Quality Assessment of Volumetric Video

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September 27th, 2019

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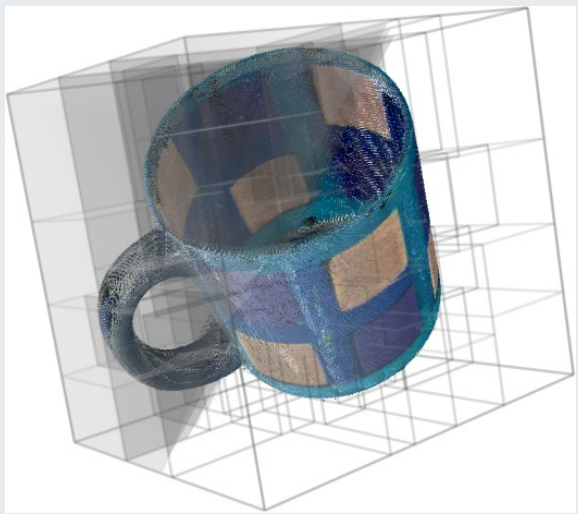
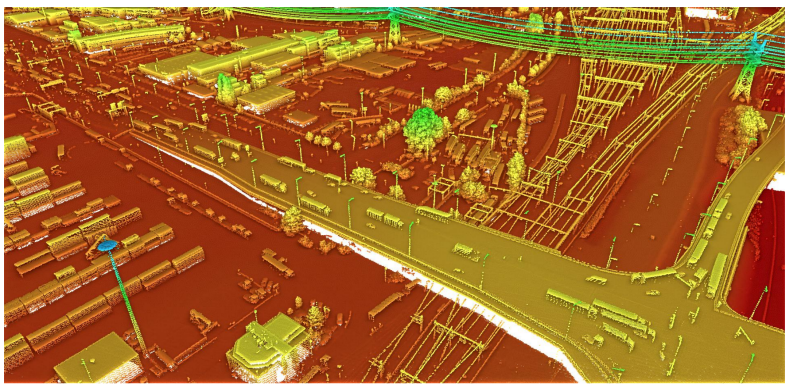
Volumetric video

- High popularity of immersive multimedia applications;
- Point Clouds:
  - Alternative 3D content representation that allows visualization of scenes in a more immersive way;
  - Set of coordinates indicating the location of each point, along with one or more attributes (such as color) associated to that particular point;
  - PCs are a viable solution to represent visual stimuli, given the efficient and simple way they capture, store and render 3D objects;



