Suggesting Design Method for Performance Evaluation System Based on IoT Data: Considering UX

Its Application to Lane Keeping Assistance System

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***Abstract*— The rapid development of Internet of Things (IoT) technology makes it possible to connect various objects among each other and to collect sensor data from the objects. Connected car, achieved by advanced driver assistance system (ADAS), is one of the representative example of IoT technology. Since massive amount of IoT data could be effectively analyzed with appropriate methods, it is helpful to introduce supportive systems for the analysis. This study proposes a method to design supportive system for the analysis of IoT data considering user experience (UX). The suggested method is applied to design the supportive system for lane keeping assistance system (LKAS), which is one of the ADAS.**

Keywords-Internet of Things; connected car; user experience; system design; advanced driver assistance system; lane keeping assistance system

I. INTRODUCTION

A. IoT and Connected Car

The rapid development of Internet of Things (IoT) technology makes it possible for connecting various smart objects together through the internet and providing more data of interoperability methods for application purpose [1]. According to European commission [10], IoT means a worldwide network of interconnected objects that is uniquely addressable, based on standard communication protocols. IoT is rapidly applied to various area, connecting many parts of our life. It brings us a new level of convenience by connecting physical and virtual objects [2].

The connected car is a representative example of IoT. It means that vehicles are not part of the connected world, rather continuously Internet-connected, generating and transmitting data, which can be helpfully integrated into applications [4]. For example, dashboard application is linked to social media services and sensors attached in cars help drivers in variety of ways for car maintenance. With the growing attention to IoT, scale of the connected car market already exceeds 25.2 billion dollars in 2014 [2].

The vehicle-to-vehicle (V2V) network is essential to realize the connected car. Advanced driver assistance system (ADAS) supports the V2V network with technologies, such as vision/camera systems and sensor technology [3]. For this reason, research of ADAS has actively been proceeded.

B. Data Colleced from IoT

Enormous amount of data is easily and quickly collected from various sensors, which are attached on a number of IoT objects. For example, there are quantified-self sensors (sensors that measure the personal biometrics of individuals like heart rate) and automotive sensors (sensors that measure quantitative automotive performance metrics like speed and braking activity) [4] attached in vehicles. These kinds of sensors collect data related with operations and status of car in real time.

The result of analyzing IoT data may be useful in various ways. The effort to analyze the IoT data is easily found in the healthcare field. In fact, a growing number of researches have been conducted using the IoT data in this field [11]. However, because the IoT data is collected in real time, its amount is significantly large. Supportive tools can be helpful to go through this process. Designers should provide decent user experience and enhance usefulness by considering UX when they design this kind of tools. Therefore, this study suggests design method for ADAS performance evaluation system based on the IoT data collected from connected car. In addition, this study aims to apply the suggested method on LKAS performance evaluation system.

In Section 2, theoretical points of whole process and techniques used to design the system from UX point of view are introduced. Section 2 also includes detailed implementation method and advantages of using each technique. Suggested system design method was applied to make performance evaluation system for lane keeping assistance system (LKAS). Section 3 shows application process and practical result.

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II. METHOD

This study suggests six main steps for system designs from writing out user persona to creating key screen designs. This process needs to be iterated several times to derive more systematic and accurate system designs. Enough iterations of the process reduce any potential risks of the system and allow the actual software development more smoothly.

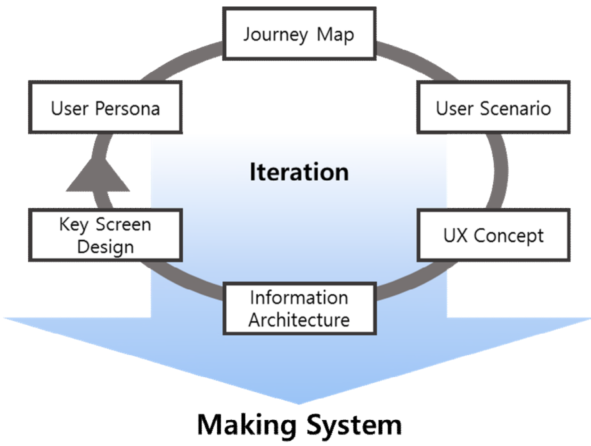

Figure 1. Whole process of making system

The main objective of the system designer is to derive proper key screens. To design persuasive key screens, systematic analysis on system users has to be preceded. This study deals from creating user persona, which is to reflect user analysis on the system, to developing information architecture (Figure 1). This section provides detailed explanations on the five steps for system designs.

