Deliverable

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D3.7 Quality of Experience

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P	Public	x
C	Confidential, only for members of the consortium and the Commission Services	

Abstract: This deliverable describes the hardware and software components for Quality of Experience (QoE) module delivered in Pilot 2. The document outlines the design and implementation of the ImmersiaTV QoE module and its interfaces to other ImmersiaTV sub-systems. In particular, the document specifies QoE module architecture, how the QoE sub-system communicates with other sub-systems and what QoE relevant data will be acquired and computed.

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REVISION HISTORY

Revision	Date	Author	Organisation	Description
0.1	10/08/2017	Saeed Mahmoudpour	Imec-ETRO	Software Description
0.2	29/09/2017	Saeed Mahmoudpour	Imec-ETRO	Second version
0.3	10/10/2017	Szymon Malewski	PSNC	Review and final styling

Disclaimer

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Statement of originality:

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LIST OF ACRONYMS

Acronym	Description
QoE	Quality of Experience
NR	No Reference
LAF	Locally Adaptive Fusion

1. INTRODUCTION

The Quality of Experience (QoE) module is a piece of software responsible for evaluating the visual quality as experienced by end-user. The QoE quality estimations will be made available in the ImmersiaTV platform which can for example be used to steer parameters inside the codec to guarantee the highest quality.

2. ARCHITECTURE

The block diagram in Fig. 1 details the QoE sub-system and its interfaces with the Encoder, ImmersiaTV server and client sub-systems:

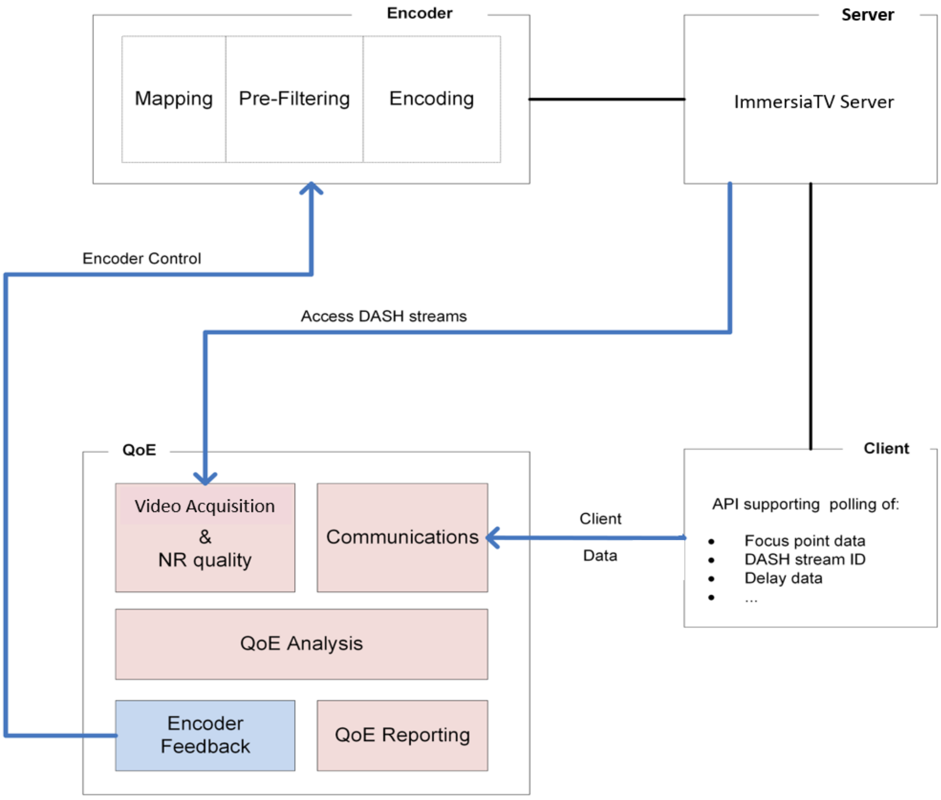


Figure 1 - QoE subsystem architecture in ImmersiaTV platform and interfaces

In the above diagram, the QoE sub-system modules shown in red colour are developed for Pilot 2, the module in blue colour (and the respective functionalities in the Encoder sub-system) are to be developed for Pilot 3. The arrows in blue colour identify data flows (and associated interface protocols) between the QoE module and other ImmersiaTV sub-systems. The role and functioning of each module is described further in the text.

3. FUNCTIONALITY

The architecture of the QoE module is built around five sub-modules:

1. To assess image quality, QoE establishes a connection with ImmersiaTV sever where video segments are available. The video acquisition module downloads and stores the video segments for off-line analysis. Once acquired, the respective video frames are stored and they are then analysed using no-reference (NR) metrics.

