Usability Evaluation on XVC Framework for In-Vehicle User Interfaces

Soonghwan Ro¹, Hanh Van Nguyen¹, Jungkwan Ryu¹, Wonil Lee², Woochul Jung², Sibok Yu³
¹Kongju National University,
²IBM Ubiquitous Computing Lab, ³Korea Automotive Technology Institute
E-mail: {rosh, nvhanh, arkil}@kongju.ac.kr, {wilee, wcjung}@kr.ibm.com, sbyu@katech.re.kr

Abstract

XVC (eXtensible Viewer Composition) is an in-vehicle user interface framework for telematics applications. It provides a document-oriented applications model enables drivers to make use of multiple information services simultaneously, while maintaining satisfactory control of their vehicles. XVC is a new client model which makes use of beneficial functions of in-vehicle navigation devices. However, there was no usability evaluation on XVC framework before this work. In this paper, we present the usability test on XVC framework that was performed to evaluate how the XVC client may affect the driving work of drivers while trying to make use of its functions. The evaluation was performed using the Advanced Automotive Simulator System at KATECH (Korea Automobile Technology Institute). Furthermore, we also analyzed the advantages of XVC Framework and compared over non-XVC Framework through test results.

1. Introduction

The XVC framework provides a document-oriented client model that delivers telematics services for extensible viewer composition. The XVC framework enables multiple providers to deliver services to users simultaneously by enabling their user interfaces to be composed onto a single screen. In addition, it addresses concerns specific to attention-limited mobile users and resource-limited mobile devices [2, 5].

Providing navigation and traffic instruction are among the functions of in-vehicle navigation devices. The functions which contribute to the enhancement of traffic safety, and smoothing of the traffic flow. However, for drivers, trying to read such information from navigation devices constitutes extra work in addition to their driving work and thereby it may affect driving control and safety of drivers. For this reason, the drivers’ tendency is to refrain from scanning and operating their display systems when the driving workload is heavy. Thus, it is very important to have a suitable client model for navigation devices in order to make use of the beneficial functions of in-vehicle navigation devices, while at the same time allowing the defensive behaviors of drivers.

XVC is a new client model which makes use of beneficial functions of in-vehicle navigation devices. However, there had been no usability evaluation on XVC framework before this work.

In this paper, we present our usability evaluation that evaluated how the XVC client (navigation device) affected the driving work of drivers while trying to make use of its functions. To perform the usability evaluation on XVC framework, we established a virtual telematics test bed by using the Advanced Automotive Simulator System at Korea Automobile Technology Institute (KAAS system) that had been developed as a test and development environment of the state of art automotive electronics.

The test results show that the navigation device with XVC framework could significantly reduce the scanning time during which the drivers could get information on the navigation device.

The rest of the paper is organized as follows. Section 2 provides the related works. Then, in section 3, we describe the usability evaluation on XVC framework. In section 4, we present the test results. Then, in section 5, we present our acknowledgements. Finally, we conclude this paper in section 6.

2. Related works

2.1. TOPAZ in Overview

TOPAZ (Telematics Open Portal Applications Zone) is a ubiquitous computing framework and system that provides an open platform of core telematics services to telematics application providers. The detailed information about TOPAZ was described in [1-5]. In this section, we introduce TOPAZ in brief.
TOPAZ Architecture is illustrated in Figure 1. TOPAZ defines a set of core telematics services:
- On-demand data acquisition from client devices; content push to client, managed for access by multiple application providers;
- Rule-based spatiotemporal event detection.
The TOPAZ applications run on servers and present user interfaces using viewers.

TOPAZ usability-computing functions can be summarized as follows:
- Adding, removing, updating applications; application providers; subscribers & devices
- Managing the requirements of diverse applications;
- Managing system load due to large numbers of subscribers; managing load on individual clients;
- Service metering, monitoring, and diagnostics.

XVC is a new, document-oriented model for the delivery of telematics services for eXtensible Viewer Composition. XVC enables multiple providers to deliver services to users simultaneously by enabling their user interfaces to be composed onto a single screen. The detailed information about XVC framework was described in [2, 5]. In this paper, we described in brief.

XVC Architecture is illustrated in figure 2 and the user interface design of XVC client is illustrated in figure 3.

XVC has three primary characteristics as follows:

1. Supports a document-oriented application model
   - XVC offers a document-oriented user interface model, in which, like the Web model, applications present user interfaces through documents rendered by universal interactive viewers.
   - No need to develop custom clients.

2. Provides viewer composition, an extension of the Web user-interfaces model
   - XVC introduces telematics-oriented viewers, each tailored to different content medium.
   - Its composite document model composes user interfaces by delivering documents to multiple viewers.
   - Inter-viewer interactions are enabled through event handlers.

3. Application composition
   - XVC composes the user interfaces of multiple applications into a merged user interface.
   - Purpose is to enable “glanceable” displays as much as possible.

2.3. KAAS System

Figure 4 illustrates KAAS (KATECH Advanced Automotive Simulator) system that has been developed as a test and development environment of the state of art automotive electronics such as Telematics, ASV (Advanced Safety Vehicle), ADAS (Advanced Driver Assistance System), ITS infrastructure and others. The detailed information about KAAS system was described
In [6]. In this paper, we just summarize the main characteristics of KAAS System.

