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Evaluation of a Privacy-Enhanced Survey System

Atsushi Iwai

Faculty of Social and Information Studies, Gunma University, 4-2 Aramaki-mach,

Maebashi City, Gunma Prefecture, 371-8510, Japan

iwai@gunma-u.ac.jp

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Abstract. This study evaluated a privacy-enhanced survey system. The basic design consisted of a framework for analyzing the input data to detect elements that could lead to information leakage and a mechanism to correct any discovered flaws by modifying the questionnaire design in the database. A previous related study only focused on evaluation data to the course evaluation system itself and thus did not analyze any course evaluation data deeply. This study examined the exact effects of jointly using the target system and target-system evaluation data. Results indicated that respondents were rather optimistic about conventional survey systems. However, the privacy enhanced design was also favored.

1. Introduction

Although conventional electronic systems designed to be used with social surveys offer various levels of privacy protection, patterns in the input data can accidentally result in personal information leakages. Thus, a survey system prototype designed to automatically prevent unintended information leakage has been proposed. The target survey system was comprised of a framework for analyzing input data to detect elements that may have caused information leakages and a mechanism for correcting any detected flaws by modifying the questionnaire design in the database. There are widely-known technical tools for enhancing privacy (e.g., k-anonymity by Sweeny ([6]) and l-diversity by Machanavajjhala et al. ([5])). However, these frameworks do not address personal information protection issues from the survey assessor perspective. Several survey projects focusing on user evaluations (e.g., course evaluation or hospital evaluation) require privacy from organizational staff to prevent the deterioration of obtained data quality. The target system is expected to be advantageous for use with this type of survey.

This study evaluated the abovementioned privacy-enhanced survey system. A prototype system has already been basically implemented and evaluated [3] in the context of course evaluation. However, the previous evaluation only focused on evaluation data to the course evaluation system itself and thus did not deeply analyze any course evaluation data. This study therefore focused on the exact effects of jointly using the target system and target-system evaluation data.

This paper is structured as follows: The next section illustrates the basic system design presented in previous studies. This is followed by two sections. The first describes the evaluation experiment while the second provides a related discussion.

2. Previous Studies

This study focused on a typical survey system design presented in previous studies [1], [3], [4]. To illustrate the inherent issues, the basic design approach was as follows: A course evaluation was conducted in a small class containing 3 male and 15 female students who were asked to complete a

single-sheet questionnaire concerning their gender and other related items. This was potentially harmful to the privacy of the male students and could have therefore deteriorated the quality of the obtained data. However, no privacy problem would have compromised the quality of student answers if the questionnaire had been divided into two sheets (i.e., the first only containing the gender question and the second only containing the course evaluation questions). The target system processed this division operation after all students had finished responding to the questionnaire and when it discovered problematic questions that could have led to information leakage. The division process was realized as a database operation designed to modify the table structure related to the questionnaire design. As the computational process was automatically triggered and was perfectly completed before the lecturer obtained the system output, no information leakage was possible (See Figure 1.)

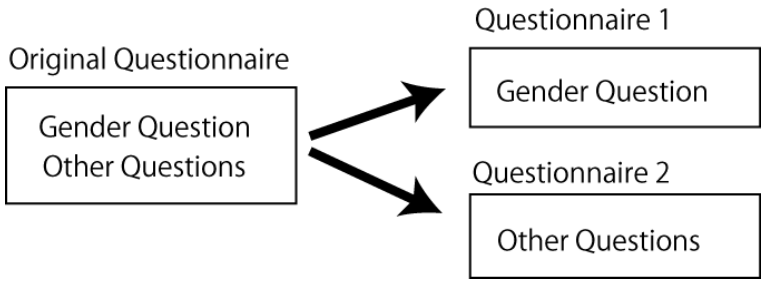

Figure 1. Modified Questionnaire Design ([3])

This system design was based on the hypothesis that all questions on a question sheet could be divided into two categories (i.e., X and Y). Here, X is defined as a category comprising individual attributes, such as gender or age, while Y is defined as a category comprising individual attitudes such as the course evaluation. For each Y category question, a cross tabulation of several X-category questions is likely to yield special cells wherein only a small number of respondents exist. These cells are likely to cause unintended information leakage. In surveys containing multiple X-category questions, the question sheet is divided by individually considering each X item (i.e., the process of protecting privacy takes the form of attribute elimination) (see the online documents from [3] and [4] for details).