A. User Persona

User centered design is significantly important for efficient system design. It considers the requirements of users to develop the system instead of simply considering technical requirements. For this purpose, designers need to identify and analyze the main users of the system. The actual observation data of how users behave provides valuable information to the designers [5]. User persona is a method for this purpose. According to Cooper and Reimann [6], user persona is a collection of realistic and representative information on users. That information is collected for the purpose of to catch the significant aspects of user behavior for designers.

The target for the user persona is not just limited to current users of the products and services. It includes all the users who has potentials to change any of the tasks of the products and services. The user persona can be developed by asking questions like "what the users do", "what frustrates them", "what makes them satisfied" and more [7]. Those questions mainly consider the role and main tasks of users related with the system, the characteristics of the tasks, and needs and pain points of current tasks. Preparing user persona allows to determine interaction characteristics like navigation scheme and the visual designs [7].

Stakeholder relationship, the relationship between users analyzed by user persona, can be created in this step. It shows the products, services, and the tasks of users. It allows how the products and services influence the relationship among users. In addition, it is able to find additional opportunities of utilize the system, which have not been thought of in the early stages of system design. These processes of user persona can derive the final outputs that can be provided to users.

B. User Journey Map

User journey map shows the behavior of the system users [8]. All the user tasks, considering the user persona which has been developed in the previous stage, can be illustrated as a diagram. User journey map has two different types, current process and expected process with the system. First, the current process shows the flow of user tasks before introducing the new system. It allows how users interact currently on the flow of tasks. Therefore, it easily figures out any problems in the current flow of the tasks. For example, overwhelming workload applied on a certain user can be found and no cooperation or communication occurred between users with the current process can be recognized. Second, the expected process with the system shows the flow of user tasks after introducing the new system. Comparing the two user journey maps helps to understand the flow of user tasks as well as what has been improved.

C. User Scenario

User scenario is a flow of user tasks on how the system can be effectively and valuably utilized. With user scenario, users can predict when the system can be helpfully utilized. Among different scenarios, it is able to set the priority of the scenario and select the most frequently usable scenario. Several methods can be applied when listing the scenario. For example, designers can conduct interviews asking about user tasks on potential type of references on features of similar systems. Those methods can help designers to determine the deepness of the user scenario that is covered by the system. The user scenario states functions that can actually be implemented, as well as functions that will be implemented in future. The system becomes more powerful by preparing the case of the system's expansion, considering the potential functions to be implemented. The usage frequency or checking the importance of each scenario can be used as a reference to set up the concept of system.

D. Define Key UX Concept

The type of UX concepts that would be mainly considered needs to be concerned when developing the system. It is important to define the key UX concepts since the characteristics of the system can be changed on which UX concept is used. Clarity, digestibility, familiarity are the examples of UX principles [9]. This step builds the base for the entire structure of the system by exploring proper UX concepts that well represent the characteristics and objective of the system.

E. Information Architecture (IA)

Information Architecture (IA) is a flow of information reflected upon the user scenario and system UX concept. UX and IA are closely connected. By forming IA, the necessary information for establishing the system can be identified. The proper IA takes the task flow in consideration and makes the flow smoother. In addition, the information can be classified with clear classifiers. In short, a good IA helps users to understand their surroundings and find what they are looking for [12]. The actual system is built based on IA. The IA needs to consider all the steps mentioned in the previous stage.

III. APPLY TO LKAS PERFORMANCE EVALUATION SYSTEM

This study applies the introduced method for system designing on LKAS performance evaluation system. LKAS is one of the key features of ADAS in connected-car. LKAS supports car to keep the lane by recognizing the lane with camera and applying torques on steering. Data collected from several sensors attached on the connected-car can be utilized to evaluate the performance of LKAS. The system suggested by this study can help as a reference in evaluating the ADAS for connected-cars.