2. A dedicated communications module manages the data acquisition from ImmersiaTV clients. Each client wishing to provide QoE data establishes a connection to the QoE sub-system with a unique QoE session identifier. The client then sends QoE data packets to the QoE sub-system.

3. The QoE Analysis module orchestrates client information and NR quality activities. It consolidates and analyses the NR quality data and integrates the client side quality parameters into a QoE figure of merit.

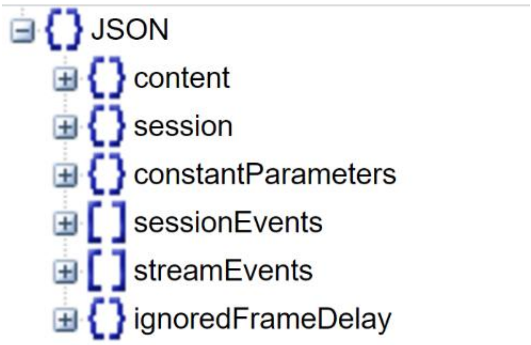
4. The results derived by the QoE Analysis module are then exposed through the QoE Reporting module.

5. For Pilot 3, an additional Encoder Feedback module will derive encoder control parameters form the data computed in the QoE Analysis module and transmit these to the Encoder sub-system

In the following sections a description of each QoE module of Fig. 1 is provided.

3.1. Communications

The clients establishes a connection to the QoE sub-system which is running on a separate server. From the client side, a number of logging information is provided to QoE sub-system for quality analysis. The client is indeed a Unity 3D player software that gathers the data from different devices (TV, HMD or tablet) and sends the logging data to a tcp socket. The QoE communication module receives the logging data in JSON format and parse them to be used in quality assessment. A schematic of logging data in JSON format is shown in Fig 2. The logging information are described in details in Table 1. The JSON tree includes six root items and multiple sub-items.



```
⊟ { } JSON
    ⊞ { } content
    ⊞ { } session
    ⊞ { } constantParameters
    ⊞ [ ] sessionEvents
    ⊞ [ ] streamEvents
    ⊞ { } ignoredFrameDelay
```

Figure 2 - The logging information in JSON format.

Parameters	Detailed sub-items	Description
Content	Content id	Video identification data. It points to an xml file in ftp server which contain basic information of the video
Session	Session id	Player session identification data
Constant parameters	Device id	This is an ID that specifies which type of device is on operation (TV, Tablet or HMD)
	FoV	Horizontal and vertical field of view in degree
	resolution	Device screen resolution in pixels
Session events	Center of looking information	The information about the clients looking direction (specified by three parameters: yaw, pitch and roll)
Stream events	Frame rate	The nominal and actual frame rate of streams
	Dash Segment ID	The address of the video segment that is currently playing on the ftp server
	Delay information	The amount of delay in seconds and the presentation time stamps (PTS)
Ignored frame delay	Ignored frame delay	The maximum delay that can be ignored

Table 1: List of logging information reported in JSON format

3.2. Video Acquisition and NR Quality

After parsing the logging information, the software acquires segment-ID which points to the address of the streaming video segments on the ImmersiaTV ftp server. The video acquisition module starts downloading the video segments, concatenates the segments and stores the constructed streams. The respective video frames are then extracted offline and analyzed using No-Reference (NR) metrics in quality assessment module. The NR quality assessment module provides the quality scores using the logging information and frame analysis. In addition, the module computes the moving averaged delay and gathers the focus point information for Pilot 3 analysis.

Several NR quality assessment methods are implemented which can be selected based on the complexity constraints. Table 2 listed the implemented NR quality metrics as well as the processing time for a 4K frame (running on Windows OS, core i7, 2.7GHz, 8M cache and 16GB memory). The Blocking metric, sharpness and blur metrics are more suitable for current architecture as they are running faster. The NR quality analysis is selected to be used since it can provide decent quality estimation while it does not need the reference frames.

Metric Name	Metric Type	Complexity (4K frame)
Blocking Metric	No-reference	0.5 sec
Sharpness degree	No-reference	0.07 sec
Blur Metric	No-reference	1.09 sec
ShearletIQM	No-reference	8.3 sec
BRISQUE	No-reference	1.9 sec
MSCN-based Metric	No-reference	2.1 sec
NIQE	No-reference	4.67 sec
BIQI	No-reference	2.54 sec

Table 2: List of the implemented NR quality metrics and their complexity

Finally, a machine learning approach called Locally Adaptive Fusion[1] (LAF) is designed to merge the quality rating of multiple metrics. The LAF system reliably combines multiple quality scores by adaptive weighting and provides the final quality scores.

