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| Project | **HMD based 3D Content Motion Sickness Reducing Technology**  <<http://sites.ieee.org/sagroups-3079/> **>** |
| Title | **Use cases of VR content services for evaluation of cybersickness levels** |
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| Abstract | HMD-based VR content users are interested in the stability of VR content because of VR sickness that occurs differently depending on the characteristics of the user who experiences VR content. We consider the application of the user's viewpoint to present the level of VR sickness to the user of the VR content and adjust it according to the sensitivity of the VR sickness of the user through the objective and subjective evaluation method for assessing the VR sickness |
| Purpose | This document deals with the user-oriented system environment configuration and user-driven scenarios for evaluating VR sickness levels |
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# Introduction

VR content allows the user to experience a safe and immersive indirect experience in the virtual world that transcends time and space in the real world.

However, VR sickness, which VR users commonly experience, has many obstacles in growing the VR industry.

Therefore, it is necessary to develop a technique for reducing VR sickness and an evaluation and control technology for VR sickness according to a user's VR sickness adaptability.

In this document, we describe a software platform for analyzing and predicting the levels of VR sickness from the user 's point of view about VR sickness that can occur when experiencing user VR content, and describe a user - based experience scenarios.

# Overview

## Purpose

This document deals with the user-oriented system environment configuration and user-driven scenarios for evaluating VR sickness levels

## Scope

We describe the range of the platform for presentation to the user, the execution examples of the user’s view, and the experience scenarios of the VR content by evaluating the cybersickness levels corresponding to the intensity of the VR sickness experienced by the user executing the VR content.

# Definition

* **VR sickness level or cybersickness level(CSL) –** The VR sickness level is used synonymously with the cybersickness level. VR sickness that can occur when a VR content user experiences VR content can be classified according to the strength of VR sickness and defined as a level. This VR sickness level can be used as a means of expressing the exciting of the VR content, and the VR user can enjoy the VR content suitable for him or her by selecting the VR content with reference to this level.