A. System Characteristic

The system introduced in this study differs from the general performance evaluating system. The general IoT data analysis system has two separate stages, data collection stage and data analysis stage. However, the system in this study performs the two stages simultaneously. Therefore, there are strong requirements for short evaluation time of the system and no additional analysis for users. The collected data are vehicle driving information including vehicle velocity, steering angle, torque applied, etc. Since large amount of data are collected in very short period of time pre-processing is necessary. The pre-processing includes selecting significant factors and filtering out unnecessary data.

B. User Persona

It is expected that there are four types of system users in LKAS evaluating system. First, performance evaluator is the user who actually evaluates the performance of LKAS and makes decisions about LKAS tuning. The mission of this evaluator is to optimize the performance of LKAS through driving tests. They have enough understanding of LKAS operating principles and of collected data. The most important paint point is evaluating the driving test results subjectively. In other words, all the decisions are made based upon evaluator's personal thoughts. It causes many problems when reporting the result to others. In addition, because of the absence of the objective evaluation criteria, the evaluation process depends on subjective feeling rather than systematic and quantitative approach. As a result, the reliability of the reporting will decrease.

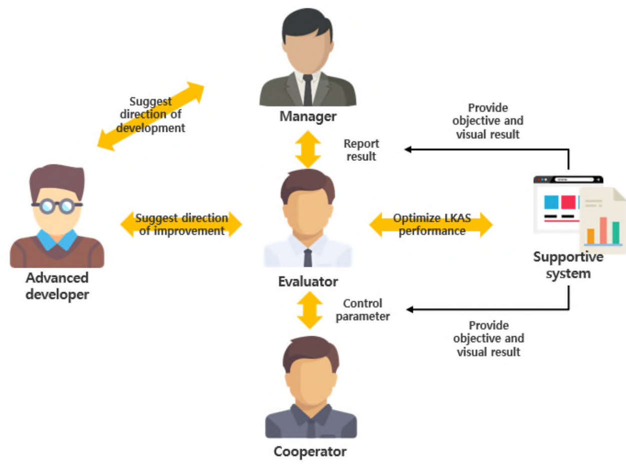

Figure 2. Stakeholder relationship

The second user is cooperator, who is in charge of controlling LKAS parameters. They control the parameter related to LKAS based on the evaluation results of the evaluator. Cooperator also have great knowledge of LKAS operating principles and of collected data as well as the behavior of vehicles according to the change in LKAS parameters. The main pain point for the cooperator is that they have to control the parameters with only subjective evaluation results.

The third and fourth system users are manager and advanced developer, respectively. Manager provides a big

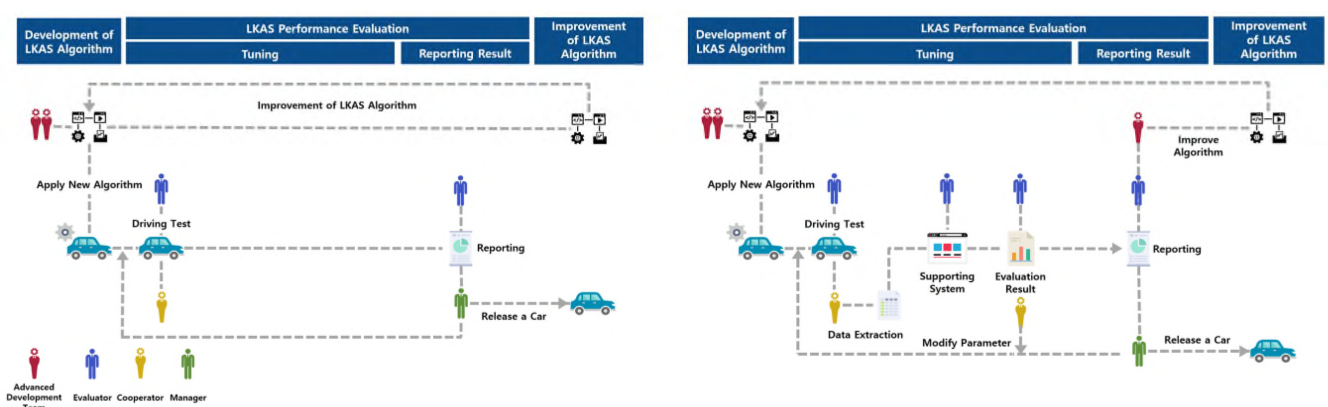

Figure 3. Current user journey map (left) and expected user journey map (right)

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outline of LKAS to other users. The advanced developer deals with developing high-performance LKAS algorithms. They have similar pain points like the cooperator that they are not able to identify objective results of LKAS performance. It makes difficult for advanced developers to clearly set the direction that they have to pursue.

