Development of an Inference System for Drivers' Driving Style and Workload Sensitivity from their Demographic Characteristics

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ABSTRACT

This paper describes an investigation of the relationships among drivers' demographic characteristics, their driving style, and their workload sensitivity using questionnaire surveys. The driver's demographic characteristics included age, gender, driving experience, annual mileage, driving frequency, and region. The driving style was assessed using the driving style questionnaire (DSQ) that presents the driver's personal features about driving attitudes We evaluated the drivers' workload sensitivity using the workload sensitivity questionnaire (WSQ) that suggests what kinds of elements in driving contexts force the driver to increase the mental workload. 1616 drivers around Japan participated in the questionnaire surveys. Bayesian network modeling was applied to the responses obtained from the questionnaire surveys. The estimated Bayesian network models present that "gender" influences more factors of the DSQ and WSQ compared to the other demographic characteristics. The models indicate that no influences of the "driving frequency" were found in the DSQ and WSQ and no influences of the "driving experience" were found in the WSQ. We use the estimated Bayesian models to infer the distributions of the DSQ and WSQ factors from the driver's demographic characteristics, and evaluate one driver's score of the DSQ and WSQ compared to the other drivers with the same demographic characteristics. In addition, this inference system could be used to select the target drivers who have the focusing driving style or workload sensitivity.

Keywords: Driving Style. Workload Sensitivity, Questionnaire Survey, Bayesian Network Model

INTRODUCTION

Driver assistance systems have been developed and some systems are now installed in passenger cars. The systems, including Adaptive Cruise Control (ACC), Forward Collision Warning (FCW), and Lane Departure Warning (LDW), are expected to enhance driving safety. The specification of the assistance systems, e.g. the timing of the warning presentation, is regulated by physical parameters including safety margins between the driver's vehicle and other road users. This specification is currently common among all drivers. Presentation timings or automatic controls of driver assistance systems would be adapted to an individual driver in order to develop the next generation of the driver assistance systems, because the adaptation could contribute to improving drivers acceptance of the assistance functions (Yoshioka, et al. 2003). We should understand what kind of driver would accept what kind of interface design of the assistance systems. Description of individual driver's characteristics is essential to

find out the driver who accepts the specification of the driver assistance systems.

Driving Style

Driving a car on a road includes several aspects of cognitive and operational tasks. Personal driving characteristics have static and dynamic aspects. The static aspects correspond to usual behaviors, attitudes, and habits while driving: for example, some drivers usually drive faster and some drivers usually drive more slowly; some drivers stop securely at an intersection with a stop sign and some drivers just slow down before entering the intersection. The dynamic aspects are due to the influence of road traffic environments on the driving operations: for example, some drivers slow down when entering a narrow road; some drivers slow down when the visibility condition becomes low due to a rain. This paper focuses on the static aspects of the individual driver characteristics. In this study, the static aspects, usual diving behaviors, attitudes and beliefs regarding driving, are called “driving style”.

Although there are no standard methods to measure the driving style, the large-scale naturalistic driving study is necessary to assess objectively the usual driving behaviors (Akamatsu, et al., 2003a). Questionnaires have been usually used to measure the driving style subjectively (West and French, 1993; Lajunen and Ozkan, 2011), and several self-assessment sheets have been developed in the last years (e.g. Gulian, et al., 1989; Wiesenthal, et al., 2000). The questionnaire survey can collect large data at more reasonably temporal and monetary costs, while the large-scale field tests need huge costs.

We conducted a questionnaire survey in which about 1600 drivers participated. Some driving style questionnaires focuses on the behaviors that are related to violations and risky driving behaviors, such as running red lights and taking closer distance to the car in front. The Driver Behavior Questionnaire (DBQ), for example, measures drivers’ errors, lapses, and violations: the errors potentially leading to dangerous failures, the lapses indicating silly mistakes that result from inattention, and the violations being defined as the deliberate breaking of traffic rules (Reason, et al., 1990; Bianchi and Summala, 2004). The driving style in this study covers driver’s attitudes, habits, and beliefs regarding usual driving tasks, and we deal with the usual driving behaviors where crashes, near-crashes, and incidents are not manifested.

Some driving style questionnaires have been developed in several countries. The Driving Style Questionnaire, which has six dimensions of “speed”, “calmness”, “social resistance”, “focus”, “planning”, and “deviance”, was developed in the UK (French, et al., 1993). The multidimensional driving style inventory, which consists of eight factors of “dissociative driving style”, “anxious driving style”, “risky driving style”, “angry driving style”, “high-velocity driving style”, “distress-reduction driving style”, “patient driving style”, and “careful driving style”, was developed in Israel (Taubman-Ben-Ari, et al., 2004). Some factors are different among the countries, because road traffic environments, road traffic conditions, and traffic rules differ by country. We used “Driving Style Questionnaire (DSQ)” in this study, which was developed and distributed by Research Institute of Human Engineering for Quality Life (HQL) in Japan (Ishibashi, et al, 2007). This questionnaire includes 8 factors: “self-confidence in driving skill”, “hesitation for driving”, “impatience driving”, “methodical driving”, “preparatory maneuvering”, “cars as self-expression” “moodiness in driving”, and “anxiety about accident”.

