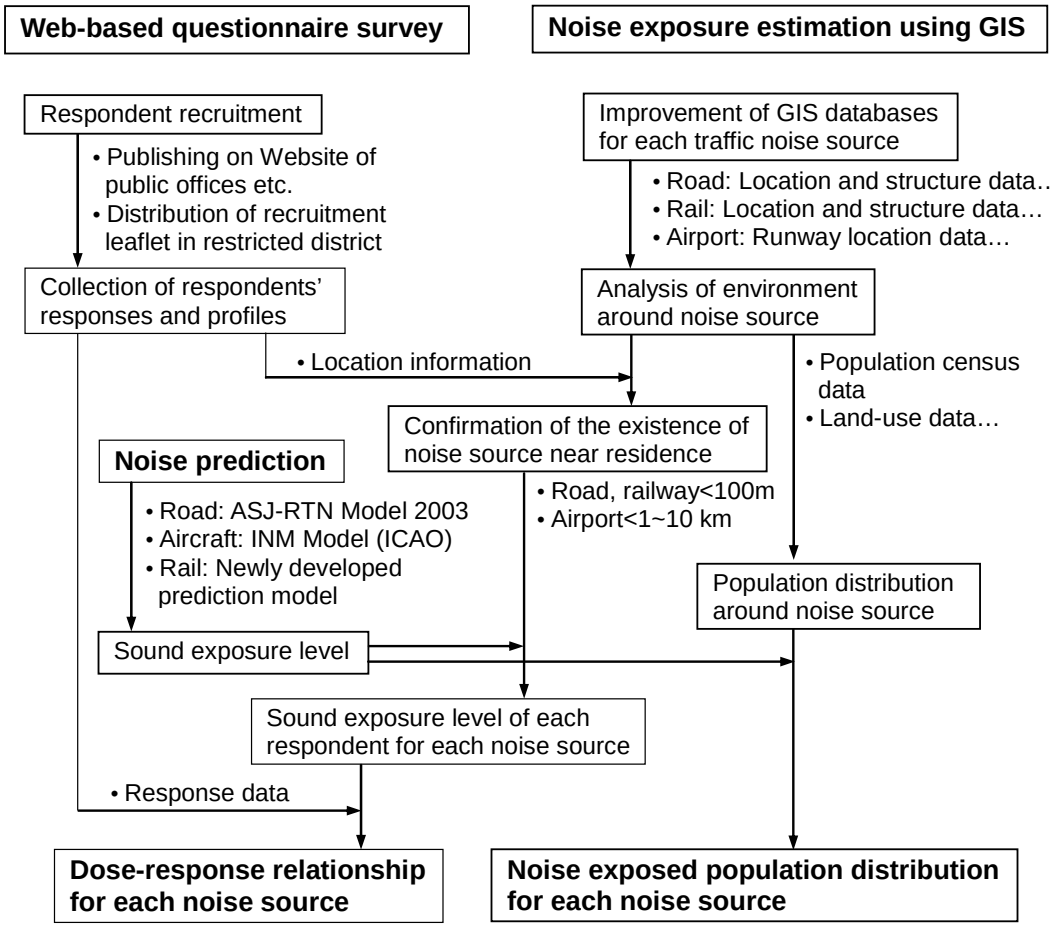


Figure 1: Research flow of the newly developed social survey method.

2.1 Web-based Questionnaire Survey

When adopting the web-based questionnaire survey to investigate the adverse effect of noise on residents, the recruitment of the survey applicants who are actually exposed to some sort of noise, the proper collection/management of the survey results and the confidentiality of respondents' personal information are the significant issues to be considered.

a. Recruitment of survey applicants

A typical way for recruiting applicants is to post a recruitment guide on the web-sites hosted by the official agencies such as the Ministry of the Environment and/or local governments. However, this method may be difficult to pick up the applicants who live in the area adjacent to a specific noise source such as road traffic or railway. To avoid this issue, we made up a recruitment leaflet and distributed it only in the area adjacent to the objective noise source as an insert of a life information journal, whose distribution area is precisely managed in each block number. The leaflet indicates the following:

- How to access the dedicated URL
- Purpose of the survey, which focuses on the living environment
- Consideration for personal information protection
- Reward for answer (1,000 yen)

The leaflet also includes an area code which varies depending on the distribution area and is required for answering the survey.

b. Collection of survey responses and respondents' profiles

Applicants can access to the survey system from a personal computer or a cell phone. By Keying in the area code provided in the recruitment leaflet, the personal information protection policy is shown on the survey system. Only applicants who agree with this policy can answer the survey questionnaire. We made up the questionnaire form based on the "*Questionnaire on Living Environment* (INCE/J-SSM-03)" which was prepared by INCE/J under the request from the Ministry of the Environment of Japan [1]. The average time to complete the survey form is about 10 minuets.

