Assessment of a Frozen Road Surface Information System by Public Demonstration

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ABSTRACT

To promote traffic safety in the winter season, a frozen road surface information system distributed over the Internet using road information collected by taxi drivers was demonstrated in the field of Morioka City, Japan, in the winter of 2004 to 2005. The principle advantages of this system are the low costs relative utility of the system. Users indicated the usefulness of the system. However, applicability of the system was limited by the irregularity of road condition reports, which illustrated the importance of increasing the frequency and number of input sources.

KEYWORDS: Internet, Frozen Road

OUTLINE OF THE SYSTEM

A schematic overview of an information system for reporting the distribution of frozen road surfaces is shown in Figure 1. Under this system, taxis are regarded as probe cars. Upon confirming the occurrence of a frozen road surface during work hours, taxi drivers report the location and time of the observation to an operator at the taxi head office by two-way radio. The operator then locates the point on a map deployed over the web, inputs the time at which the observation was made and this data is registered in the database. A user can subsequently determine the exact location and time at which the observation was made by looking at the icons representing frozen points on the map (Figure 2). In instances when the entire area was covered with ice, it was difficult to depict the full extent of ice cover using discreet icons. We therefore designed a screenshot to represent areas that were totally frozen over (Figure 3). Consequently, frozen areas that were limited in extent like in figure 2 were defined as “frozen points” and more extensive frozen areas like in figure 3 were defined as “frozen areas”.

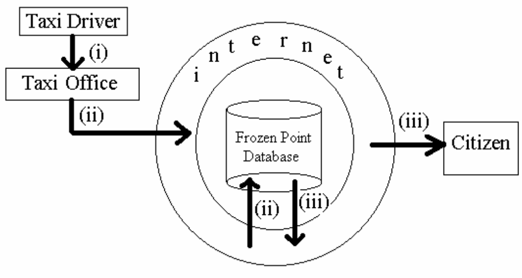

Figure 1 Schematic diagram of the system

Figure 2 Sample screenshot (1) (Frozen point)

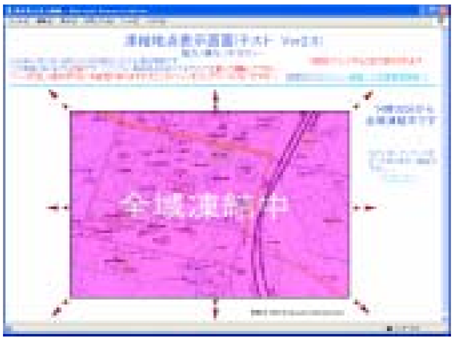

Figure 3 Sample screenshot (2) (Frozen area)

FIELD TEST

Outline of the experiment

The system was demonstrated in the field by conducting a trial in the winter season of 2004 to 2005 with cooperation of 179 taxi drivers from a taxi company in Morioka City, Iwate Prefecture. A training seminar was held for participating taxi drivers to standardize the way in which personnel submitted field reports. The field trial was conducted 24 hours a day from December 24, 2004 to March 23, 2005 (90 days). The area within the trials were conducted was approximately 40 km x 40km and consisted of Morioka City and several neighboring towns and villages. A questionnaire survey regarding the evaluation of the system was administered on the same web site.

Comparison with the previous year experiment

The prototype of this system was presented at the previous ITS conference [1]. New version contains the following modifications to that tested in 2003 to 2004.

1. Definition of “Frozen Road” by taxi driver

Last year, we initially defined a frozen road as a, “Slippery and dangerous road”. However, reports from taxi drivers of this condition were surprisingly low. Given that this definition was subjective and depended on the skill of the driver, most of whom are experienced and skilled, the definition of this condition was changed to the less ambiguous, “Road covered by snow or ice”. It was relatively easy for a driver to identify roads that were covered by snow or ice. While this definition suffered from not being able to distinguish between snow and ice, it was employed for the sake of convenience.

2. Overview screenshot

Users were able to determine the exact location of frozen points on roads by looking at a map such as the one depicted in Figure 2. However, it was difficult to view all of the frozen points in an area. In general, users only wanted to know about the condition of the route that they were planning to use. In response to this need we designed a new overview display (Figure 4). In this figure, red areas depict contiguously frozen areas and yellow areas depict frozen points.