Workload Sensitivity

Driver assistance systems are expected to reduce driver’s workload while travelling from an origin to a destination as well as to enhance the driving safety. The workload in driving situations involves energy demands in a variety of functions: perception, attention and concentration, memory, decision-making, emotional stress and anxiety, and motor muscle control. Workload sensitivity is defined as the degree to which a driver experiences or anticipates the cognitive and physical workload during the driving tasks. The workload while driving can come from several sources, including the operational characteristics of the vehicle, road traffic conditions, the route, and the conditions of the driver at the time. The multiple sources lead to a variety of individual differences of the workload sensitivities.

The influence of the driver assistance systems on the driver acceptance might be different among the drivers with different workload sensitivities. The driver assistance functions have less effect on the drivers whose workload is low under the conditions where the system will work. For example, when a driver experiences an automatic acceleration or deceleration of the ACC while approaching a lead vehicle, the driver who are not sensitive to the workload in operating vehicle controls might accept any kinds of specification of the automatic controls, while the driver with a high workload sensitivity of the vehicle controls might be concerned with each automatic operation.

The description of the workload sensitivity of an individual driver is important to evaluate the effects of the assistance systems on the driver acceptance. In this study, we used "Workload Sensitivity Questionnaire (WSQ)", which was also developed and distributed by HQL in Japan (Akamatsu, et al, 2003b).

The WSQ focuses on the continuous workload characteristics leading to the driver's fatigue and does not focus on the transitory workload while driving. This questionnaire is based on a questionnaire survey which included 116 items about driving situations and conditions contributing to higher workloads for drivers. An exploratory factor analysis of the responses produced 10 factors: "understanding traffic situation", "understanding road condition", "disturbance of concentration on driving", "driving with a low degree of physical energy", "disturbance of driving pace", "driving with physical pain or road fatigue", "understanding and searching for route", "driving with bad environmental condition in the vehicle", "frequent operation of controls", and "driving in an uncomfortable posture". In this study, we excluded the "driving with bad environmental condition in vehicle" from the WSQ factors because many participants in the questionnaire survey did not experience such driving condition.

Aims of This Study

It is hypothesized that the DSQ and WSQ can be influenced by driver's demographic characteristics such as age, gender, and driving experience. Female drivers, for example, might have the driving style that is different from that of the males. For another example, elderly drivers might be more sensitive to the changes of road traffic conditions than young drivers. The aim of this study is to investigate relationships between the driver's demographic characteristics and the DSQ and WSQ.

When we evaluate whether a driver's driving style and workload sensitivity is higher or lower, one criterion is an average of the responses to the DSQ and WSQ within the drivers who participate in the experiment or an average of the responses which we have collected in previous questionnaire surveys. However, the criterion should be changed according to the driver's demography, based on the hypothesis that the driver's demographic characteristics are related to the driving style or workload sensitivity. It is necessary to set a criteria of the DSQ and WSQ in each driver group categorized based on the driver's demographic characteristic, but that is not realistic because of huge numbers of the combination of the drivers' demographic characteristics, such as drivers' age, gender, experience, and mileage. The responses to the DSQ and WSQ have any distributions in the drivers' groups subdivided. This corresponds to conditional probability of the DSQ and WSQ when the driver's demographic characteristics (age, gender, experience,…) were given. Therefore, we used Bayes' theorem and applied Bayesian network model to the responses in the questionnaire surveys in order to describe the relationships between the driver's demographic characteristics and the DSQ and WSQ factors.

QUESTIONNAIRE SURVEYS

Methods

The questionnaire surveys were conducted several times in almost all of prefectures in Japan. The questionnaire sheets were distributed through the Web or the mail. Some participants answered the questionnaire forms on-site. We collected the responses from a total of 1616 drivers. The following drivers were out of the target of this study: the professional drivers including a bus driver, a taxi driver, and a truck driver; the drivers who had had almost no experiences in drive although they had driver licenses; the drivers who did not answer all queries.

Items

The questionnaire about the driver's demographic measures included age, gender, driving experience, annual mileage, driving frequency, and region. The driving experience corresponds to the years experienced by a driver after holding a driving license. The driving frequency is the number of times a driver drives per a week. The region presents the location where a driver drives in his/her daily living. The DSQ and WSQ were also distributed to the participants.

(1) DSQ (Ishibashi, et al, 2007).

The DSQ consists of the eight factors and each factor has two component items (some are negative scores) as shown in Table 1. The participant is asked whether the sentence is appropriate to his/her own way of driving. Responses are recorded using a four-point scale as follows: 1, It does not fit for me at all; 2, Slightly yes; 3, Relatively yes; 4, It fits me well. The score for each DSQ factor is the average of the responses to the 2 component items. Higher scores mean that the driving style described for each factor fit the driver better.

Table 1 DSQ (Driving Style Questionnaire)

Self confidence in driving skill 'I am not skillful at changing lane in congestion.' 'I have confidence in sensing the width of the car.'
Hesitation for driving 'I use a bus or train rather than a car when there is no large difference in the time required.' 'I choose a well arranged wide road with traffic lights installed instead of a narrow back road.'
Impatience driving 'I keep a sufficient distance to the lead vehicle without minding another car cutting in.' 'I like to go forward whenever possible by changing lane.'
Methodical driving 'I stop my car securely at the stop line.' 'I confirm safety when changing lane or at an intersection.'
Preparatory maneuvering 'I change the speed in far advance depending on traffic sign ahead.' 'I control speed not to stop at the red signal.'
Cars as self-expression 'I consider cars are just a means of transportation and I satisfy if they run.' 'I consider cars as a status symbol (I like to have a good looking car).'
Moodiness in driving 'I cannot concentrate on driving when troubled.' 'I drive carelessly or at high speed depending on the state of mind.'
Anxiety about accident 'I am always in fear of hitting a pedestrian.' 'I always worry about meeting a traffic accident.'