# Defining the User Environment for VR Content

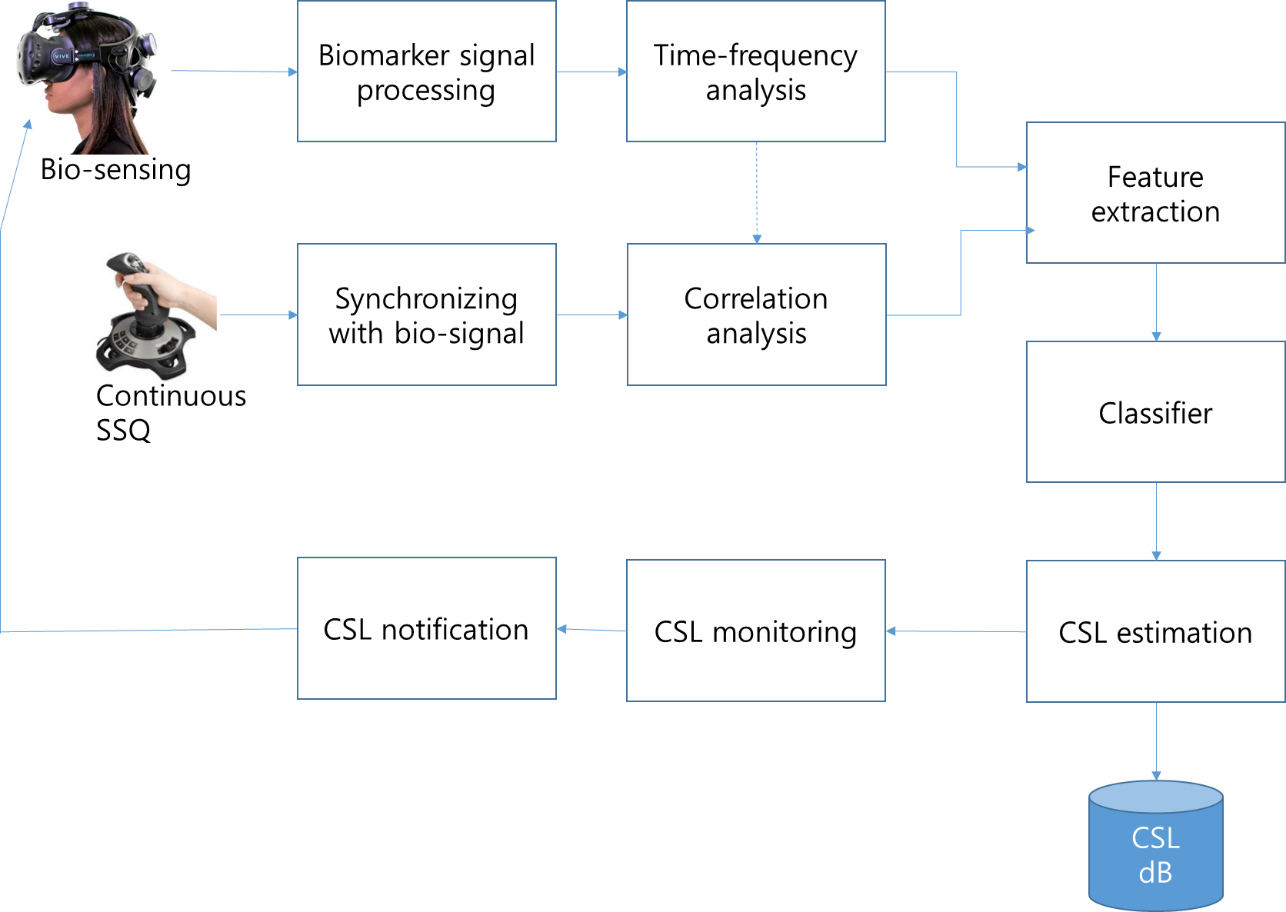
## Classification of user

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| --- | --- |
| **User** | **User’s role** |
| Player | * Playing VR content * Subject for CSL testing |
| Content designer | * Designing visual scene and stages with best practice for controlling CSL |
| Content programmer | * Implementing rules and modules for VR content SW |
| System operator | * Operating and clinical test system |
| CSL evaluator | * Analyzing subjective and objective component for predicting CSL |
| CSL data manager | * Managing CSL data |