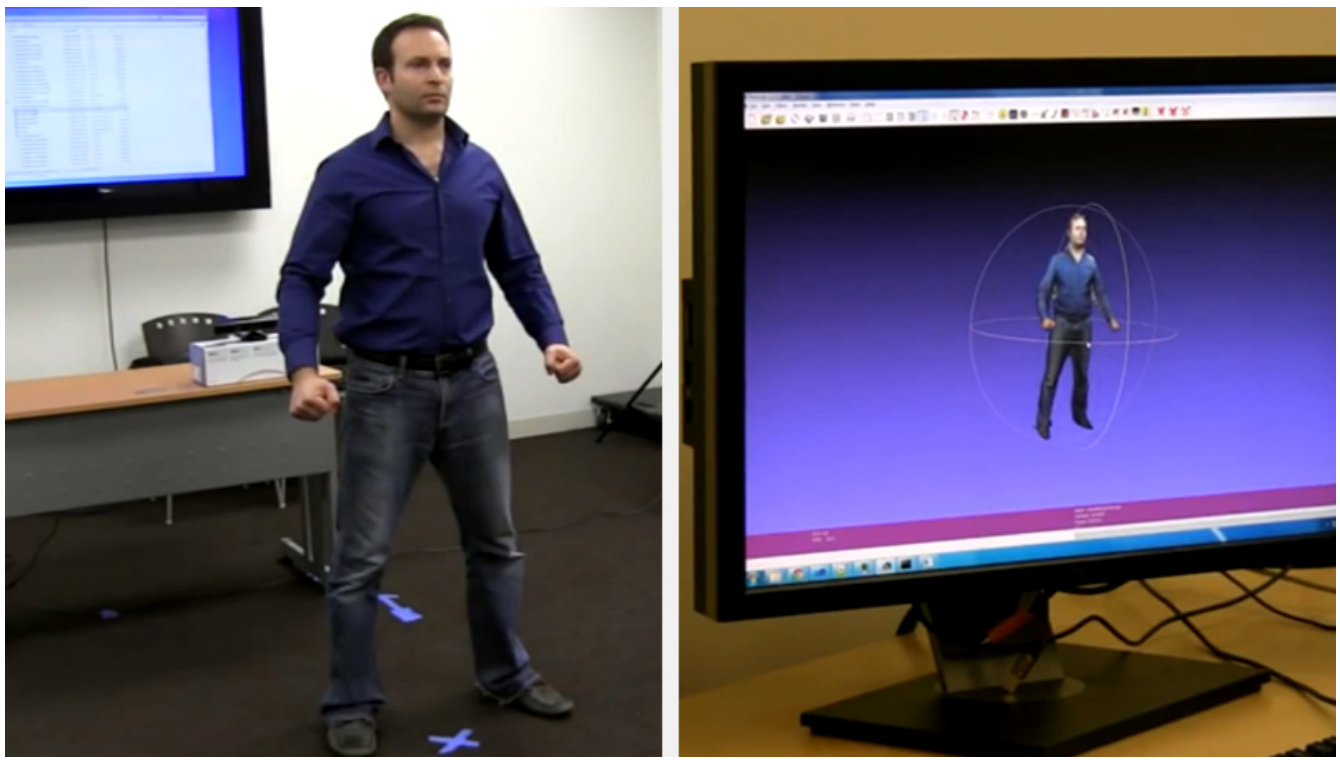
Applications

- It is believed that a wide range of applications and use cases can benefit from this type of data representation.



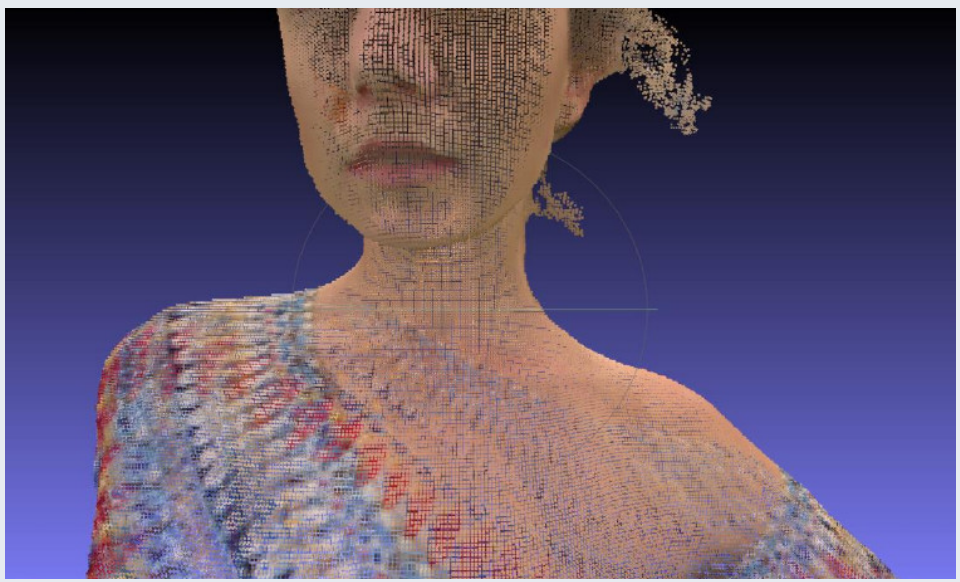
Challenges

- 3D point clouds are captured using multiple cameras and depth sensors, arranged in various setups;
- This results in thousands up to **billions of points** to represent realistically objects or scenes;



Challenges

- Efficient PC representation is needed to store or transmit these information;
- In order to evaluate PC encoders, a way to objectively assess the quality of encoded PC to a human is needed.