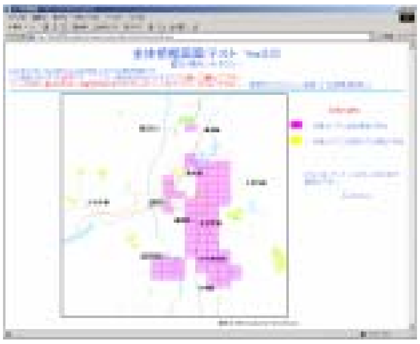

Figure 4 Overview Screenshot

3. Improved scrolling

When a user or operator scrolled a map, the application would scroll to the next adjoining screen. However, this made it inconvenient to look at areas, or input an icon, along the periphery of a map. We therefore changed the scroll function such that it would only scroll by half a page at a time.

4. Change in the reset time

The number frozen points that had been reported and captured on the maps began to accumulate on the map. However, as time passed, the condition of the road surface would change due to differences in the weather and changes in traffic. We therefore configured the system to reset all frozen information at 2 p.m. when diurnal temperatures reached their maximum. However, based on observations from the previous year, most roads would be dry by noon even after heavy snowfall the day before. Reset time was subsequently changed from 2 p.m. to 11 a.m.

RESULTS AND EVALUATION OF THE EXPERIMENT

The results of the experiment were evaluated after considering, (1) the relationship between snowfall and the report, and (2) user's reactions to the system.

Relationship between snowfall and report

1. Frozen report by taxi drivers

According to the Morioka Meteorological Observatory, the study area received a total of 35 days of snowfall exceeding 1 cm per day during the experiment. Table 1 shows the number of reports submitted by taxi drivers during the experiment. A total 2,088 reports were received and with a daily average of 24.3.

Table 1   Number of frozen reports

	Frozen point	Frozen area	Total
Total	325	1,763	2,088
Daily Average	3.8	20.5	24.3

Figure 5 shows the relationship between the number of frozen points or areas along roads reported by taxi drivers and the depth of snowfall. The correlation coefficient was 0.66, with null hypothesis testing indicating a correlation threshold of 1%. The increased incidence of ice on the roads increased in response to increased snowfall was reflected by an increase in the number of icons and frozen areas displayed by the system. This finding indicated that the system worked appropriately.

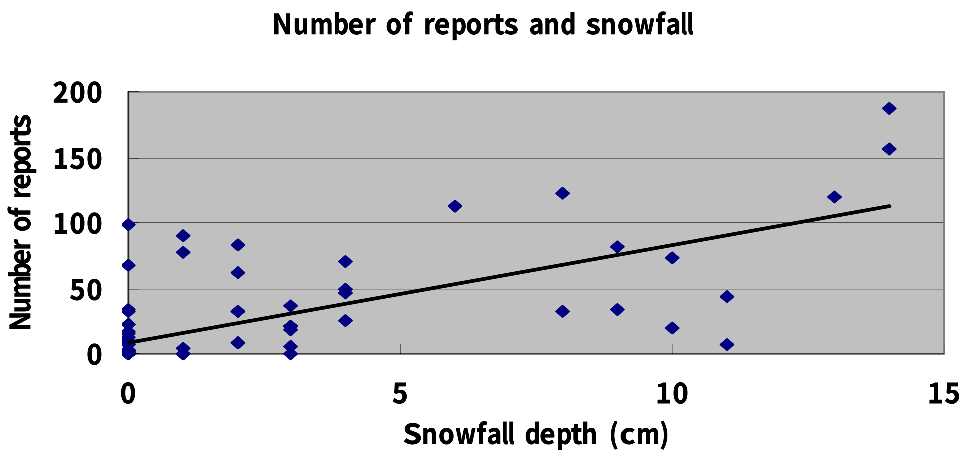

Figure 5　Correlation between observed snowfall and reports

A multiple regression analysis was conducted to determine the relationship between snowfall and reports (Table 2). The number of reports was treated as a criterion variable while snowfall per day and snow depth were treated as explanatory variables. The result shows a slightly higher multiple correlation coefficient (r=0.71). The partial regression coefficient for snowfall depth per day was greater than snow depth, indicating that taxi drivers were more sensitive to snowfall than snow depth when reporting frozen road conditions.