2.2 Noise Exposure Estimation using GIS

We have built a system that can estimate the sound exposure level of respondents by integrating both the results of noise prediction and the respondents' location information on the GIS database. The following summarizes the system for aircraft noise and conventional railway noise which were the research targets in 2006.

a. Aircraft noise

The GIS database for airport was improved by incorporating the information on the location and the length of runaway, the location of respondent's residence, the population distribution obtained from the census data etc. into the database. The INM Ver.6.2 developed by FAA was used for the estimation of the sound exposure level of residents. The flight path and operational conditions of aircrafts necessary for the calculation were obtained from public information and field investigations. In the calculation, a part of aircraft types was summarized into a typical category, and the takeoff profile was adjusted to the standard operation pattern provided in Japan. By overlaying the noise contour line on the GIS object, we finally estimated the sound exposure level of respondents.

b. Conventional railway noise

The GIS database for conventional railway was also improved by incorporating the information on the location of railway line, the structure and the height of rail track, the location of respondent's residence, the population distribution along the railway lines within the area of 100 m both sides using the census data etc. into the database. The noise prediction was carried out using a calculation formula introduced in 1999 [2] with some modifications. Train types, number of cars for a train, operation speed, and operation schedule etc. necessary for the calculation were also obtained from public information, paid data, field investigation, and so on.

In addition, the excess attenuation of noise caused by building cluster was calculated based on the building parameters, such as average building height, porosity of building cluster and building density between rail track and residents of respondents, derived from the GIS database.

3 RESULTS

3.1 Web-based Questionnaire Survey

In 2006, we conducted surveys on two international airports and five conventional railways, collecting 2000 responses in total from the residents around the noise sources.

a. Application rate

The method of accessing the dedicated URL was corrected several times in the process of proceeding with the survey, and was finally modified to allow applicants to connect to the URL via the Web site of Kobayasi Institute of Physical Research. As a result of this modification, the rate of application with the recruitment leaflet increased from less than 1 % to 1.8 % on average. The ratio of the applications via PCs and cell phones was about 3 to 1. Given that much more people must have cell phones than PCs, we speculate that the guard against the phishing is a cause of the lower application of cell phones.

b. Respondent attribute

Table 1 shows the age distribution of the respondents by sex. The overall ratio of male to female is 1 to 2, however, the percentage of male increases with age. Although a large number of respondents are in their thirties or forties, the distribution is more flat across the age than the interview survey conducted by INCE/J [1], in which 65 % of the respondents were 50 years of age or older.

Table 1: Gender-segregated age distribution of respondents.

Age / Sex	18-20	20s	30s	40s	50s	60s	>70	No answer	Total
female	22	223	534	304	144	56	14	31	1,322
male	11	86	160	172	100	66	61	12	668
Total	33	309	694	476	244	122	76	43	1,996

c. Available data

Almost all responses were valid for the survey on the airports. On the other hand, many responses in the railway noise survey are from the residents outside the target area, which was within 100m from the railway. As a result, about 32 % of the responses were valid. In the case of railway and road noise surveys in which the target residential area is limited, it is necessary to carefully choose the way to distribute the recruitment leaflet, such as posting.

3.2 Sound Exposure Level

The accuracy of noise prediction models is validated by comparing the calculated values with the measured values.

a. Aircraft noise

We used the field data measured by Civil Aviation Bureau of Japan at the Fukuoka Airport in 2005 and Osaka Itami Airport in 2003. The measurements include the noise of airplanes like B747-400 that are currently not in operation. The measured *WECPNL*, which is a noise index for aircraft noise in Japan, was converted to L_{den} using the empirical relationship 'L_{den}=*WECPNL*-13'. The results of comparison are shown in Table 2. While the calculated values are smaller at all points, the estimation can be practically used considering the difference of airplane types between before 2005 and now.

Table 2: Comparison between predicted values and measured values in L_{den}.