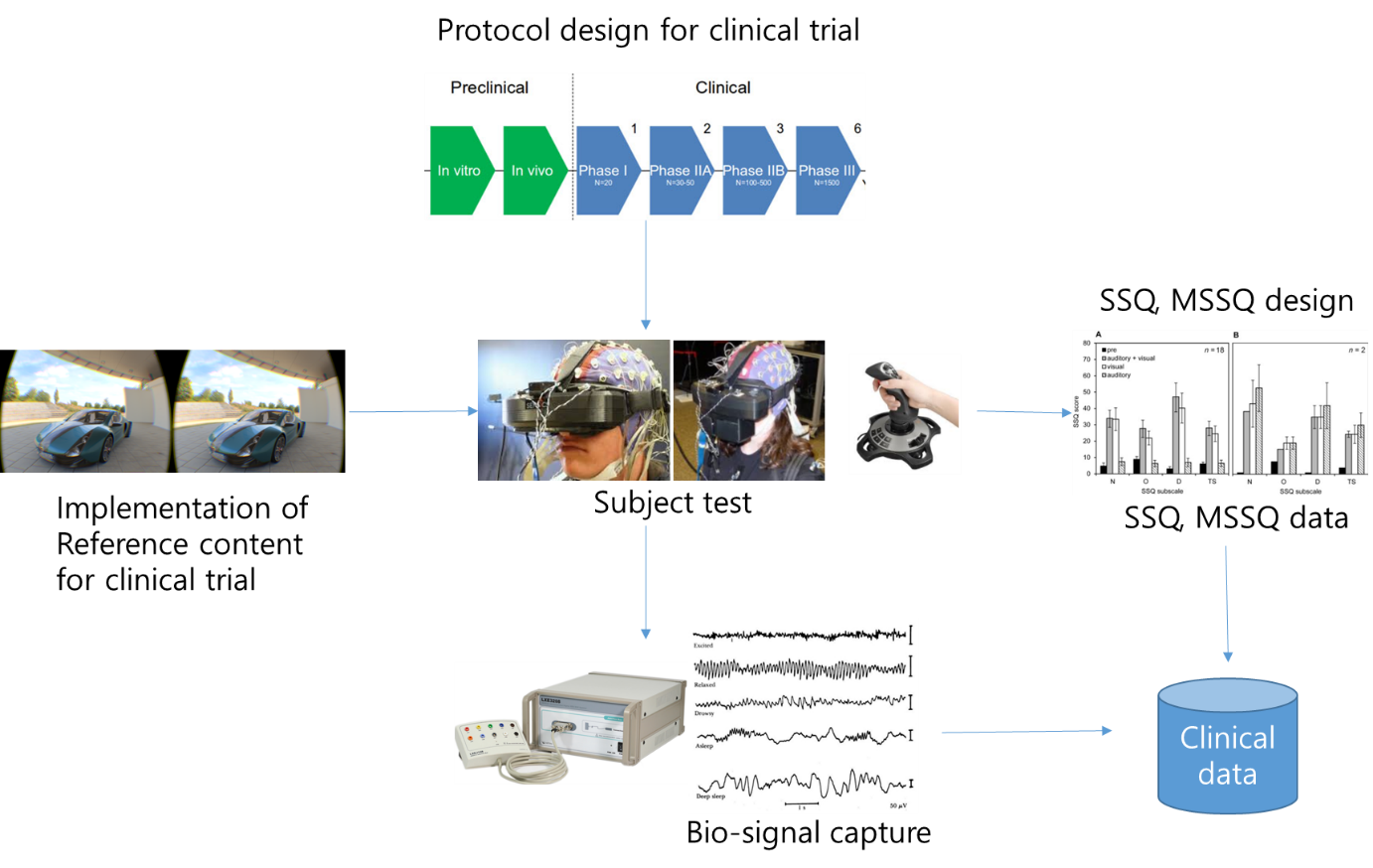
## User environmental variables

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| **User interface** | **Environmental variables for VR content** |
| User(player) | * Sit-down * Stand * Walk and run |
| Content | * 1st personal view * 3rd personal view * Play with walking * Play on riding * Watching mode/broadcasting mode * Interaction mode/navigation mode * Single-user * Multi-user |
| Display Device | * PC-based * Smartphone-based * All-in-one type(stand-alone type) |
| Play Environment | * Sit-down * Stand * Working attractions * Treadmills |
| Motion Platform | * Hong-on * Riding-on * Lay-down |
| Getting sickness data | * Biomarker * Continuous SSQ with joystick * Pre/post SSQ |
| Clinical test boundary | * Stand-alone(local) * Cloud(network) |
| Management system configuration | * Stand-alone(local) * Client-Server(network) |
| Estimation of CSL | * Analysis * Evaluation * Prediction * Notice |

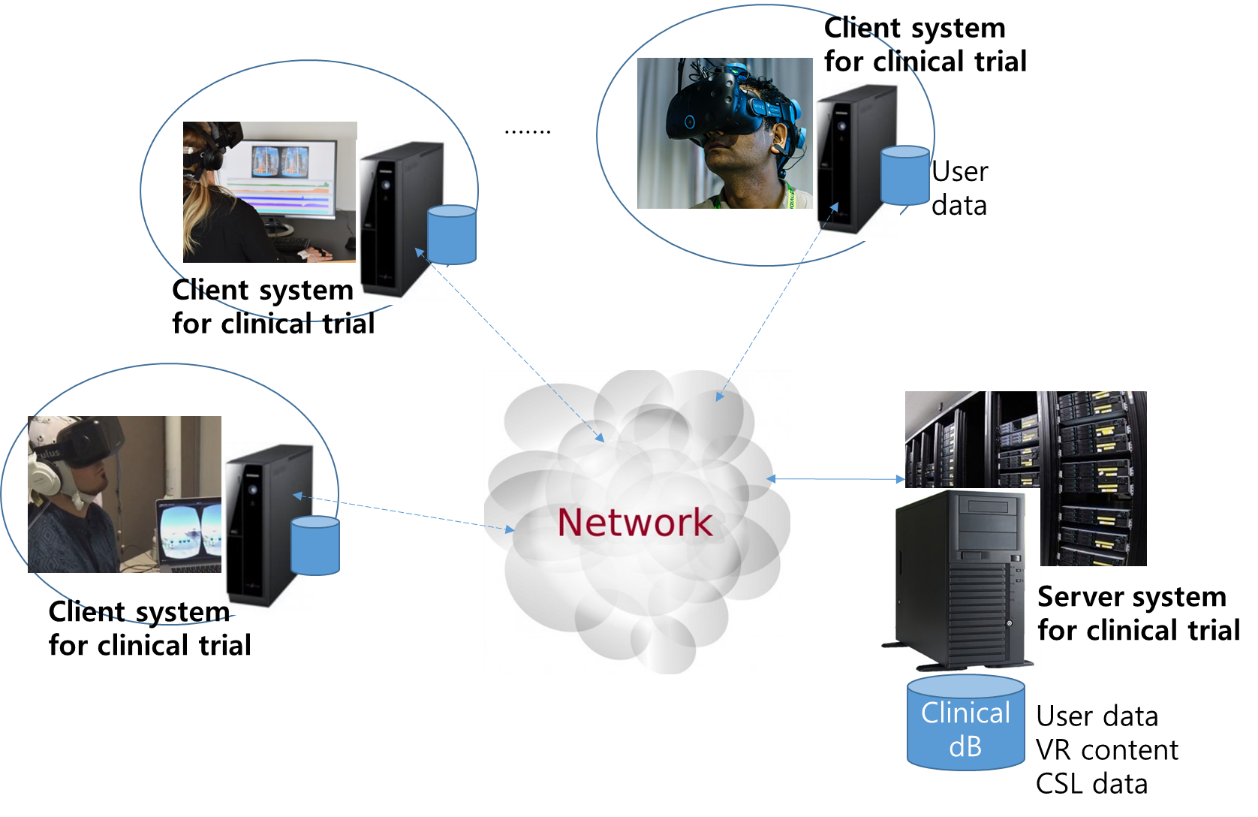
## System block diagram for CSL evaluation



