Financiado por la Unión Europea NextGenerationEU
Plan de Recuperación, Transformación y Resiliencia
UNICO 5G I+D
GOBIERNO DE ESPAÑA
MINISTERIO DE ASUNTOS ECONÓMICOS Y TRANSFORMACIÓN DIGITAL

TALLER DE COMPRESIÓN DE VIDEO VOLUMÉTRICO

TELECO RENTA

PLAN DE
PROMOCIÓN DE LOS ESTUDIOS
DE TELECOMUNICACIÓN

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Telecorenta - Video Compression Workshop 2023

Proyecto TSI-063000-2021-68

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Introduction for the teacher

With this workshop we aim at introducing volumetric video processing, in particular compression, to students with a previous knowledge on traditional 2D video compression, and making them comfortable with using this new technology understanding the challenges related to the bulky size and limitations when streaming and other real time applications are needed. If you have any doubt you can contact us at the above e-mail addresses.
Before the actual exercise, the student will be:

- Initially introduced to traditional 2D video compression, to refresh the concepts and highlight those that will be important for the workshop
- Then introduced to volumetric video compression, with a specific mention of the standardisation work
- Able to read a description of the possible use case scenarios where volumetric video is crucial

Further, the students will have to face an exercise where they will be able to:

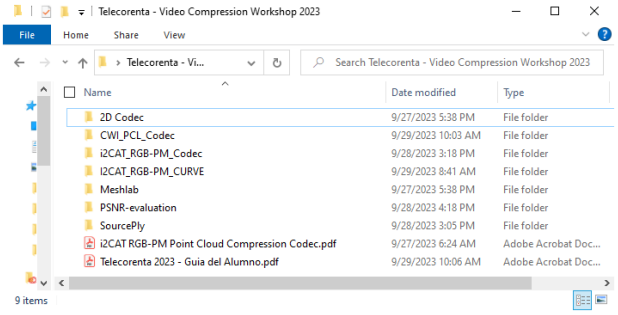
- Get familiar with of the of the volumetric video compression methods developed in the standardisation community
- Get familiar with the i2CAT alternative volumetric video compression method
- Run a further test to better understand how the codec parameters can be tuned to obtain different results in terms of bit rate and distortion

Workshop Methodology

The work has been designed in a way that the executable files are launched for a set of bathes.
In the exercise 1, the batches are ready to go and will show, to the students, the effects of the two compression methods involved
In the exercise 2 the students will be able to tune parameters, play with different trade offs for bit rate and distortion to personally play with the effects of compression (bit rate and distortion)

Package Structure

The downloadable package presents the following structure:



- The **Meshlab** folder is where the visualisation sw is located
- The **CWI_PCL_Codec** folder represents the location of the batch to launch the first volumetric video codec
- The **i2CAT_RGB-PM_Codec** folder represents the location of the batch to launch the i2CAT volumetric video codec
- The **I2CAT_RGB-PM_CURVE** folder represents the location of the batch to launch the second exercise to parametrise the i2CAT volumetric video codec
- The **SourcePly** folder represents the location of the raw video for the testing
- The **PSNR-evaluation** folder contains the sw for the distortion evaluation
- Finally, the **2D codec** folder includes the libraries that the several sw call. It should not be used.

Introduction

Volumetric video represents a new way of experiencing immersive media content. It refers to the process of capturing objects (e.g., people) from multiple cameras, which can be later viewed from any angle at any point in time. This enables a variety of applications with particular relevance for the fields of Augmented Reality (AR) and Virtual Reality (VR). Volumetric objects are typically stored as point clouds or meshes. Compared to traditional two-dimensional video, volumetric video requires the storage of geometric information in addition to texture (i.e., colour information), which results in a huge amount of data. For example, a raw point cloud object consisting of 2.8 million points requires a bandwidth of about 110 billion bits per second at 30 frames per second. Therefore, efficient compression is essential for such applications.