Table 2　Relationship between reports and snowfall (multiple regression analysis)

	Standard regression coefficient r	Partial correlation coefficient r	Level of significance
Snowfall depth a day	0.64	0.66	p=0.0000000047
Snow depth	0.18	0.24	p=0.047

2. Geographical distribution of frozen reports

Figure 6 shows the geographical distribution map of total frozen reports for the duration of the experiment. The color of the square indicates the frequency of reports, with red blocks indicating observation frequencies exceeding 15. Compared to the center of the map where the city center is located, the relative absence of reports for the periphery of the map is apparent. This phenomenon may be a consequence of the method of data acquisition as the red areas closely reflect the service area of the taxi company. The findings also reveal that the reliability of frozen reports is high in areas frequently serviced by taxis in the city center and low near the map periphery.

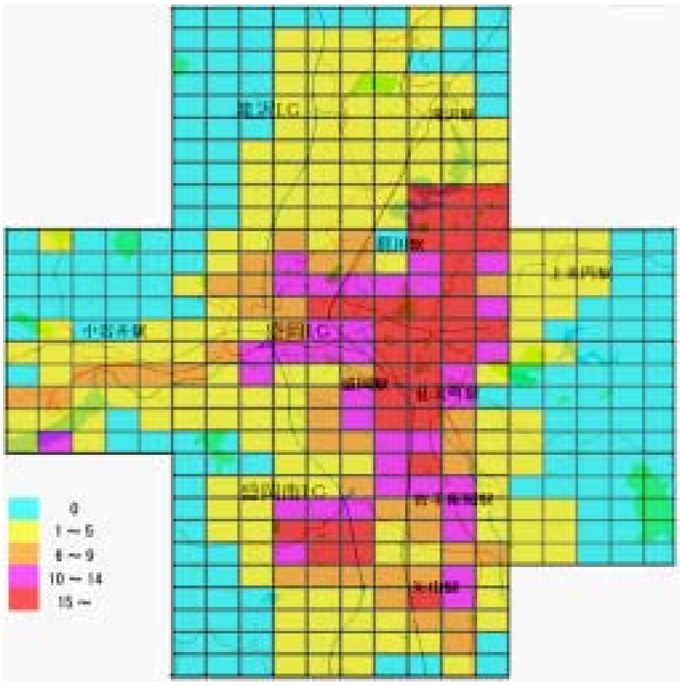

Figure 6　Frequency of frozen reports relative to city geography

User's reaction including taxi drivers

<u>1. User questionnaire administered web site</u>

While conducting the experiment, a questionnaire page was made available to users on the same web site. However, given that only 35 responses were obtained, the reliability of data acquired from the survey is unlikely to be accurate. Regarding the reliability of the locations of frozen points, 35% respondents rated the system as "high" or "fair", 24% of respondents responded that it was "unreliable" and 41% of respondents did not respond. This result may be related to the unevenness in the distribution of the reports mentioned above. Regarding the usefulness of the system, 11% of respondents responded that it was "very useful" and 52% of respondents responded that it was "useful". This means that approximately two thirds of the respondents evaluated the system positively. Many respondents indicated this system should be incorporated into a car navigation system.

2. Questionnaire survey by taxi drivers

A questionnaire survey was conducted among taxi drivers who participated in the experiment. One hundred and eleven of the 179 drivers who participated in the experiment responded the questionnaire to give a return rate of 62%. Figure 7 is a comparison between the evaluations of taxi drivers and users. Taxi drivers evaluated the system more positively than users probably because the drivers contributed more to the experiment.