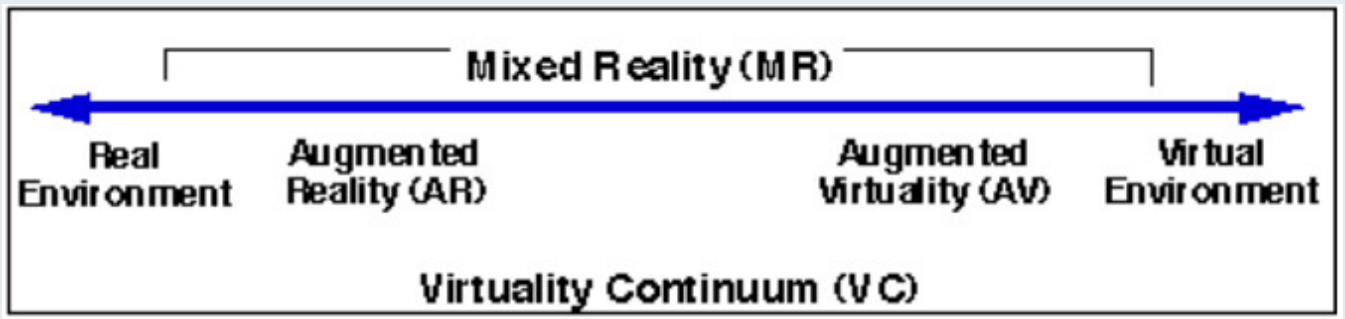


Applications

- Video communications is certainly one exciting application, but once equipment is affordable and a good quality to the user can be provided.

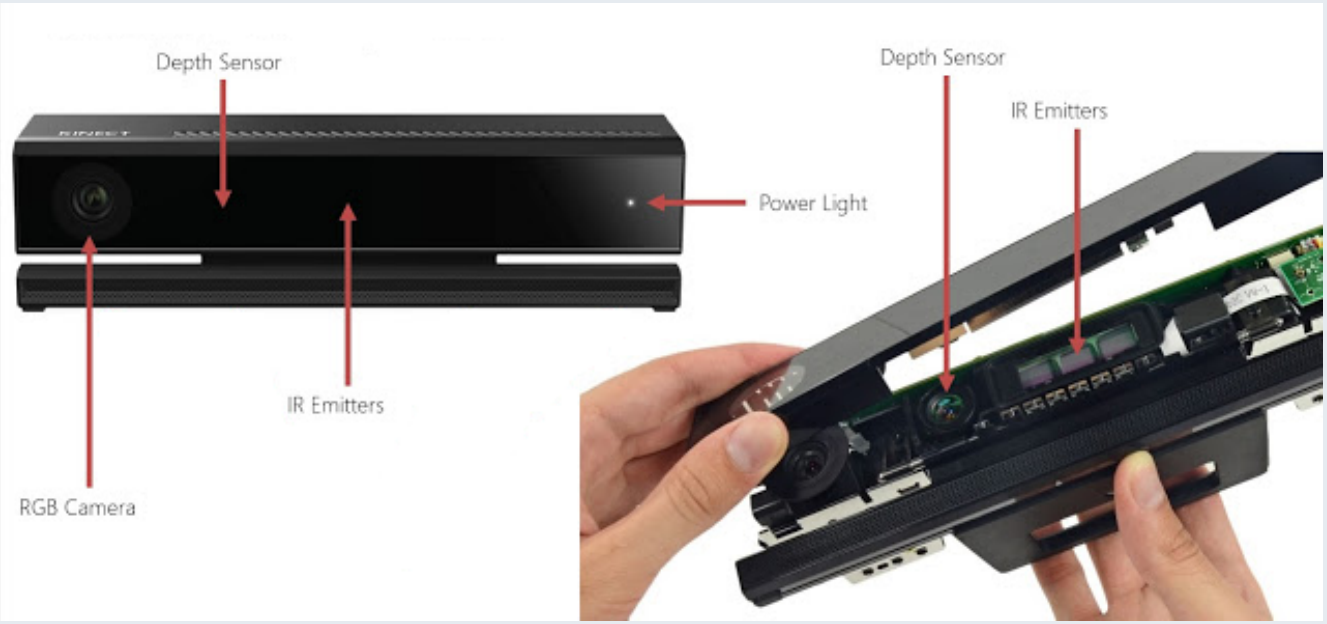
Mixed Reality

Milgram and Fumio:



Kinect-2 capture device

- Time-of-Flight depth ranging technology
- Depth resolution of 512x424, distances from 0.5 to 4.5m, FoV of 70.6° by 60° (HxV), millimeter accuracy
- RGB in HD, downsampled to match depth resolution



Typical volumetric video capture setup
Example with 4 Kinect-2 devices.