(2) WSQ (Akamatsu, et al, 2003b)

The WSQ in this study consisted of 9 factors. Each factor has three to five component items (Table 2). The WSQ deals with driving situations or conditions where drivers feel workload sensitivity, which may result in stress and tiredness. The participants are asked to indicate, on a five-point scale, whether the participant feels the workload and gets tired if the situation described in each statement continues while driving. The scales are 1, I feel comfortable to drive in this situation; 2, I drive carefully, but do not feel any workload sensitivity in this situation; 3, I feel a certain level of workload sensitivity to drive in this situation; 4, Workload sensitivity is high requiring great effort to drive in this situation; 5,Workload is so high that I do not drive in this situation. The average of the responses to the items is the score for each WSQ factor, and the scores are higher when drivers feel higher workload sensitivity.

Categorization and Results of the Data Collected

Each driver's demographic character was classified into several categories. The "age" was categorized into six classes, the "gender" was into two classes, the "driving experience" was into four classes, the "annual mileage" was into five classes, the "driving frequency" was into four classes, and the "region" was into three classes. Figure 1 presents the categorization and the results of the collected demographic measures.

We categorized the region from the viewpoint of the degree to which automobiles are necessary in everyday life.

This category was based on the rates of automobile ownership. “Low automobile reliance areas” are areas with fewer than 1.0 automobiles per household (e.g. Tokyo, Osaka, Kanagawa), “Moderate automobile reliance areas” are areas with more than 1.0 but fewer than 1.5 automobiles per household (e.g. Aichi, Hiroshima, Chiba), and “High automobile reliance areas” are areas with 1.5 or more automobiles per household (e.g. Hokkaido, Ibaraki, Gunmma).

Table 2 WSQ (Workload Sensitivity Questionnaire)

Understanding traffic situation ‘Driving on a road where there are many vehicles that perform unexpected maneuvers (e.g., motorcycles passing cars or vehicles suddenly emerging from an alley).’ ‘Driving on a road where many cars are parked along the roadside’ Other three items
Understanding road condition ‘Driving on a road where night lighting conditions change frequently’ ‘Driving on a road with a complex lane structure, such as multiple lanes for right or left turns’ Other three items
Disturbance of concentration on driving ‘Driving when the road and surroundings are difficult to see due to direct sunlight in the evening or at dawn’ ‘Driving with fragile or expensive baggage that requires careful handling’ Other two items
Driving with a low degree of physical energy ‘Driving when your physical condition is not good (e.g., headache, fever)’ ‘Driving after mentally hard work’ Other two items
Disturbance of driving pace ‘Driving in congestion requiring frequent and precise accelerator and brake control’ ‘Driving too slowly due to excessively low speed limits’ Other two items
Driving with physical pain or road fatigue ‘Driving when feeling pain, stiffness, or numbness in the legs, waist, or back’ ‘Driving for a long time without being able to take breaks (e.g., unable to find a stopping place)’ Another one item
Understanding and searching for a route ‘Driving while searching for the route or destination using guide signs or maps’ ‘Driving when it is difficult to determine your location because the road is unfamiliar’ Another one item
Frequent operation of controls ‘Driving on a road that requires careful steering and speed control (e.g., a mountain road or a road with many curves)’ ‘Driving while steering carefully and frequently due to continuous narrow roads’ Another one item
Driving in an uncomfortable posture ‘Driving in a seat that is too soft or uncomfortable for your body’ ‘Driving with an unsuitable seat position or pedal layout’ Another one item