For developing telematics devices and software, traditional development methods including unit function test, compatibility test and T-car test often show limitations. Telematics devices have various functions that require consideration of interactions among three major elements of automotive electronics—the vehicle, the device unit and the driver. KAAS system is a largest virtual reality based driving simulator in Korea designed to test and analyze the three elements in one place.

The available test includes the device, modules, middleware, application software, contents, HMI (Human Machine Interface), driver’s reaction and preference, and vehicle behavior when using the visual display including device. The completed KAAS system will be an integrated system with a VR based driving simulator, real-time HILS (Hardware in the Loop Simulator) systems, a vehicle network simulator, wireless communication devices and software, a 3D DB of real city area, a real time GPS simulator, a CDMA simulator and human analysis devices.

The KAAS system is consisted of three major components.

1) A driving simulator system
2) Driver monitoring system
3) Target device simulation system including Real-Time HILS system, a GPS simulator system, and CDMA wireless communication simulation system

The driving simulator is consisted of an 8 channel visual system, a dynamics computer, a real-car cabin CFLS (control force loading system), a motion platform system, a main computer and a sound rendering computer. The driving simulator has a full dome with 360 deg screen which is mounted on the 7 ton capacity motion platform. The car cabin is also mounted on the motion platform. The motion platform can accelerate the dome system over 0.5G in any direction. The simulator system mainly communicates through UDP connection except the communication between the CFLS and the dynamic computer employs CAN (Controller Area Network).

The driver monitoring system is consisted of a 6-channel infra-red camera to monitor the behavior of driver and a face LAB system to trace the gaze, head direction of driver and scene camera to merge a live video-feed of the subject’s actual view with the data feed from face LAB.

KAAS is integrated with real-time HILS to monitor KAAS states, to computes and save necessary information, and to produce required signal for test device. The GPS simulator is the system to generate and to radiate the real-like satellite RF signal for vehicle positioning in 3D virtual environment.

In order to test the GPS based navigation devices, it is essential to provide the GPS signal which are received at the vehicle location. This implies that the 3D virtual environment for the virtual driving needs to be precisely matched with the real-world environment. A 3D virtual environment is constructed based on the real city area of
Ilsan. Ilsan is a district of Koyang city which is located just north of Seoul, Republic of Korea. Some images in real city and virtual city in KAAS System are correlative showed in Figure 5.

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3. Usability Evaluation

The objective of the usability evaluation for XVC framework was to evaluate how the TOPAZ client with XVC framework (XVC Client) affected the driving work of drivers while trying to make use of its functions.

In order to perform the usability evaluation on XVC framework, we had to perform the following tasks:
- Establish a virtual telematics test bed by using KAAS System which is illustrated in Figure 6.
- Create test scenarios with and without XVC framework
- Create service contents for test scenarios
- Organize testers who played role as drivers to perform test scenarios.

Test scenarios and service contents to be provided for test scenarios were created based on two different paths (Figure 7) in Ilsan city area with the traffic status, weather and road conditions in test scenarios simulated similar as in real world (Figure 5). Test scenario 1 based on Path 1, whereas test scenario 2 based on Path 2.

In order to force the testers to make use of the functions of the navigation device, at specific positions on the driving path, testers had to get answers to questions of the supervisor that related to service contents providing on the navigation device. Each question could cause the different behavior of the tester depending on the type of information related to the answer. The behaviors of drivers could be classified into the following categories:
- No action: Testers only need to read information that the system automatically are providing and do not need to operate the navigation device.
- Interaction: Testers need to operate the navigation
device to get information.

Figure 7. The Map and Paths for Test Scenarios

In order to evaluate the advantages of XVC framework over non-XVC framework, each tester had to perform two test scenarios for both XVC framework and non-XVC framework.

4. Test Results

Twenty testers participated in the evaluation and played role as drivers and can be grouped by sex, age and driving experience as shown in figure 8. We divided testers into two test groups and to give no priority to XVC or non-XVC, testers in Test Group 1 must perform XVC test before non-XVC test, but testers in Test Group 2 must perform XVC test after non-XVC test as described in table 1.

Table 1. Test Scenarios and Models for each Test Group

| Group# | Scenario 1 | Scenario 2 |
|--------|------------|------------|
| 1      | XVC        | Non-XVC    |
| 2      | Non-XVC    | XVC        |

In case of XVC framework, drivers do not need to operate the navigation client during driving. Moreover, XVC framework provides shared viewers scheme by multiple applications and therefore, the scanning time of drivers to get information could be reduced. Thus, driving control and safety of drivers could be enhanced. Indeed, the test results were illustrated so.
Figure 11 shows the variation in velocity of the car of a tester and figure 12 shows the variation in velocity of the cars while testers were trying to get the answers. The graphs show that the velocity variation in case of XVC framework was much less than that in case of non-XVC framework.
In summary, the test results show that in XVC test, the testers needed much shorter time and affected the driving work less than that in non-XVC test to get the same information on the navigation device. It also means that the navigation system with XVC framework could enhance the driving control and safety of drivers.

5. Acknowledgements

This work was supported by IBM Korea and Korea’s Ministry of Information and Communications.

6. Conclusion

In this paper, we presented a usability evaluation on XVC framework. The test results showed that XVC framework could significantly reduce scanning time during that the drivers can get information on the navigation device. Furthermore, the velocity variation in case of XVC framework was much less than that in case of none-XVC framework. Therefore, XVC framework could enhance the driving control and safety of drivers. In future work, we will evaluate and analyze the XVC model from different aspects and what and how are the negative sides of this model.

7. References

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