## Design tools of clinical trial for CSL estimation



## Configuration of cloud based clinical trials



# Use Case

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| --- | --- | --- |
| Cases | Descriptions | Remarks |
| 1 | Evaluating CSL using bio-signal and SSQ |  |
| 2 | Clinical trials for getting the characteristic data of CSL for VR content users |  |
| 3 | Cloud based clinical trial method for evaluating CSL |  |

## Use Case 1

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| 1. Use case name | Evaluating CSL |
| 1. Overview | While the user is experiencing the VR content, the user is allowed to evaluate the VR sickness level using the bio-signal and the SSQ. |
| 1. Priority | High |
| 1. Related actor | Player, System operator, CSL evaluator, CSL data manager |
| 1. Pre-condition | -Prepare VR content for testing  -setting biomarker and bio-signal measurement equipment  -on-line SSQ  -defining tne number of CSL |
| 1. Event flow | -acquire bio-sinal from measuring equipment  -getting SSQ data during the VR content play  -synchronizing bio-signal with SSQ  -time-frequency analysis and correlation analysis  -frequency selection and feature extraction  -classify extracted feature data using the deep learning method, etc  -leveling CS, monitoring  -notification of CSL |
| 1. Post-condition | -store CSL data for the VR content and user  -notify CSL |
| 1. Non-functional requirement | -Biomarker : EEG, ECG, PPG, GSR |

## Use Case 2

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| --- | --- |
| 1. Use case name | Clinical trials |
| 1. Overview | While the user is experiencing the VR content, the user is allowed to evaluate the VR sickness level using the bio-signal and the SSQ. |
| 1. Priority | High |
| 1. Related actor | System operator, player, Content designer, Content programmer |
| 1. Pre-condition | -implement reference VR content  -design protocol for clinical trials  -design SSQ/MSSQ |
| 1. Event flow | -playing reference VR content  -acquiring bio-signal and on-line SSQ data  - synchronizing bio-signal and SSQ data |
| 1. Post-condition | -store bio-signal and on-line SSQ/MSSQ |
| 1. Non-functional requirement | -Biomarker : EEG, ECG, PPG, GSR |

## Use Case 3

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| 1. Use case name | Cloud based clinical trials |
| 1. Overview | We will conduct cloud-based clinical trials to ensure that the number of clinical trial patients will be sufficient when conducting clinical trials to reduce VR sickness. |
| 1. Priority | High |
| 1. Related actor | Player, System operator, CSL data manager |
| 1. Pre-condition | -setting for client clinical trial environment  -setting for server clinical trial environment  -downloading user’s CSL data from server |
| 1. Event flow | -Initialize client/server dB  -execute client system, start clinical trials and estimating CSL for VR content  -uploading CSL data and user’s data from client to server system  -CSL data mining to server system for clinical trials |
| 1. Post-condition | -managing CSL data  -analysing CSL data |
| 1. Non-functional requirement | -supporting subjects more than 100 |