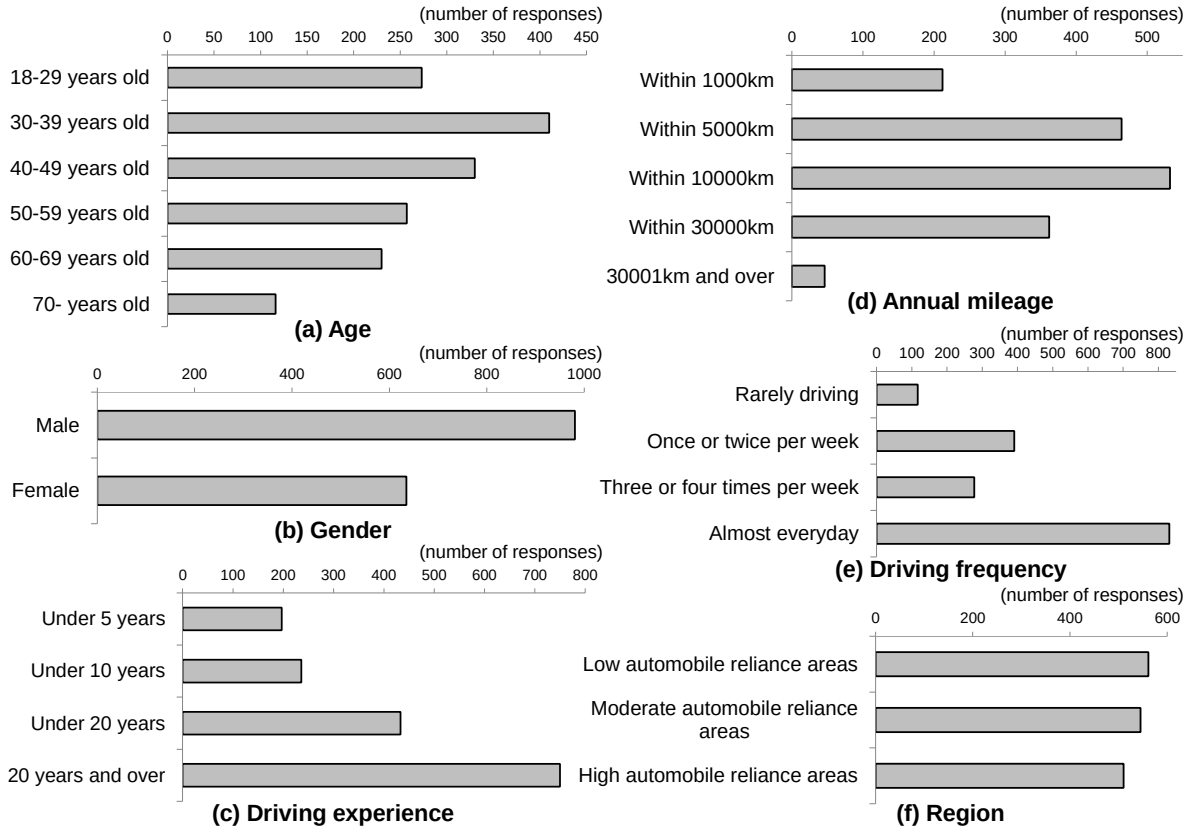

Figure 1 Results of the participants' demographic characteristics

The driver with thirties in age was the most category. More male participated, and nearly half drivers had the driving experience more than 20 years. The most category in the annual mileage was from 5000km to 10000km. About half drivers drove almost every day. And the region was similar among the three areas.

The DSQ was classified into seven categories and the WSQ was into eight categories, based on the data distributions of each factor score. Figure 2 presents averages and standard deviations of the DSQ scores and their data distributions. The averages and standard deviations of the WSQ scores are shown in Figure 3, and this also presents the data distributions of each factor. Some factors do not suggest normal distributions, especially in WSQ factors such as the scores of "Understanding road condition", "Understanding and searching for route", and "Frequent operation of controls". This supports the application of the Bayesian network model to the data collected in order to investigate the influence of the driver's demographic characteristics on the DSQ and WSQ factors.

BAYESIAN NETWORK MODEL

Methods

The relationships between the driver's demographic characteristics and the DSW/WSQ factors were investigated by Bayesian network model. This model presents causal networks between multiple parameters using a set of variables and a set of direct links between variables (Jensen and Nielsen, 2007). The direct link between A and B suggests that the two variables have a strong relationship, that is, the data distribution of the variable "A" is changed according to the variable "B", and vice versa. The connection in the Bayesian model presents a conditional probability between the objective and explanatory variables, indicating quantitative relations between the variables.

For the prior knowledge of the Bayesian network model structure, we decided that “age”, “gender”, and “region” have no parents. Only the driver’s demographic characteristics were parents of the DSQ and WSQ factors, in order to assess the relations between the demography and the driving style or workload sensitivity. The relations among the factors in t DSQ/WSQ were not focused in this paper.

K-2 algorithm was used to search for the belief-network structure (Cooper and Herskovits, 1992), and AIC was applied as the criteria when assessing the belief networks (Bozdogan, 1987).

