"Technical Research and Development for Road Policy Quality Improvement"

Study Summary

No.	Title	Principal Researcher
No.2021-3	Design of Proactive Traffic Management on Expressways	Gifu Univ. Prof. Fumitaka Kurauchi

Research and development of a proactive traffic management approach that safely proposes behavior changes during driving through a chatbot, triggered by AI technology-based traffic nowcasts, by constructing a design algorithm for behavior change proposals using gamification.

1. Backgrounds and Objects

In recent years, there has been a growing expectation for dynamic pricing, and considering the widespread use of ETC onboard units, its technical feasibility is high. However, various options for improving traffic conditions, such as fare amounts that vary with changing traffic conditions, alternative routes including less congested surface streets, and incentives for adjusting departure times, require careful consideration as they interfere with drivers' operations.

This study explores the use of the concept of "gamification," increasingly utilized in disaster prevention and urban planning fields, and proposes behavior change through the use of "chatbots." Gamification involves applying game structures to different fields to solve problems by incorporating game elements. A chatbot is an automated conversation program utilizing AI, capable of conversing with humans seamlessly, and is considered effective under the specific condition of proposing behavior changes during driving. This study aims to develop proactive traffic management measures that actively encourage users to change their behavior while driving on highways by effectively implementing measures such as point rewards and other benefits.

2. Activities in Research Period

To achieve the above objectives, the study will develop a traffic nowcast model based on real-time observations, a behavior change design algorithm using gamification, a chatbot-based behavior change proposal system, and evaluate the

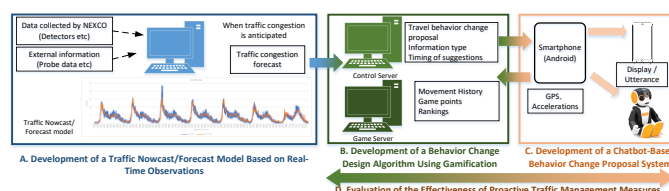Figure 1. Research overview.

effectiveness of proactive traffic management measures (Figure 1).

3. Study Results

A. Development of a Traffic Nowcast/Forecast Model Based on Real-Time Observations

Achieved the development of a traffic forecast model predicting the traffic situation the next morning, capable of forecasting four levels of congestion, and a nowcast model predicting traffic 45 minutes ahead, used as a reference for drivers' behavior changes.

B. Development of a Behavior Change Design Algorithm Using Gamification

Developed a model predicting the pre-effects of gamification and created the "Congestion Mitigation Game!!" (Figure 2).

C. Development of a Chatbot-Based Behavior Change Proposal System

Developed a control server, an app, a web-based game app, and a game app, establishing a flexible chatbot-controllable behavior change proposal system and game system.

D. Evaluation of the Effectiveness of Proactive Traffic Management Measures

Analysis of driving simulator experiments and field experiment data demonstrated that information provision using driver agents is effective as a means to reinforce proactive traffic management

measures. The app demonstration experiment revealed that some participants continuously enjoyed the game and changed their behavior. Many positive opinions were gathered regarding the idea of congestion mitigation using games, indicating a potential for the effects of gamification.

Figure 2. Game Overview.

4. Papers for Presentation

1. **Kurauchi F.**, Azuma Y., and Shibagaki T.: "Design Evaluation of 'Ooimongachi: Congestion Mitigation Game!!' Based on Gameful Design Heuristics" presented at Replaying Japan 2023, Nagoya, August 2023.

2. Matsuo Y., Kimura Y., Uno N.: "Promotion of Behavior Change by Gamification for Alleviating Traffic Congestion", JSCE Journal, accepted for publication, 2024.

3. Araki S., **Kurauchi F.**: "Construction of Traffic Forecast Model for Behavior Change Proposals on Highways," Proceedings of the 43rd Traffic Engineering Conference, 97, 659-666, 2023.

4. Asaoka T., Nakamura T.: "Fundamental Study on the Applicability of Behavior Change Through Gamification for Highway Users," Ergonomics, Vol. 58 Supplement, 1B3-06, 2022.

5. **Kurauchi F.**, Azuma, Y.: "Reviews on Potentials of Gamification Application on Infrastructure Planning," Proceedings of the Infrastructure Planning Conference, 66, November 2022.

6. Asaoka T., Nakamura T.: "Consideration for Gamification Design Aimed at Behavior Change for Highway Users," Proceedings of the Infrastructure Planning Conference, 66, November 2022.

7. Asaoka T., Nakamura T., Zhou G., Kurauchi F., Ozawa Y.: "Study on Behavior Change Through Reward-Based Experiments for Highway Users," Proceedings of the Infrastructure Planning Conference, 67, P01-55, June 2023.

8. Azuma, Y., **Kurauchi F.**, Shibagaki T., Nakamura T., Araki S., Hirota Y.: "Approaching Drivers for Congestion Mitigation Using Gamification - Development of 'Ooimongachi Congestion Mitigation Game!!'," Proceedings of the Infrastructure Planning Conference, 68, November 2023.

9. Matsuo, Y., Kimura, Y., Uno, N., Matsunaka, R and Tanaka K., "An Analysis of Potential of Gamification to Enhance Behavioral Change Based on Stated Preference of Intercity Expressway Users", Proceedings of the Infrastructure Planning Conference, 68, November 2023.

5. Study Development and Future Issues

This research established a method of proactive traffic management by utilizing gamification to encourage drivers to actively change their behavior, verifying the potential for behavior change through gamification and developing a chatbot-based behavior change proposal system to promote its effects. The system was developed without issues, and demonstration experiment results confirmed the potential of proactive traffic management and the effectiveness and safety of the chatbot-based behavior change proposals. Additionally, a subcommittee on "Utilizing Gamification for Solving Social Issues" (Chair: Fumitaka Kurauchi) was established within the Infrastructure Planning Research Committee, scheduled to be active until May 2026. Establishing a forum for researchers interested in gamification is an important outcome, as it expects the development of gamification for various social issues. Future challenges include the practical application of traffic forecast/nowcast models, enhancement of driver agent experiments and smartphone app experiments, and horizontal expansion of congestion mitigation games.

6. Contribution to Road Policy Quality Improvement

Regarding the impact on future practical applications, Gifu National Highway Office and Gifu University have signed a "Collaboration Agreement," aiming to enhance the effectiveness of Gifu Prefecture's TDM efforts, not only during normal times but also in emergencies. Under this collaboration, efforts using gamification for Gifu Prefecture's TDM scheme will commence this fiscal year. Additionally, discussions with Kyoto National Highway Office are ongoing regarding the potential use of these efforts for mitigating tourism congestion.

7. References, Websites, etc.: https://oimongachi.jimdofree.com/