# Scenario

## Case 1 (FPS VR game in the walking attraction with CSL estimation)

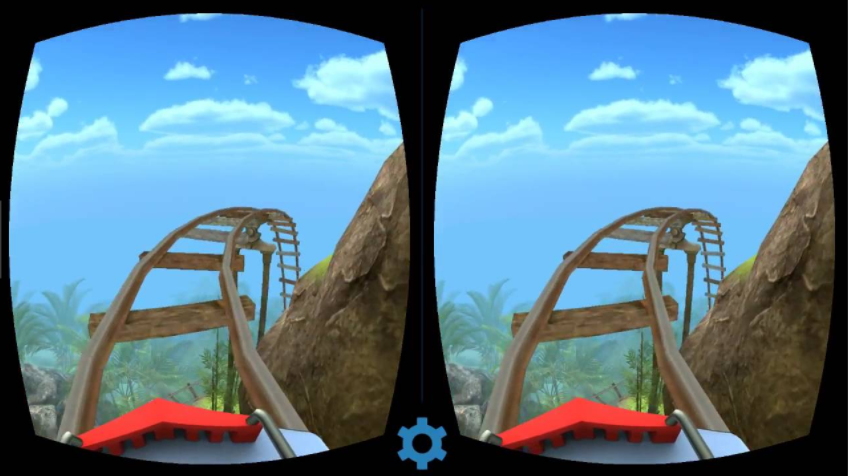
Users of VR content participate in the battle simulation game between the multiple users while wearing personal protective clothing with haptic feedback function in the personal space in the attraction space for the gun shooting game wearing the HMD.

The user can walk while moving through the VR game. When the gamer reaches the boundaries of the designated game space, he / she will see a warning sound and a visual warning effect as an indication of the boundary. You can also move the game stage using a jeep. You can ride on the elevator to move to a higher floor. When you are shot, haptic feedback on the shooting is delivered through your protective clothing.

Particularly, when moving the game stage or moving from left to right in a state of sudden head tracking or left to right in a state of severe change of the screen, the user feels severe dizziness and nausea. At this time, by presenting the nausea according to the severity of the change, the nausea can be reduced by allowing the gamer to predict the nausea in advance.

Also, when moving to a higher place, the motion feeling of the height difference becomes serious due to the virtual feeling At this time, it is possible to experience the effect of reducing the motion picture by adjusting the viewing angle of the screen or presenting the visual guide. The variation of the VR sickness of each game stage experienced by the user is stored and stored as the personalized information of the user. Cumulative changes of the user's VR sickness are comprehensively determined to determine the sickness of the VR content. Update personalized VR sickness information about changes in the user's rehabilitation of VR sickness.

## Case 2 (Roller Coaster VR game on the Motion Platform with CSL estimation)

VR content users will experience content that implements a roller coaster. The motion platform is implemented based on the 6-DOF degrees of freedom. The user experiences VR content in the watching mode while the HMD is mounted and the pre-configured contents are loaded on the motion platform without any additional navigation input of user.

When riding a roller coaster in the real world or playing VR content with HMD, the user has an similar experience to motion sickness symptoms. The user experiences a sudden height change in the VR content. The VR user will experience severe VR sickness due to sudden changes in height and severe accelerating speed. On a very fast curve travel content, the user experiences very severe VR sickness. Information about the user's VR sickness effect is stored in the image of the content experiencing VR sickness. At this point, the user can be provided with a visual guide to reduce the VR sickness or alleviate the VR sickness symptoms in the whole contents by reflecting the appropriate constant velocity motion to the image and moderately adjusted image in the sudden fluctuation of the image.

# Conclusion

# This document describes procedures and methods for evaluating the VR sickness phenomenon that a VR content user experiences when playing VR content. Thus, the VR sickness level for the VR content is determined so that the user can select the VR content and activate the VR market.

# To evaluate the VR sickness of the content, the objective data, the bio signal, and the subjective data, SSQ/MSSQ, are used. By performing time-frequency analysis and feature extraction of such user biometric data, prediction of VR sickness is performed and the level of VR sickness is determined.

# Clinical trials of VR sickness are performed to clarify the correlation between the symptoms of VR sickness and the VR sickness of the content. In order to increase the reliability of the clinical trial results, it is appropriate to introduce a cloud clinical trial method in order to construct an analysis environment for the result data of more than 100 participants.