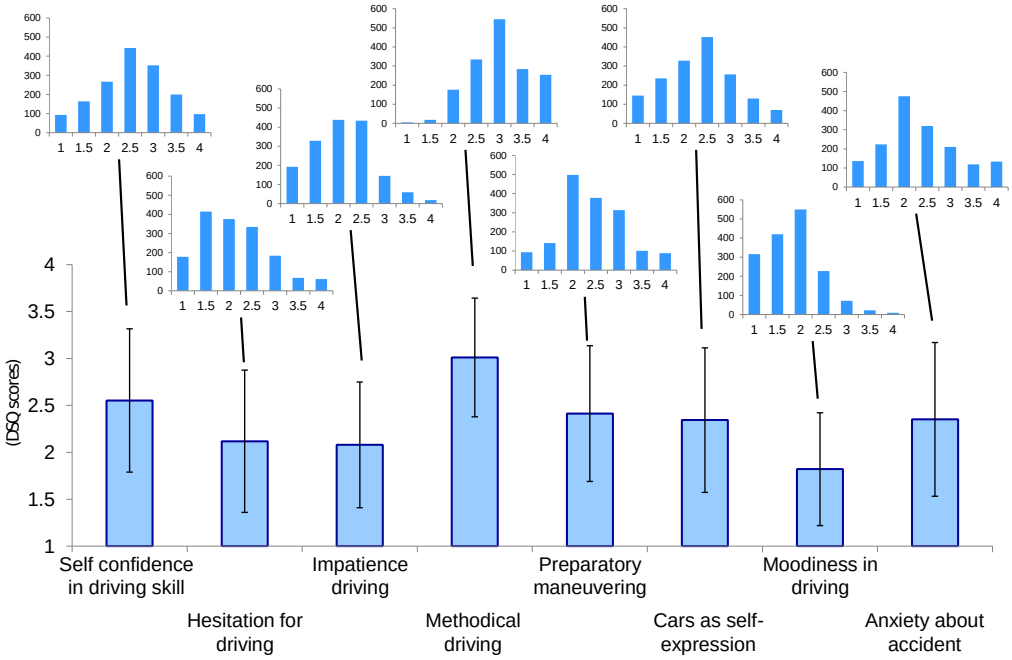

Figure 2 Averages and data distributions (numbers) of DSQ factors

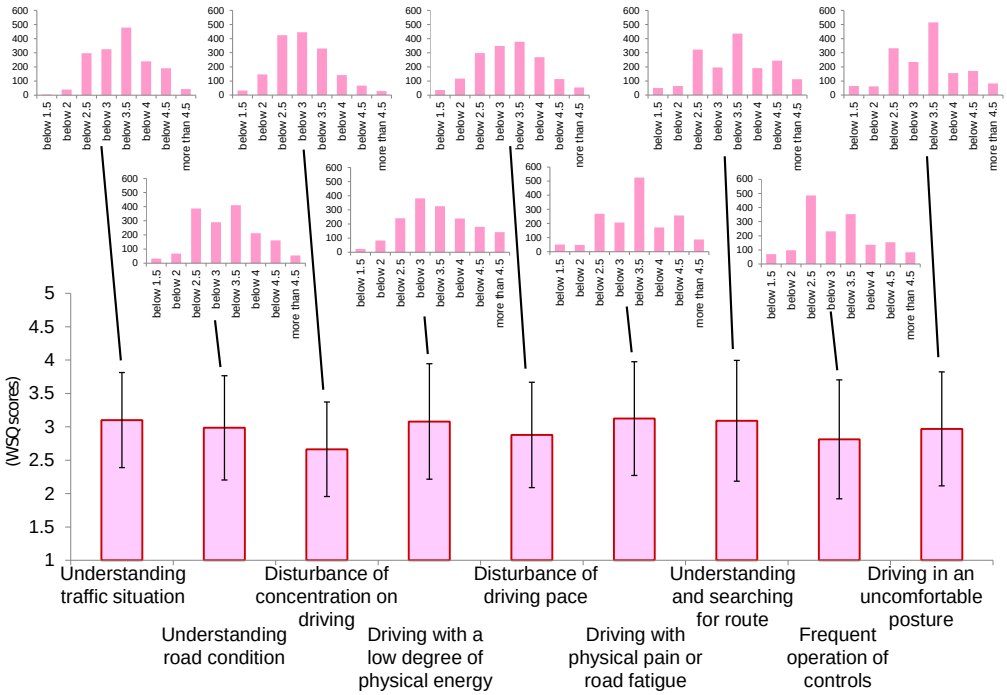

Figure 3 Averages and data distributions (numbers) of WSQ factors

Results

Figure 4 presents the result of the Bayesian network model estimation applied to the DSQ. In the demographic characteristics variables, “Age” and “Gender” has a relation with “Driving experience”. The “Gender” influences “Annual mileage” and “Driving frequency”. The “Driving frequency” influences the “Annual mileage”, and is influenced by “Region”. Only the “Driving frequency” has no direct influences on any factors of the DSQ.

The “Age” influences three factors of the DSQ: “Moodiness in driving”, “Methodical driving”, and “Preparatory maneuvering”. The “Gender” has influences on the most factors of the DSQ: “Preparatory maneuvering”, “Self-confidence in driving skill”, “Cars as self-expression”, and “Impatience driving”. The “Driving experience”, “Annual mileage”, and “Region” are related to one factor of the DSQ; “Self-confidence in driving skill”, “Hesitation for driving”, and “Impatience driving”, respectively.

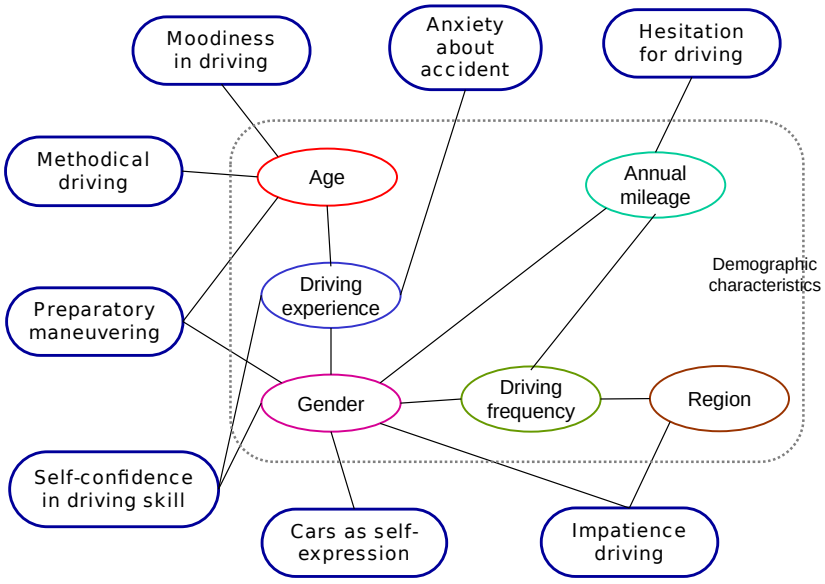

Figure 4 Bayesian network model of relationship between driver’s demographic characteristics and the driving style (the DSQ factors)