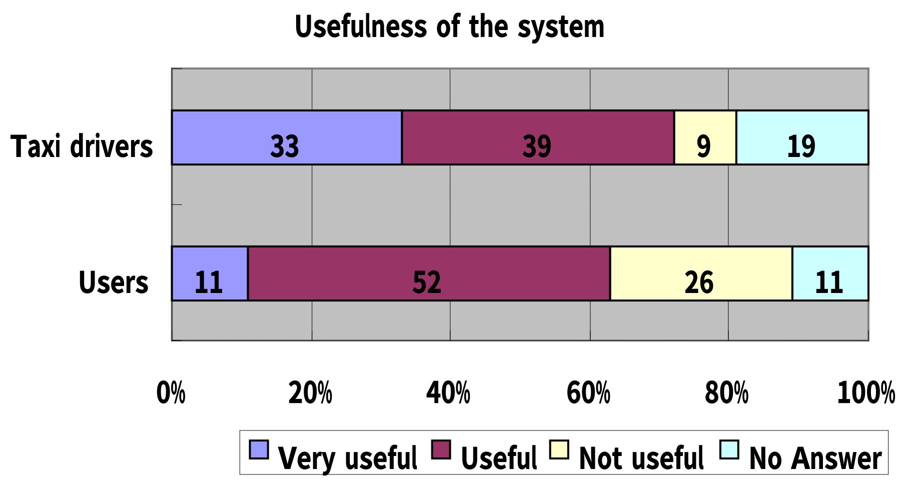

Figure 7 Evaluation of the system by taxi drivers and users

3. Website activity and access log

Access to the web site was also recorded while conducting the experiment and a total of 4,226 hits were recorded. The average daily hit rate was 54.9, which was twice that of the previous year (25.6). Figure 8 shows the number of hits on the web site by day. Access was greater during the week than on the weekends, implying that users visited the site while at work.