Video Compression

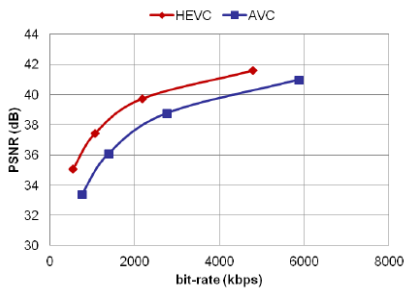
Video compression is the process of reducing the number of bits needed to represent a video without compromising its visual quality.

Main Standards:

- MPEG2
- AVC/H.264
- HEVC/H.265

Open Source implementations:

- HEVC HHI Reference SW
- H.264 HHI Reference SW
- FFMPEG - Includes several codecs among wich H.264 and HEVC

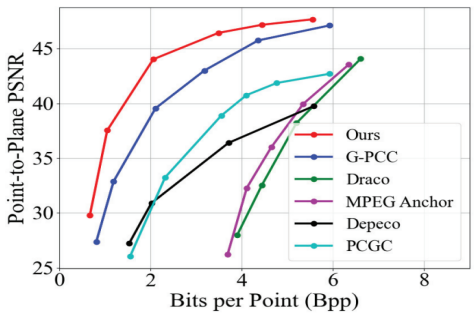


Compression performance is usually measured with a Rate Distortion (RD) curve. Where the rate considers the bit-rate needed to transmit a certain compressed video at a specific frame rate and the distortion is usually measured as the PSNR calculated on the YUV or Luma, Cb, Cr components separately

In order to provide different trade offs between i) the bit rate needed for the compressed representation and ii) the quality of the reconstructed decoded video, 2D video compression systems allows the parametrization of the compression through the Quantization Step that quantifies the coefficients of the transformed pixel values. Codecs such as H.264 and HEVC allow 52 values that can be provided as input through the so-called Quantization Parameter (QP).

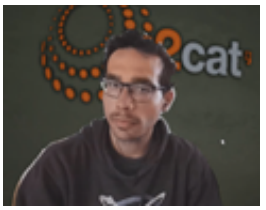
Volumetric Video Compression

Augmented, virtual and mixed reality experiences (AR/VR/MR) are currently increasing in popularity, as it enables users to navigate in multisensory 3D media experiences. The interest of capturing the real world in multiple dimensions and presenting it to the user has never been higher. However, such technology requires enormous amounts of data, so it is necessary to improve compression quality and signal processing. Volumetric visual data is typically computer-generated or is captured from the real world. Point cloud is a common representation format for this data, the other being polygonal mesh. Point Cloud Compression (PCC) is thus the way of compressing volumetric visual data.
A point cloud is a set of individual 3D points, each point having a 3D position but also being able to contain some other attributes such as colour, surface normal, etc. Point clouds are more flexible than polygonal mesh when representing non-manifold geometry and could be processed in real-time. The standard currently being developed is a point cloud comprising a list of 3 points coordinate (x, y, z) along with RGB attributes associated with each point.



Volumetric Compression performance is also measured using RD curves. However, in this case, apart from the YUV PSNR, there is also the need to evaluate the PSNR of the geometry information. This can be obtained using point-to-point and point-to-plane distances, where the point-to-point distance is determined by the Euclidean distance between a reference point and a nearest point, and the point-to-plane distance is determined by estimating the distance between the reference point and a projected point along a normal direction.

Use Case Scenario



Integrating digitalised humans in XR experiences is one the main research challenges in the XR domain. Volumetric video is used nowadays to create holograms and developing technologies such as 3D capturing, holoportation, volumetric video processing of multiple holograms remotely located. The research work on volumetric video capturing and processing is also used in XR experiences oriented to the entertainment industry, such as interactive movies and immersive broadcasting and TV productions. Further, it can be also used in cultural heritage experiences based on MR where sites of interest are recreated and digitalised humans are integrated within the environment

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Intro and Pre-Requirements

This workshop will focus on testing several 2 different Volumetric Video Codecs :