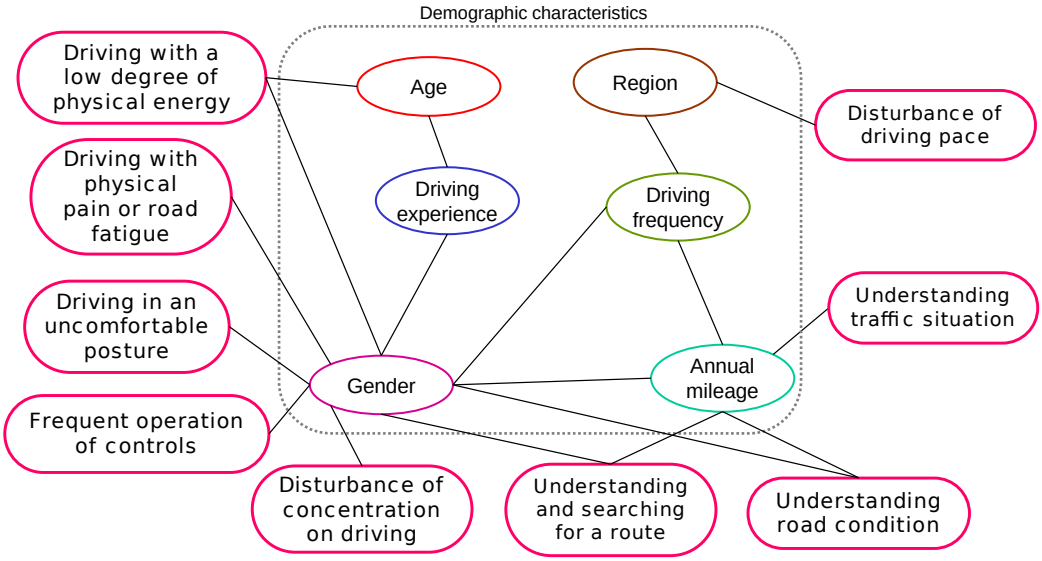

Figure 5 Bayesian network model of relationship between driver’s demographic characteristics and the workload sensitivity (the WSQ factors)

Figure 5 presents the model estimation result of the WSQ. “Driving frequency” influences no factors of the WSQ, similar to the results obtained from the DSQ. “Driving experience” also influences no factors of the WSQ. “Gender” influences the most factors of the WSQ: “Driving with a low degree of physical energy”, “Driving with physical pain or road fatigue”, “Driving in an uncomfortable posture”, “Frequent operation of controls”, “Disturbance of concentration on driving”, “Understanding and searching for route”, and “Understanding road condition”. “Driving with a low degree of physical energy” is influenced by “Age” in addition to the “Gender”. “Understanding and searching for route” and “Understanding road condition” have relations with “Annual mileage” and the “Gender”. The “Annual mileage” also influences “Understanding traffic situation”. “Disturbance of driving pace” is influenced by “Region”.

IMPLICATIONS OF THE BAYESIAN MODELS

Comparison of Driver’s Driving Style and Workload Sensitivity with Those of the Drivers with the Same Demographic Characteristics

The distributions of the DSQ and WSQ factors would be changed according to the driver’s demographic characteristics. This hypothesis is supported by the results of the Bayesian network model estimation. One application using the Bayesian network model is an inference of driver’s driving style and workload sensitivity based on his/her demographic variable (Cowell, et al., 1999). Figure 6 and 7 presents the results of the inference of the DSQ and WSQ using the Bayesian network models. The figures show the distributions of the DSQ and WSQ factors inferred from the Bayesian models as well as the averages of 1616 drivers.

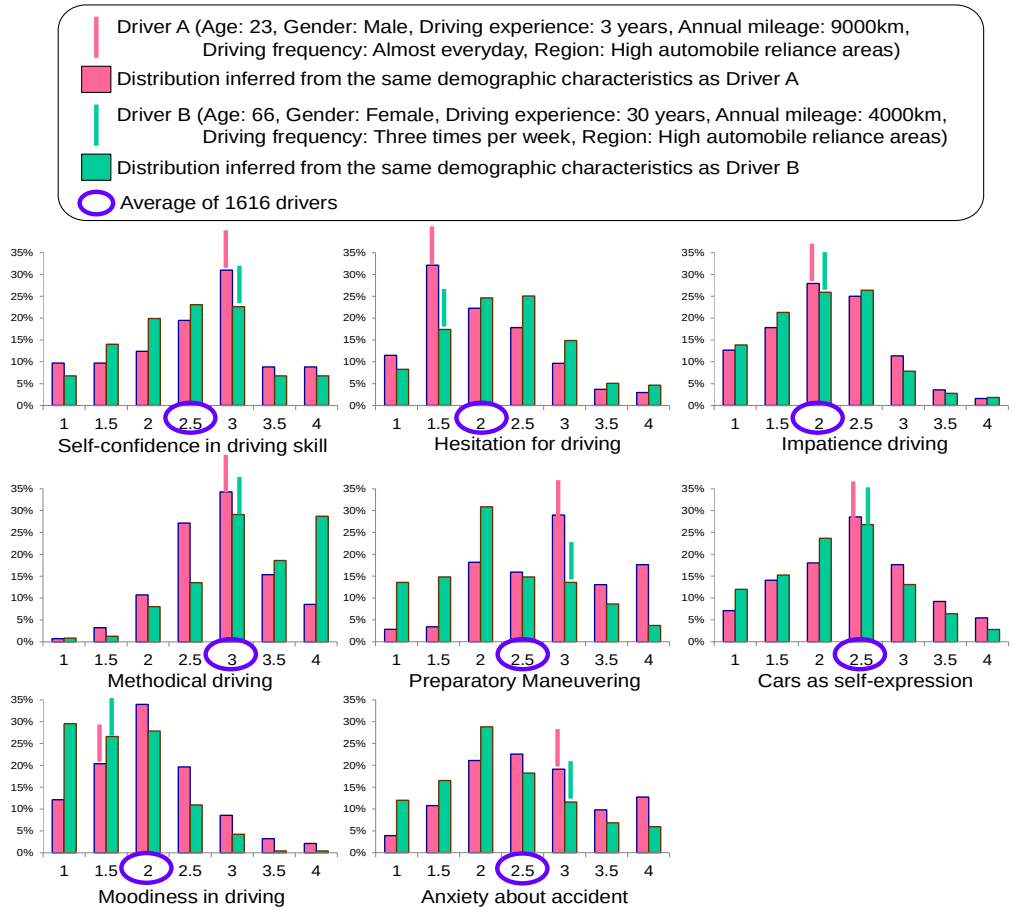

Figure 6 Evaluation of driver’s driving style in comparison with the DSQ factor distributions inferred from the same demographic drivers