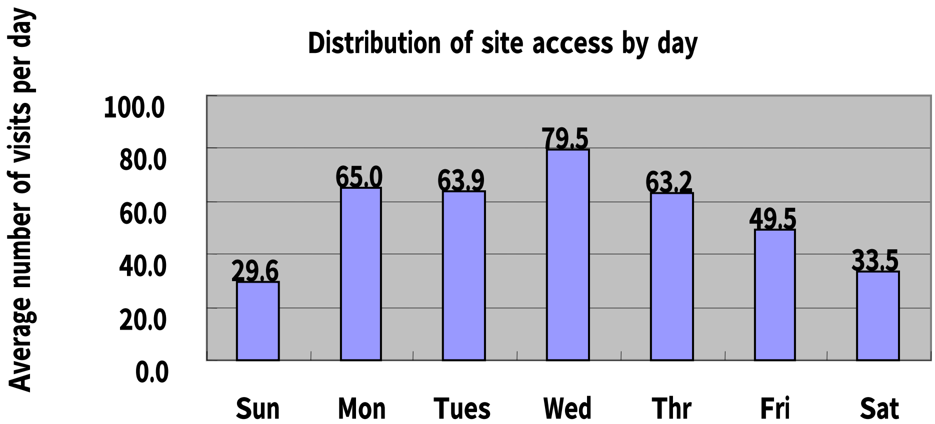

Figure 8 Number of hits per day per day

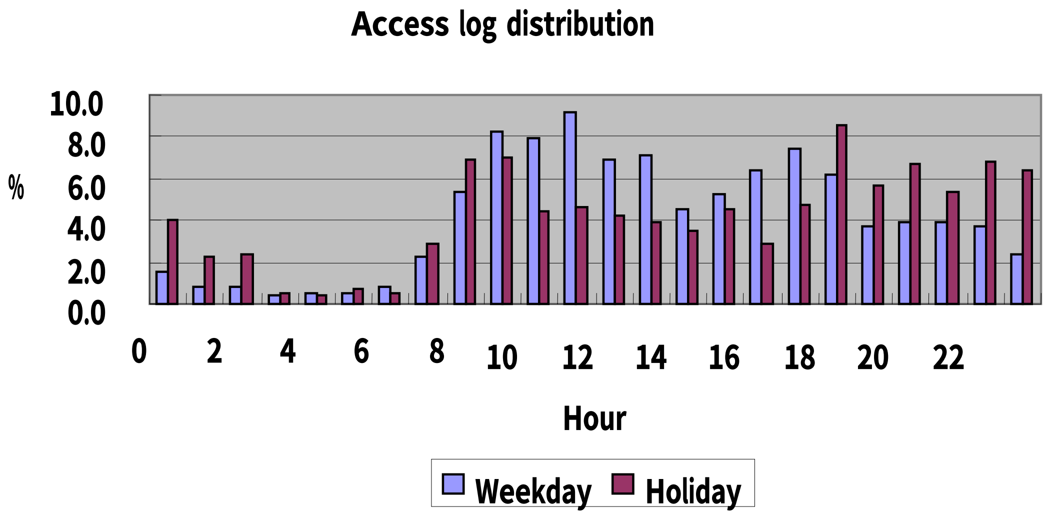

Figure 9 Distribution in access by hour

Figure 9 shows the distribution of visits to the web site by hour and day. Hits were high during the day and during the evening and low at midnight, reflecting the activities of the people. Visits peaked at 11 a.m. on weekdays and 6 p.m. on holidays. Given that users were expected to use the system for commuting, the number of hits was expected to be the highest in the morning before users left home. However, the access log shows that the number of hits was relatively low in the early morning implying that the system was not frequently used for commuting in the morning. However, the peak in the evening on weekdays implies that users used the system to check on frozen conditions in the evening before leaving their offices. Since the coverage of the internet user at a office is higher than at home, more access was made at a office than at home. Therefore access to the system in the morning was low when user was still at home. In order to assess the relationship between access and other parameters, multiple regression analysis was conducted. Snowfall depth per day, snow depth, minimum temperature per day and weekday dummy variable were selected as criterion variable. The results are shown in Table 3.

Table 3 Relationship between access and other variables (multiple regression analysis)

	Standard regression coefficient	Partial correlation coefficient	Level of significance
Minimum temperature	-0.45	-0.46	p=0.000037
Weekday dummy variable	0.38	0.42	p=0.00023
Snow depth	-0.35	-0.37	p= 0.0012
Snowfall depth per day	0.25	0.29	p=0.013

Table 3 shows that the largest correlation existed between access and minimum temperature. Users therefore accessed the site more often when temperatures were low and the likelihood of frozen areas on the road was high. Figure 10 shows the relationship between access and the minimum daily temperatures.

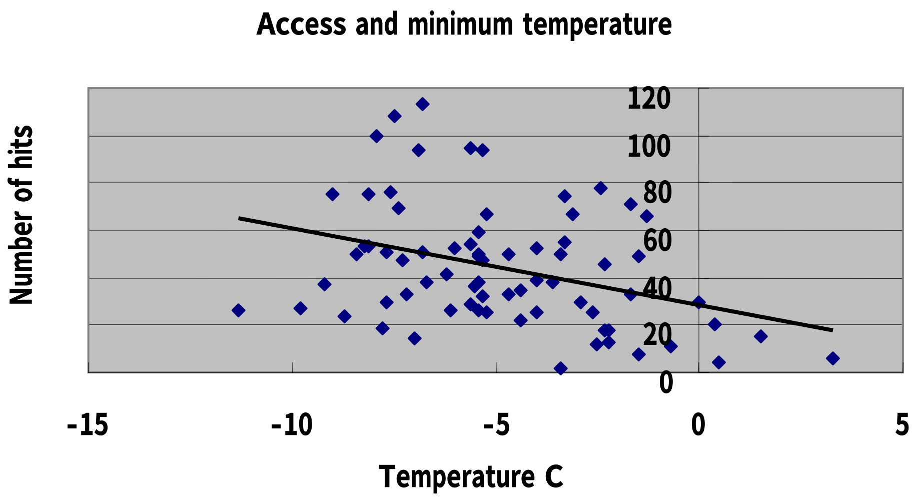

Figure 10 Relationship between number hits and minimum daily temperature

In Table 3, the inverse relationship between the number of hits and snow depth was surprising. The reasons for this relationship were not immediately apparent except that users may not need frozen road information when they know it has been snowing heavily and frozen conditions are expected.

CONCLUSION

The experiment was successfully conducted for a period of 90 days. There was a positive correlation between snowfall depth per day and the number of reports which means that the system works properly. While there was an uneven distribution in the geographic distribution of reports, this may have been due to service area of the taxis. This apparent deficiency in the number of reports can be resolved by increasing the number of input sources to more than one taxi company. Most users and taxi drivers in this experiment felt that the system was useful. However, given the uneven distribution of reports, reliability was rated as being relatively low by users. Access statistics showed that the system was used in offices and primarily when the minimum temperature was low. Improvements to the system will involve increasing the number of input sources and adapting this information for use with a car navigation system.

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[1] T. Takayama, Y. Motoda, S. Kamafuchi, H. Ohkubo, T. Ikeda, Y. Sano, S. Abe - EXTENSION OF INFORMATION SYSTEM FOR FROZEN ROAD SURFACES AND ITS PUBLIC DEMONSTRATION EXPERIMENT, In Proceedings of the 10th World Congress on ITS, Nagoya, ITS, Japan, 2004

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