	Fukuoka Airport		Osaka Itami Airport			
	Point 1	Point 2	Point 1	Point 2	Point 3	Point 4
Predicted	62.7 dB	66.2 dB	67.8 dB	61.9 dB	56.9 dB	59.4 dB
Measured	64.5 dB	70.0 dB	68.8 dB	63.2dB	58.3 dB	63.7 dB

b. Conventional railway noise

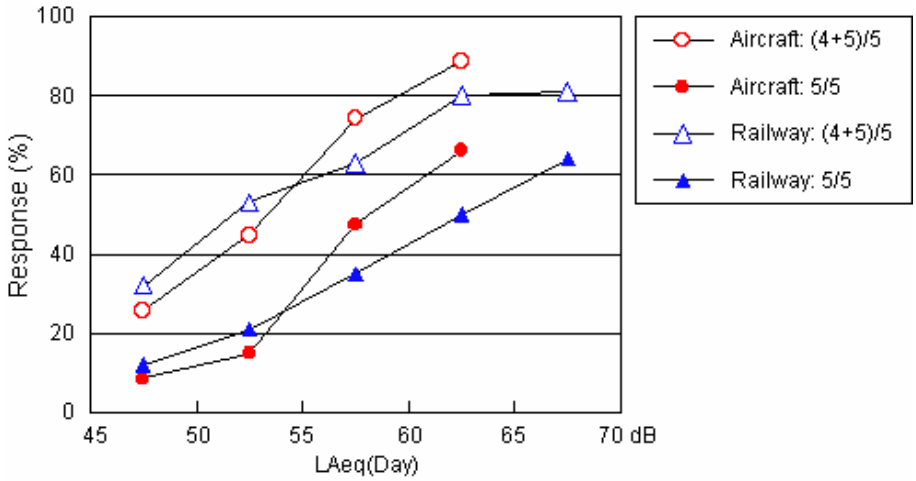
We conducted field measurements along the JR Chuo Line and the Hankyu Kobe Line. Three areas were chosen for each line. In each area, the noise of running trains was measured at six points from which the rail track can be directly seen. Table 3 shows the average and standard deviation of the difference of sound exposure level between the calculation and measurement over all measuring points in each area. Although the trend of larger predicted values than measurements is observed, it can be concluded that the calculation method we used is feasible for practical noise prediction.

Table 3: Difference between predicted values and measured values in $L_{AS,max}$.

	JR Chuo Line			Hankyu Kobe Line		
	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3
Mean value and SD of difference of $L_{AS,max}$	1.0 ± 1.3 dB	2.7 ± 1.9 dB	1.7 ± 2.0 dB	1.2 ± 1.1 dB	0.8 ± 2.7 dB	-1.6 ± 1.8 dB

3.3 Dose-response Relationships

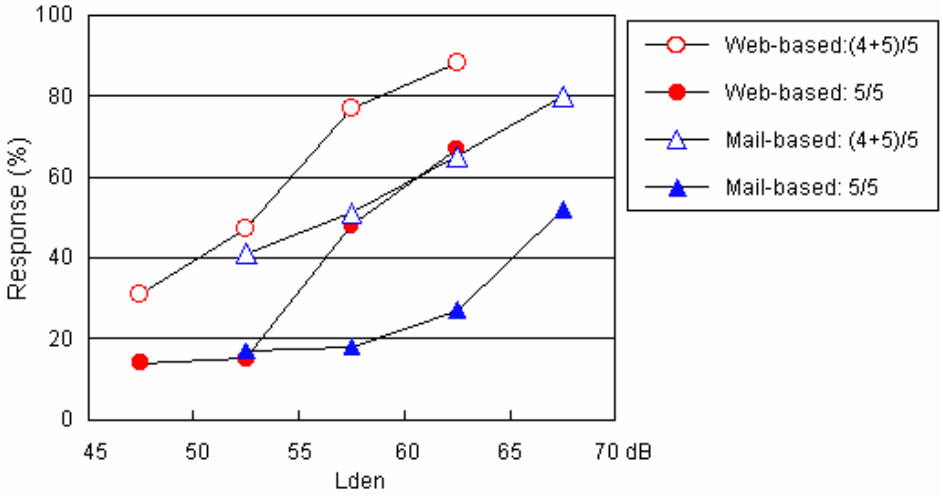
Figure 2 shows the dose-response relationships for aircraft noise and conventional railway noise, which are derived by combining the results of both the questionnaire survey and the noise exposure estimation. The horizontal axis is the L_{Aeq} during the daytime (6:00 – 22:00), and the vertical axis is the percentage of the responses for "highly annoyed (5/5)" and "annoyed ((4+5)/5)." The clear trend of increase of annoyance with increasing noise level implies that both the questionnaire survey and the exposure investigation were appropriately performed respectively.