3. Experiment and Results

3.1 Comparison of Course Evaluations

Three types of course evaluations were conducted in a class titled “Database” at a national university in Japan. The first was a paper-based evaluation (Ex. 1). It was conducted on the final class day by the lecturer. The second evaluation was conducted using the university’s conventional online evaluation system (Ex. 2). The input time was not limited. However, most evaluation data were expected to be input on the examination day (i.e., one week from the final class day). The third evaluation was conducted on the examination day (after explaining the system design to the students), using the target online system described in the previous section (Ex. 3).

A total of 70 respondents participated in Ex. 1; the survey was taken on January 30th, 2019. A total of 47 respondents participated in Ex. 2; data were collected from the university system on February 9th, 2019. A total of 46 respondents participated in Ex. 3; the survey was taken on February 6th, 2019.

The following were the major questions for evaluating the course evaluation system and the mean

value of answers given by student respondents (question numbers were relabeled for this paper). All questions were answerable on a scale of alternatives ranging from 1 to 4. The mean value of each question was the weighted average number of the alternatives. Alternatives 1, 2, 3, and 4 represented "Strongly agree," "Agree," "Disagree," and "Strongly disagree," respectively. However, this did not apply to Q6 through Q8. For Q6, alternatives 1, 2, 3, and 4 represented "It is very promising," "It is promising," "It is not promising," and "It is not promising at all," respectively. For Q7, the alternatives represented "very proactive," "somehow proactive," "not so proactive," and "not proactive at all," respectively. For Q8, the alternatives represented "2 hours or more," "1-2 hours," "less than 1 hour," and "did not at all," respectively. The number of the alternatives basically reflected the degree to which respondents held negative attitudes. The three numbers in each parenthesis represented the p-value of the result of the corresponding T test. For example, Ex.1-2:p-value in the parenthesis at Q1 section represents the p-value score of the T test with the result of Q1 answer in Ex.1 and Q1 answer in Ex.2.

Q1) You felt that the lecture content was interesting.
Ex. 1) 2.214 Ex. 2) 1.894 Ex. 3) 1.897
(Ex. 1-2: p-value = 0.0365*, Ex. 2-3: p-value = 0.9841, Ex. 3-1: p-value = 0.0188*)

Q2) You felt that the lecture content was easy to understand.
Ex. 1) 2.143 Ex. 2) 1.936 Ex. 3) 2.086
(Ex. 1-2: p-value = 0.1170, Ex. 2-3: p-value = 0.3081, Ex. 3-1: p-value = 0.6628)

Q3) You think that the lecture content was helpful for improving your ability to think.
Ex. 1) 1.629 Ex. 2) 1.511 Ex. 3) 1.397
(Ex. 1-2: p-value = 0.2917, Ex. 2-3: p-value = 0.2809, Ex. 3-1: p-value = 0.0257*)

Q4) You think that the lecture content was helpful for your future life.
Ex. 1) 2.229 Ex. 2) 1.979 Ex. 3) 2.017
(Ex. 1-2: p-value = 0.0860, Ex. 2-3: p-value = 0.8038, Ex. 3-1: p-value = 0.1212)

Q5) You think the lecturer taught according to the reactions and understanding level of the students.
Ex. 1) 2.014 Ex. 2) 1.957 Ex. 3) 2.069
(Ex. 1-2: p-value = 0.6795, Ex. 2-3: p-value = 0.4241, Ex. 3-1: p-value = 0.6681)

Q6) Please evaluate and classify this lecture into one of the following four levels.
Ex. 1) 1.771 Ex. 2) 1.766 Ex. 3) 1.793
(Ex. 1-2: p-value = 0.9621, Ex. 2-3: p-value = 0.8288, Ex. 3-1: p-value = 0.8364)

Q7) Did you take a proactive learning stance during this lecture?
Ex. 1) 2.171 Ex. 2) 2.064 Ex. 3) 2.155
(Ex. 1-2: p-value = 0.4183, Ex. 2-3: p-value = 0.5234, Ex. 3-1: p-value = 0.8885)