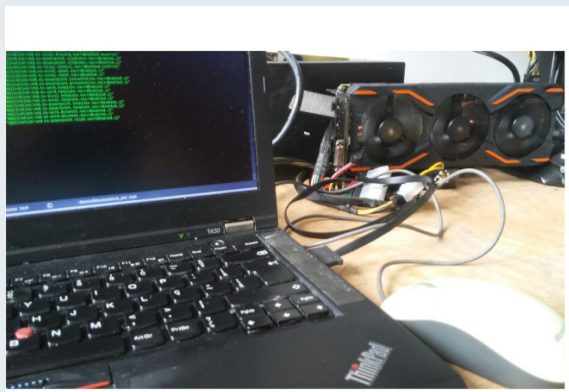
Prior Work

Volumetric reconstruction from single view RGB-D

- We implemented a Mixed Reality Volumetric Video Communication prototype using a single RGB-D capture device

Experimental Setup

- Kinect-2 as main capture device;
- Lenovo T430 for mobile capture device;
- Intel Xeon E5-2620, with 80GB of RAM hardware;
- Code written in C and C++;
- Libraries used: Open3D and Libfreenect.



Prior Work

Constraints:

- Assumes that the back of the head of the person is non-deformable;
- The speaker is looking ahead during most of the time;
- Self-occlusions do not occur often;
- This way, higher dynamics of the object (mouth, nose, eyes) can be fully present in the reconstructed 3D volumetric stream;
- The method can be extended to other types of objects.

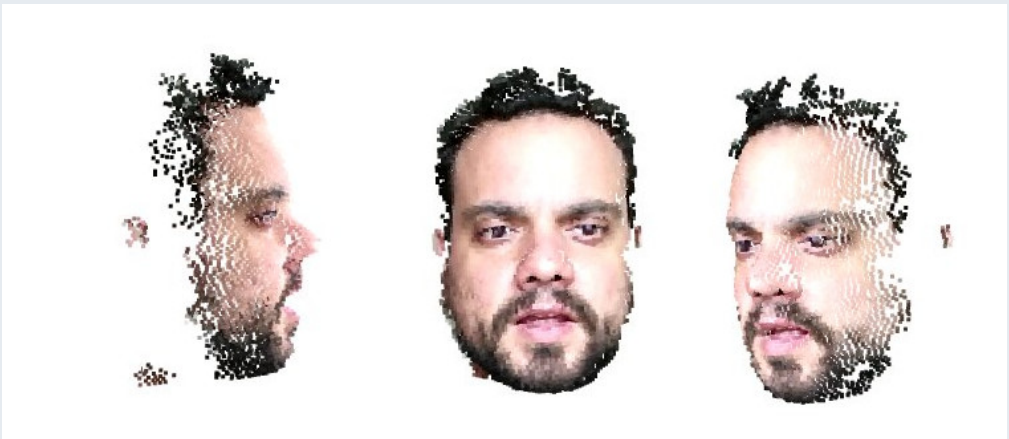
Step 1

Captured model examples

Step 2

Segmented model examples

Step 3



Point-cloud from live single view capture examples

Step 4

Reconstructed Point-cloud

Summary of Results

- Realtime CPU execution - under 33ms at 30fps;
- Better experience when compared to incomplete objects;
- Room left for GPU offloading optimization;

Objective Volumetric Video Quality Assessment

Current work

- Volumetric Video Quality Assessment: Full-reference metric for point-clouds
- Current work is exploring LBP (Local Binary Patterns) texture descriptor and its variations: Default LBP, Uniform LBP, Rotation Invariant LBP, Non Rotation Invariant Uniform LBP e Rotation Invariant LBP Variance
- Based on previous extensive knowledge on objective quality 2D image analysis, adapted to 3D Point-Clouds.

Objective Volumetric Video Quality Assessment

WIP

Download of all available Point-Cloud subjective quality analysis data based on evaluations with real people which adherence to recommendation

- E. Torlig, E. Alexiou, T. Fonseca, R. de Queiroz, and T. Ebrahimi, "A novel methodology for quality assessment of voxelized point clouds," in Proc. SPIE Optical Engineering+Applications, 2018, pp. 107520I.1–107520I.17.
- E. Zerman, P. Gao, C. Ozcinar, A. Smolic. "Subjective and objective quality assessment for volumetric video compression." IS&T Electronic Imaging, Image Quality and System Performance XVI, San Francisco, California, USA, January 2019.