3.3. QoE Analysis

The QoE analysis module will collect the client information and ratings from NR analysis for decision making. The QoE Analysis module has two main tasks.

1. Gathering the quality ratings and delay information for quality monitoring. The data presents the variation of quality. From the logging information, we also report the moving average delay of the streaming videos in timestamps to take care of other quality degradation factors such as video stalling and jerkiness.

2. Analysis of the user view (focus) direction data to compute the fixation points, and multi-user fixation maps. The fixation information present the regions focused by users and it will be delivered to Encoder. Based on such information, the encoder can decide to assign more bits to salient regions observed by users and less bits to other non-important regions. The fixation maps can be generated every 1-2 seconds depending on the type of video content.

3.4. QoE Reporting

The module provides the output information of QoE subsystem that will be used in Pilot3. A stream of (a) quality ratings, (b) delay information, and (c) fixation point information are reported and made accessible (as txt files) in the output. The quality ratings are numbers

[1] http://www.locally-adaptive-fusion.com/

between 0 and 1 which indicates the frame quality (the higher score shows higher quality). The delay information are a stream of moving averaged values of delay in seconds. In case of stalling, the moving averaged values will be increased which shows quality degradation. The fixation point information represents the locations where are more focused by users and will be used in Pilot3 for adaptive resource allocation in Encoder.

Fig. 3 provides a graphical representation of the output files (numerical data) for better understanding.

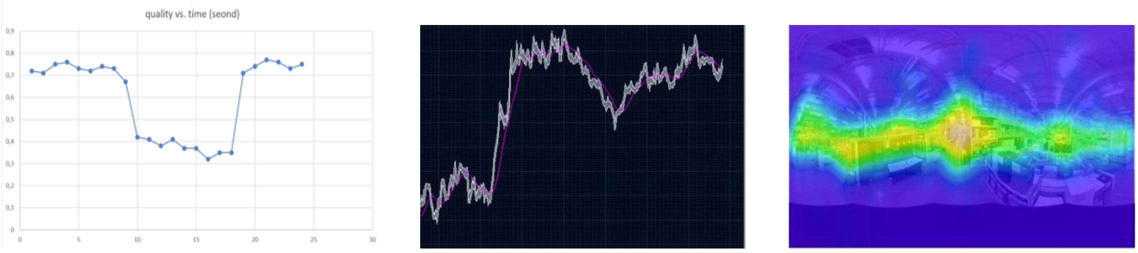


Figure 3 - Graphical representation of the output data. a) Video quality changes in time b) Moving averaged delay which shows the trend of delay changes (red line) c) Fixation map shows the locations focused by users.

3.5. Encoder Control

The encoder subsystem is dynamically controlled (in Pilot3) with a feedback provided by QoE subsystem.

Mapping or re-mapping submodule of the encoder applies geometrical transformations, i.e. changes panoramic representation of an omnidirectional video frame. This action is performed only if needed and depends on the incoming signal which can be already represented in the required projection format.

Pre-filtering use the visual attention information acquired in real-time from viewers to reduce the amount of self-information (entropy) of the omnidirectional video frames by applying weighted Gaussian (or other suitable) filtering. The former is based on statistical interpretation of viewers’ focus of attention.

Bitrate control adjusts the output visual quality of the bitstream by changing the parameters of the core encoder (HEVC) according to the information provided by the QoE Feedback submodule. Alternatively the bitrate can be controlled by the CDN module with respect to QoE feedback.

Unlike a traditional rate distortion control in common encoders, the QoE system takes into account additional information acquired from clients, such as visual attention data, frame delays, and no-reference visual quality scores performed on the actual signals which are presented to the viewer.

4. CODE REPOSITORY

https://www.dropbox.com/sh/6wb2px5q4sxlrva/AABaPyabsD2S95RuFW5AxbLSa?dl=0.

The file is password protected. Please send an email to smahmoud@etrovub.be to obtain the password.

5. INSTALLATION GUIDE

1. Create a folder in your hard drive
2. Unzip the file in the created folder.
3. Execute QoEModule.exe in QoEModule folder

The QoE software is running on Windows OS. After executing the QoEModule.exe, if any client is running and it provides data packets to the tcp socket, the QoE software will receive the logging data and provide output reports as .txt files.

6. CODE DOCUMENTATION

The current release does not include documentation in form of README files and changelog files.