The stakeholder relationship can be drawn from the above user persona (Figure 2). It shows the work relationship among users and how the system helps the current workflow.

C. User Journey Map

Figure 3 shows the task flow of LKAS optimization process. The picture on the left side is current process and right side is expected process with the system. These journey maps are derived from the user persona. We can easily see the difference between task flows. In current journey map, because there is no objective results of the evaluation, algorithm development and adjustment of LKAS are in separate procedures. With the expected process with the system, these separated processes can be integrated as a single process. It also improves communication among the users. By comparing the two journey maps, it can be easily identified that the problems are solved with the introduced system.

D. User Scenario

Considering characteristics of each scenario, three phases are suggested in this study (Figure 4). Phase 1 is composed of scenarios that is essential to the system. Phase 2 covers the scenarios achieved in advanced version. Scenarios with highly advanced function are contained in phase 3. Each scenario is assigned by considering the possibilities to be implemented, user requirement, etc.

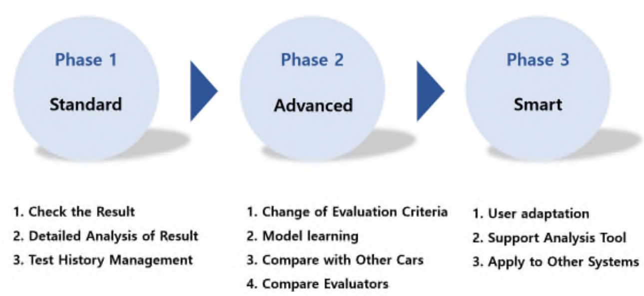

Figure 4. User scenario with three phases

E. Define Key UX Concept

The term ‘simplicity’ and ‘glanceable’ are chosen as key UX concepts for the system, considering characteristics of the system and user scenarios. ‘Simplicity’ means the design of the system should be simple and easy for users. It can be achieved with the simple screen construction and navigation. In addition, the system has to provide proper shortcuts by figuring out the tasks that takes long period of time. Similarly, ‘glanceable’ means that the design which is shown on the screen should be quickly understood by users without particular attentions.

F. Information Architecture (IA)

IA for the system is developed by reflecting the steps shown in Figure 5. We distinguish the background information and future functions. Background information is the information that has to be considered on the back-side of

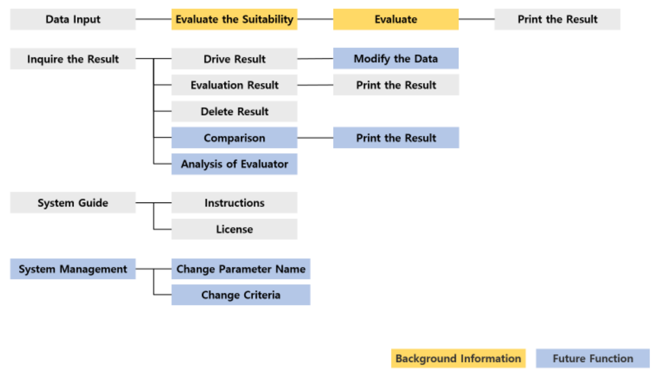

Figure 5. Information architecture

the system. Future function is the information that is achieved in the advanced version. System developers can refer this IA when they actually implement the system.

IV. CONCLUSION

This study suggests the method to consider UX when we design the performance evaluation system based on the data collected from IoT. The introduced method is applied to LKAS, one of the ADAS. With the suggested method, designers can systemically reflect the requirement of the user from user’s aspect. In addition, it helps the advancement of the system in the future by considering advanced version. It will be applied to various systems for analyzing enormous data collected from connected products and services.

Although only researcher’s analysis is considered in this study, in actual situation, designers are able to use various methods to reflect user’s needs. By considering user’s behaviors, characteristics, pain points and requirements, it is expected that designers can provide better UX.

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