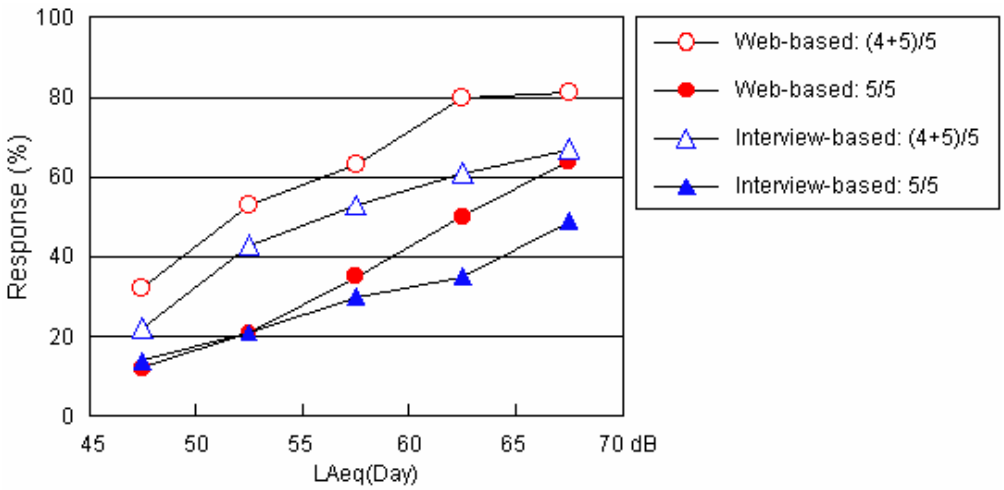
Total number of respondents – Aircraft: 588, conventional railway: 448.
Figure 2 – Annoyance vs. L_{Aeq}(Day) for aircraft and conventional railway noise.

Next, in order to verify the availability of the survey method, above dose-response relationships were compared with those which were obtained by traditional survey methods such as interviews and mailing. Figure 3 and 4 show the comparison of dose-response relationships, where the results of social surveys carried out in 1999~2000 and 2002~2003 [3, 4] are used as comparison data. It is obvious that the responses via Web-based survey are more severe than the responses obtained by the traditional survey methods. In particular, the differences tend to increase in proportion to the increase of sound exposure level.

However, considering the discrepancies such as time and area of the survey, we cannot conclude that these differences of responses originate in the difference of survey method. We intend to examine this difference in more detail by conducting a questionnaire survey based on a traditional method in the areas where we did the Web-based survey.



Total number of respondents – Web-based: 588, mail-based: 970.
Figure 3: Annoyance vs. L_{den} for aircraft noise.



Total number of respondents – Web-based: 448, interview-based: 662
Figure 4: Annoyance vs. L_{Aeq}(Day) for conventional railway noise.

3.4 Free Opinion of Respondents

In this Web-based questionnaire survey, we received a lot of opinions as a free answer from respondents. The followings are examples of favorable opinion.

- Favorability of answering by own convenience (↔anxiety of receiving an investigator's visit)
- Simplicity of questionnaire and shortness of response time
- Appropriateness of reward

On the other hand, more following opinions with anxiety and distrust of this Web-based survey were received.

- Reliability of research agency

- Leakage of private information
- Opacity of survey purpose and usage of result

It is needless to say that these factors cause low application rate. Therefore, the future task for improving the application ratio includes to eliminate the distrust toward the research agency and to arrange the environment in which the respondents can access to the survey Web-site without anxiety.

4 CONCLUSIONS

The outline of a newly developed social survey method on traffic noise using the Internet and the geographic information system (GIS) and its availability are briefly reported. We have managed to accomplish the initial objective of collecting a large amount of effective data relatively easy. However, the results of dose-response relationships suggest that we have to entrust the validity of the method to the future examination. Moreover, considering the free opinions from the respondents, it is urgently necessary to secure the reliability of the Web-based question survey method as well as research agencies. The newly revised survey method will be used for future surveys soon and further modification will be made as necessary.

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5 REFERENCES

[1] J. Kaku, et al., “Standardization of Social Survey Method in Japan,” Proceedings of INTER-NOISE 02, 2002.

[2] T. Kitagawa, et al., “Estimation of Prediction Method for Narrow-gauge railways,” Proceedings of the Meeting of ASJ 99, 1999. (in Japanese)

[3] Narita Airport Regional Symbiosis Promotion Foundation, “Report of Investigation on the Health Effects of Aircraft Noise,” March, 2003. (in Japanese)

[4] The committee set up by INCE/J, “Comprehensive research on the evaluation of noise effects,” The report of the research sponsored by the Ministry of the Environment of Japan, 2004. (in Japanese)