Q8) How many hours did you spend each week preparing for and reviewing this lecture?
Ex. 1) 3.086 Ex. 2) 3.085 Ex. 3) 3.017
(Ex. 1-2: p-value = 0.9964, Ex. 2-3: p-value = 0.6230, Ex. 3-1: p-value = 0.5849)

3.2 Evaluation of the Course Evaluations System

A simple evaluation of the target system was also conducted in the abovementioned class titled "Database." This was a paper-based evaluation. The following were the major questions for evaluating

the course evaluation system and the answers given by students. A total of 72 respondents participated; the survey was taken on February 6th, 2019. Alternatives a, b, c, and d represented "Strongly agree," "Agree," "Disagree," and "Strongly disagree," respectively. However, this did not apply to Q5, for which a, b, c, and d represented "It is very promising," "It is promising," "It is not promising," and "It is not promising at all," respectively.

Q1) You could understand how the system worked to increase the anonymity of the input data (i.e., by separating the questionnaire).

a)	19 [26.39%]	b)	37 [51.39%]
c)	15[20.83%]	d)	1 [1.39%]

Q2) You think that this system can contribute to the collection of more accurate course evaluation data.

a)	23 [31.94%]	b)	36 [50.00%]
c)	13 [18.06%]	d)	0 [0.00%]

Q3) You think that the lecturer gave you an accurate explanation of this system and did not deceive you.

a)	38 [52.78%]	b)	27 [37.50%]
c)	4 [5.56%]	d)	3 [4.17%]

Q4) You think that this system correctly processed data and will not cause information leakage.

a)	8 [11.11%]	b)	42 [58.33%]
c)	20 [27.78%]	d)	2 [2.78%]

Q5) Please evaluate and classify this system into one of the following four levels.

a)	21 [29.17%]	b)	50 [69.44%]
c)	1 [1.39%]	d)	0 [0.00%]

Q6) You think that course evaluations contribute to the general improvement of lectures.

a)	7 [9.72%]	b)	35 [48.61%]
c)	28 [38.89%]	d)	2 [2.78%]

Q7) You think that using this system in place of the conventional paper-based course evaluation system is a good idea.

a)	15 [20.83%]	b)	33 [45.83%]
c)	20 [27.78%]	d)	4 [5.56%]

Q8) You think that using this system in place of the conventional online course evaluation system is a good idea.

a)	15 [20.83%]	b)	38 [52.78%]
c)	17 [23.61%]	d)	2 [2.78%]

Q9) You understood the difference between "all data method" and "partial data method" within this system.

a)	4 [5.56%]	b)	28 [38.89%]
c)	35 [48.61%]	d)	5 [6.94%]

Q10) You think that "partial data method" is better than "all data method" within this system.

a)	8 [11.11%]	b)	39 [54.17%]
c)	23 [31.94%]	d)	2 [2.78%]

4. Discussion

In 3.1, the mean values of Ex. 3 were expected to be larger than those from Ex. 1 and Ex. 2. However, no such statistically significant difference was observed. For an example, with the Q1 section, the p-value of Ex. 3-1 was 0.0188*, but the Ex. 3 score was smaller than that of Ex. 1.

The above student answers first indicated that respondents seemed rather optimistic about conventional survey systems. The different number of respondent among each survey also seemed to affect the results. Students were basically reluctant to participate in course evaluations. Perhaps only the more proactive students participated in the online methods and helped to improve the evaluation scores.

On the other hand, the privacy enhanced design was rather favored at the same time. Answers from 3.2 indicated that users thought the prototype system offered improved privacy (answers to Q1, Q2, Q3, and Q5 were significantly positive). Results from the other questions were not fully positive, however, and thus require further examination. The negative answers given for number 22 in Q4 were remarkable. Students indicated skepticism and anxiety over possible information leakages from the target online system.

5. Concluding Remarks

Experiment results indicated that the prototype system was evaluated as offering improved privacy. Respondents seemed rather optimistic about conventional survey systems, but also favored the privacy enhanced design. However, the validity of these findings are limited based on the different number of respondents among each course evaluation. Further experiments should thus be conducted. Some students also exhibited anxiety about the system processing methods based on possible information leakages. This is also an area for future examination and a specific issue for the next stage of this study.

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