- An implementation of the **MPEG Anchor CWI-PCL-Codec**
- An implementation of the **i2CAT RGB-PM Codec** for real time holoportation

MPEG Anchor CWI-PCL-Codec:

- Published Paper

i2CAT RGB-PM Codec:

- Tutorial Explaining the codec features - Document

Download the Codecs

- Download Package

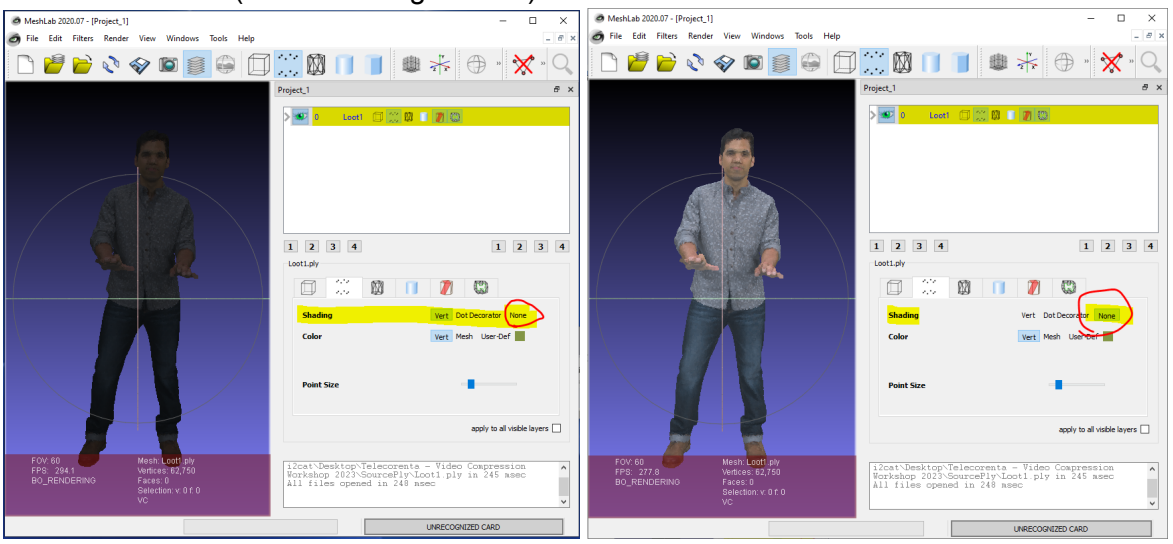
What will you need

- A PC with an NVIDIA graphic card

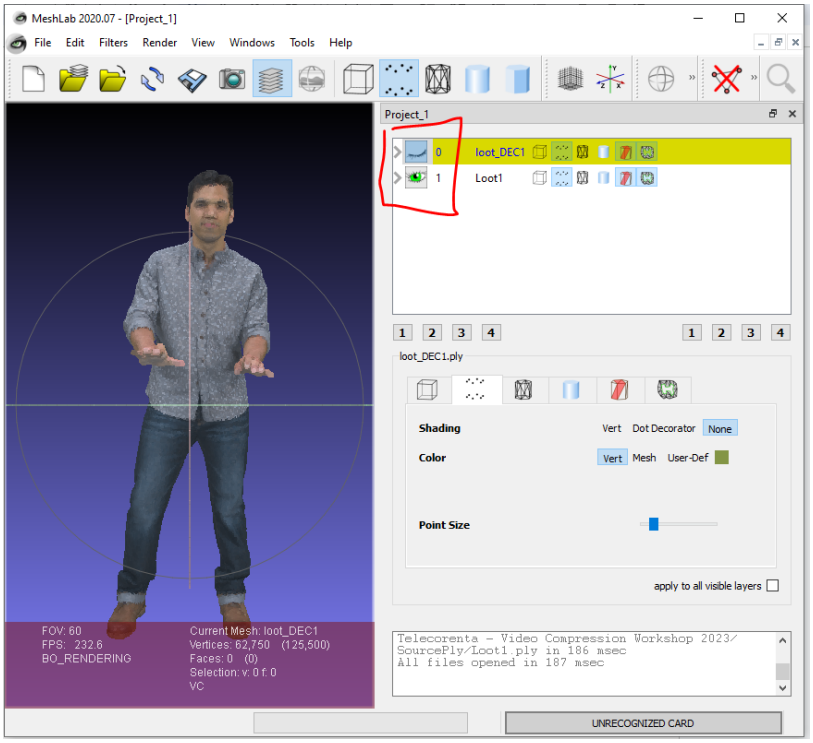
Exercise 1: Environment Preparation and first steps