Figure 7 Evaluation of driver's workload sensitivity in comparison with the WSQ factor distributions inferred from the same demographic drivers

We set two drivers as the examples of the inference. Driver A is a typical young male driver with 23 years old. His driving experience is 3 years, and his annual mileage is 9000km. He drives almost every day and lives in high automobile reliance areas. Driver B is a typical elderly female driver with 66 years old. Her driving experience is 30 years, and her annual mileage is 4000km. She drives three times per week and lives in high automobile reliance areas. When the responses of the DSQ and WSQ factors are the same between the two drivers, we compared the responses with the distribution inferred from the drivers with the same demographic characteristic and with the averages of the 1616 drivers.

In the DSQ, the "self-confidence in driving skill" responses of the two drivers are judged to be higher in comparison with the average of the sampling drivers. However, the self-confidence of Driver A is not high and is located in the category with the most numbers of the same demographic drivers. The "Hesitation for driving" response of Driver A is lower than that of the average, but the value is not lower within the distribution of the same demographic drivers. The "Methodical driving" of Driver B is equal to the average of the 1616 drivers. The response is located in the lower category when assessing it within the distribution of the same demographic characteristics. The response of "Moodiness in driving" of Driver B is lower compared to the 1616 drivers' average, but it is not lower compared to the same demographic drivers.

The assessment of the WSQ within the same demographic drivers is interpreted in the same way as the DSQ. The

"Understanding road condition" and "Frequent operation of controls" of Driver A are lower than the averages of the 1616 drivers, but these categories are located in the highest element, indicating typical responses within the same demographic drivers. When the scores of "Driving with a low degree of physical energy" of the two drivers are the highest, the response of Driver A is also the highest within the same demographic drivers. However, the highest score is typical within the drivers with the same demographic measures as Driver B. The distributions of "Disturbance of driving pace" is the same between in Driver A and B, because this factor is influenced only by "Region" and the Driver A and B live in the same region: high automobile reliance areas.

Estimation of Drivers Who should be Focused When Recruiting Participants

The Bayesian network model could be applied to an efficient participant recruiting. The feature of Bayes' theorem is an internal symmetry between the prior and posterior probabilities. We can calculate the posterior probability under the prior condition. And we can also calculate the prior probability using the Bayes' rule when we know the posterior probability of the given condition (Murphy, K. P., 1999). The feature of the Bayes' theorem indicates that the driver's demographic characteristics will be estimated using the Bayesian network models. The calculation of the inverse probability would contribute to a selection of the participants who have the driving style or the workload sensitivity on which we want to focus when evaluating a driver assistance system.

Figure 8 and 9 presents an example of the inference of "Age" and "Gender" of the target drivers using the Bayesian network models. The target driving style "Preparatory maneuvering" and the target workload sensitivity "Driving with a low degree of physical energy" are influenced by "Age" and "Gender", as shown in Figure 4 and 5. The distributions of "Age" and "Gender" are estimated when the "Preparatory maneuvering" is the highest and the lowest in Figure 8. The target drivers with high preparatory maneuvering are younger male, from 18 to 39 years old, and the target drivers with low preparatory maneuvering are elder female, over 60 years old. Figure 9 suggests that younger male drivers and elder female drivers will be recruited when the experiment will focus on the drivers who are sensitive to driving with a low degree of physical energy.

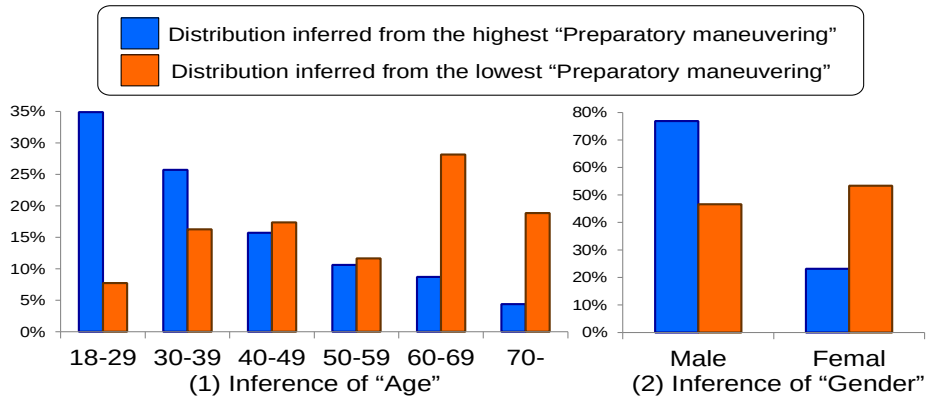

Figure 8 Estimation of the target drivers with high or low "Preparatory maneuvering"