1.1: Download the package and extract the Testing Environment

- Install Meshlab running the file **"..\Meshlab\Windows x64\MeshLab2022.02-windows.exe"**
- Go to **..\SourcePLY**
- Import, in Meshlab, the file **Loot1.ply** and visualise the volumetric image
- If you see a dark figure, deactivate the Shading in the left column of meshlab clicking on “None” (as in the image below)



- In order to visualise 2 point clouds in the same Meshlab Window, you have 2 options:
  a. Open two instances of Meshlab, opening a volumetric image in each of them
  b. use the “eye” icon to switch on and off the rendering of one of the point clouds (as in the image below)



- Take screenshot of the visualised point cloud and paste it to the report

1.2: First test for CWI PCL Codec

- Go to the folder **..\CWI_PCL_Codec** and locate the batch file called **Test1Frame_CWI.bat**
- Make sure that the paths are correct
- Open a CMD window
- Run the file **Test1Frame_CWI.bat**
- Identify the file **loot_DEC1.ply** and open it with Meshlab
- Take screenshots of the noticeable differences between **loot_DEC1.ply** and **Loot1.ply**

1.3: First test for **i2CAT RGB-PM Codec**

- Open the folder **..\i2CAT_RGB-PM_Codec** and locate the batch file called **Test1Frame_i2CAT.bat**
- Make sure that the paths are correct
- Open a CMD window
- Run the file **Test1Frame_i2CAT.bat**
- Identify the file **PLY_dec1.ply** and open it with Meshlab
- Take screenshots of the noticeable differences between **PLY_dec1.ply** and **Loot1.ply**
    - Please consider that this codec compresses only the geometry, so no colors will be visualized in the file **PLY_dec1.ply.**

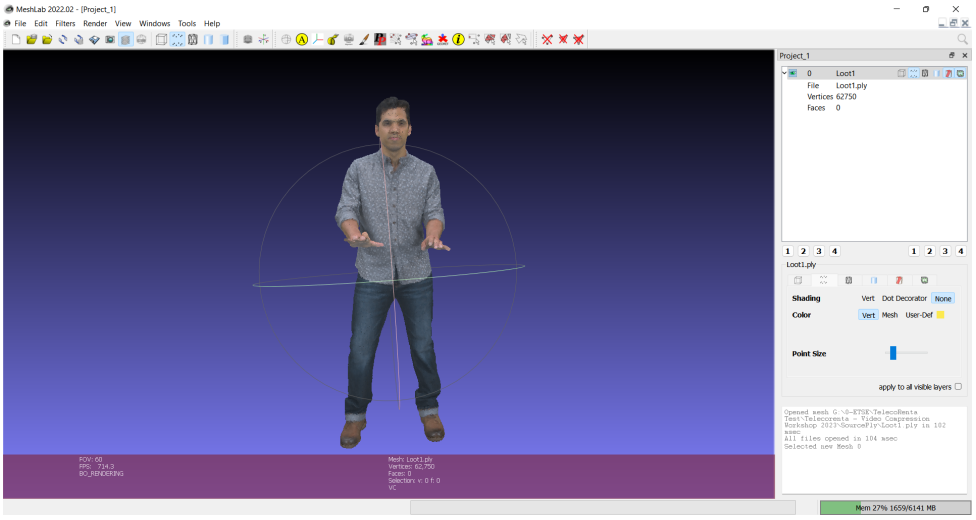
Exercise 2: RD Curve for the i2CAT RGB-PM Codec