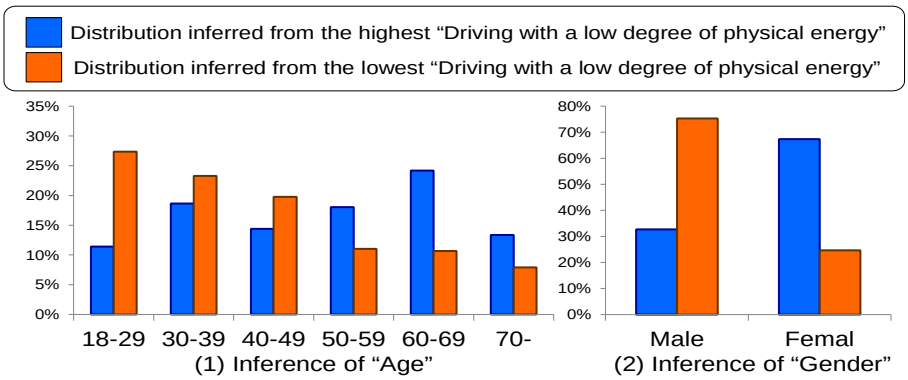

Figure 9 Estimation of the target drivers with high or low "Driving with a low degree of physical energy"

CONCLUSIONS

This study deals with an investigation of relationships between drivers' demographic measures and their driving style during usual driving and between the demography and their sensitivities to the driving workload. Driving style questionnaire and workload sensitivity questionnaire, which have been developed in Japan, were used in the questionnaire surveys focusing on a total of 1616 drivers. Bayesian network model was applied to the description of the relationships. In addition, we presented two implications of the Bayesian network models, to which the probabilistic inference of the Bayes' theorem was applied. One is an evaluation of a driver's driving style and workload sensitivity in comparison with the distribution of the drivers with the same demographic characteristics. Another is an efficient recruiting of the target drivers based on their demographic characteristics who have the driving style and workload sensitivity focused by experimenters.

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REFERENCES

Akamatsu, M., Sakaguchi, Y., Okuwa, M. (2003a), "Modeling of driver behavior when approaching an intersection based on measured behavioral data on an actual road", Proc. of The Human Factors and Ergonomics Society 47th annual meeting, pp.1895-1899

Akamatsu, M., Kurahashi,T. Ishibashi, M. (2003b), "Driver's status assessment using physical measures", Proc. of XVth Triennial Congress of the International Ergonomics Association (IEA 2003), CD-ROM

Bianchi, A., Summala, H. (2004), "The "genetics" of driving behavior: parents' driving style predicts their children's driving style", Accident Analysis and Prevention, Vol. 36, No. 4, pp.655-659

Bozdogan, H. (1987), "Model selection and Akaike's Information Criterion (AIC): The general theory and its analytical extensions, Psychometrika, Vol.52, No. 3, pp.345-370

Cooper, G. F., Herskovits, E. (1992), "A Bayesian method for the induction of probabilistic networks from data", Machine Learning, Vol.9, No.4, pp.309-347

Cowell, R. G., Dawid, A. P., Lauritzen, S. L. Spiegelhalter, D. J. (1999), "Logic, Uncertainty, and Probability", in: Probabilistic Networks and Expert systems, pp. 5-23

French, D. J., West, R. J., Elander, J., Wilding, J. M. (1993), "Decision-making style, driving style, and self-reported involvement in road traffic accidents", Ergonomics, Vol. 36, No. 6, pp.627-644

Gulian, E., Matthews, G., Glendon, A. I., Davies, D. R., Debney, L. M. (1989), "Dimensions of driver stress", Ergonomics, Vol. 32, No. 6, pp.585-602

Ishibashi, M., Okuwa, M., Doi, S., Akamatsu, M. (2007), "Indices for characterizing driving style and their relevance to car following behavior", Proc. of the 2007 International Conference on Instrumentation, Control and Information Technology (SICE), pp.1132-1137

Jensen, F. V., Nielsen, T. D. (2007), "Causal and BayesianNetworks", in: Bayesian Networks and Decision Graphs, pp.23-50

Lajunen, T., Ozkan, T. (2011), "Self-Report Instruments and Methods" in Handbook of Traffic Psychology, Porter, B. E. (Ed.), pp. 43-59

Murphy, K. P., Weiss, Y., Jordan, M. I. (1999), "Loopy Belief Propagation for Approximate Inference: An Empirical Study", Proc. of Uncertainty in AI, pp. 467-475

Reason, J., Manstead, A., Stradling, S., Baxter, J., Campbell, K. (1990), "Errors and violations on the roads: real distinction?", Ergonomics, Vol. 33, No. 10-11, pp.1315-1332

Taubman-Ben-Ari, O., Mikulincer, M., Gillath, O. (2004), "The multidimensional driving style inventory –scale construct and validation", Accident Analysis and Prevention, Vol. 36, No. 3, pp. 323-332

West, R., French, D. (1993), "Direct observation of driving, self reports of driver behavior, and accident involvement", Ergonomics, Vol. 36, No. 5, pp.557-567

Wiesenthal, D. L., Hennessy, D., Gibson, P. M. (2000), "The Driving Vengeance Questionnaire (DVQ): The Development of a Scale to Measure Deviant Drivers' Attitudes", Violence and Victims, Vol. 15, No. 2, pp.115-132

Yoshioka, M., Akamatsu, M., Matsuoka, K., Sato, T. (2003), "Aim of "Behavior-Based Human Environment Creation Technology", Proc. of XVth Triennial Congress of the International Ergonomics Association (IEA 2003), CD-ROM