- Open the folder **..\i2CAT_RGB-PM_CURVE**
- Locate the batch file called **i2CAT_RGB-PM_Curve_test_1.bat**
- Open the batch file with a text editor
- Within the batch file you will find **a loop** that drives the different Quantization Parameter (QP) values for the test. Please choose a starting QP and a finishing QP. Also choose the step for the loop. The line to consider is the following one:
    - *for /L %%a in (Start_QP, QP_step, End_QP) do (*

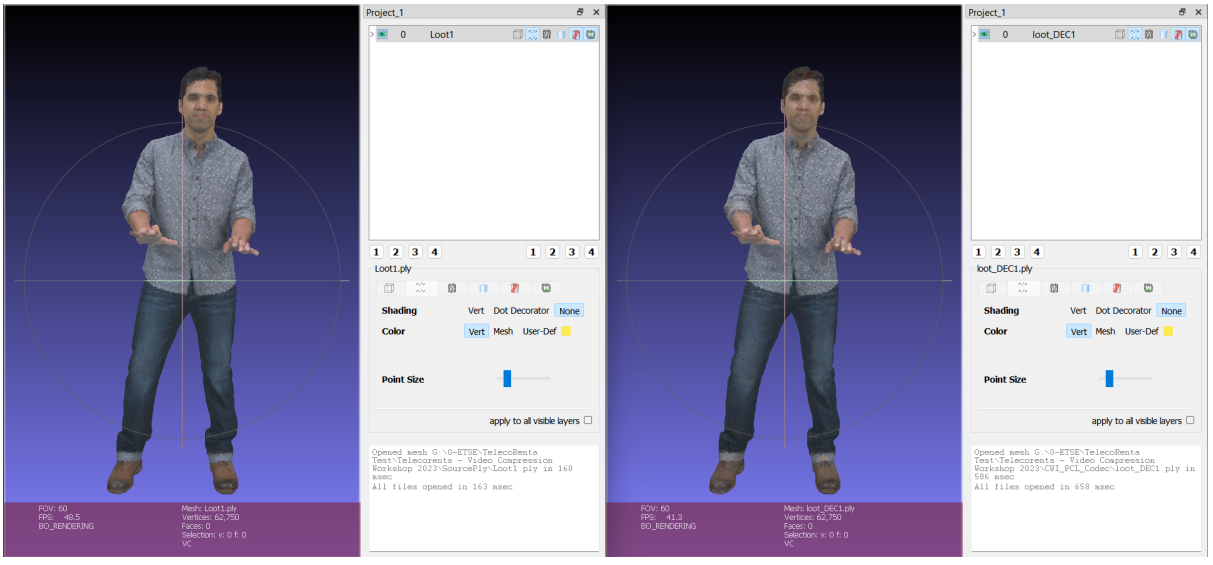
  - Please substitute the values Start_QP and End_QP with numbers included between 1 and 51
  - Chose QP_step to define how the QPs will be updated within the loop
- Open a CMD window
- Run the file **i2CAT_RGB-PM_Curve_test_1.bat**
- Locate, in the folder **..\I2CAT_RGB-PM_CURVE\Results**, the 2 (two) files called:
  - **i2CAT_PSNR_Values.txt**
  - **i2CAT_Files_size_bytes.txt**
- Use a plotter to generate the Rate Distortion curve for the experiment.
  - The curve should have:
    - On the X axis, the size of the compressed file, expressed in bits
    - On the Y axis, the PSNR calculated
  - Use the data stored on the 2 generated files to generate the curve

Expected Results

Exercise 1.1:



Exercise 1.2:



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Exercise 1.2

Exercise 2

File size	PSNR
440290	31.7231
396346	24.9995
348459	20.9926