Objective Volumetric Video Quality Assessment

WIP

Future most likely datasets to be acquired:

- E. Alexiou, T. Ebrahimi, M. Bernardo, M. Pereira, A. Pin- heiro, L. da Silva Cruz, C. Duarte, L. Dmitrovic, E. Dumic, D. Matkovic, and A. Skodras, "Point cloud subjective evalua- tion methodology based on 2D rendering," in Proc. IEEE Int. Conf. Quality of Multimedia Experience, 2018, pp. 1–6.
- Su, H., Duanmu, Z., Liu, W., Liu, Q. and Wang, Z., 2019, September. "Perceptual Quality Assessment of 3d Point Clouds". In 2019 IEEE International Conference on Image Processing (ICIP) (pp. 3182-3186). IEEE.

Objective Volumetric Video Quality Assessment

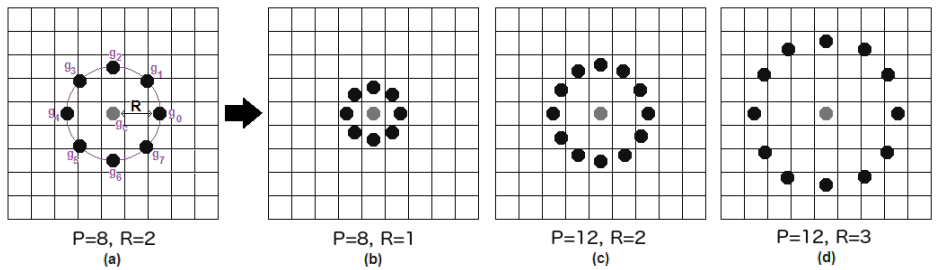
Objective Volumetric Video Quality Assessment

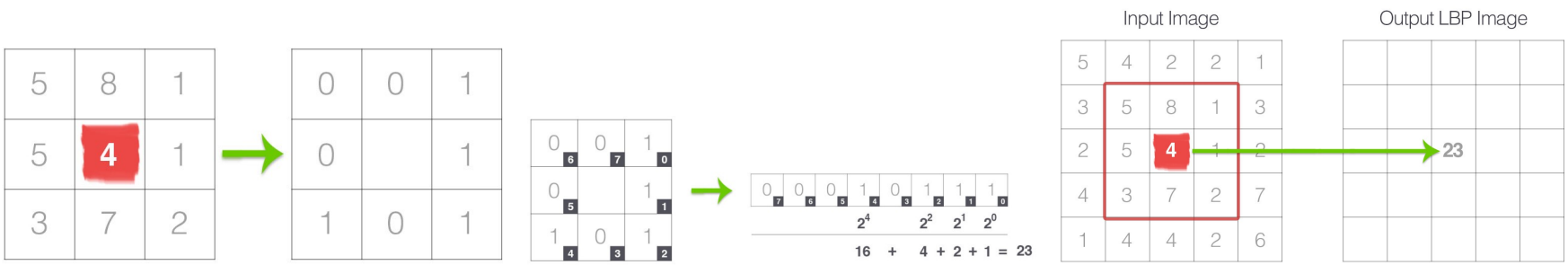
Objective Volumetric Video Quality Assessment

Run LBP for all PC points and get the histogram

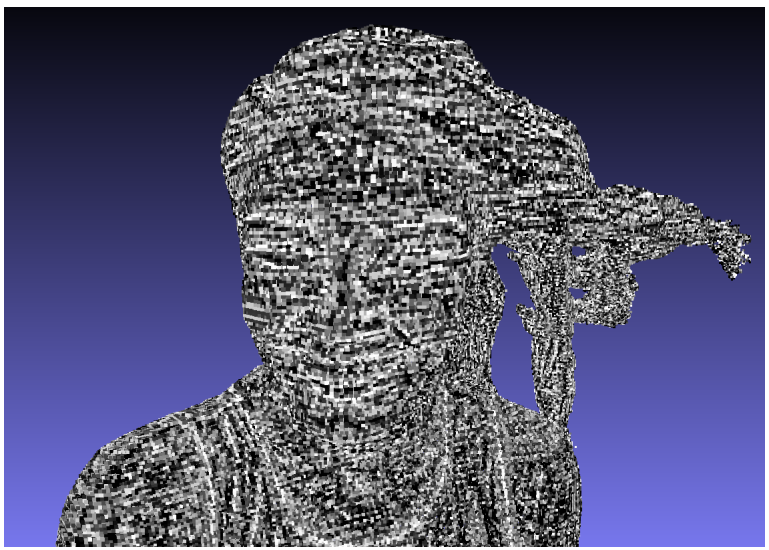
- The neighborhood are the nearest points
- Create a normalized histogram of the LBP labels
- Create “feature map” Point-Clouds

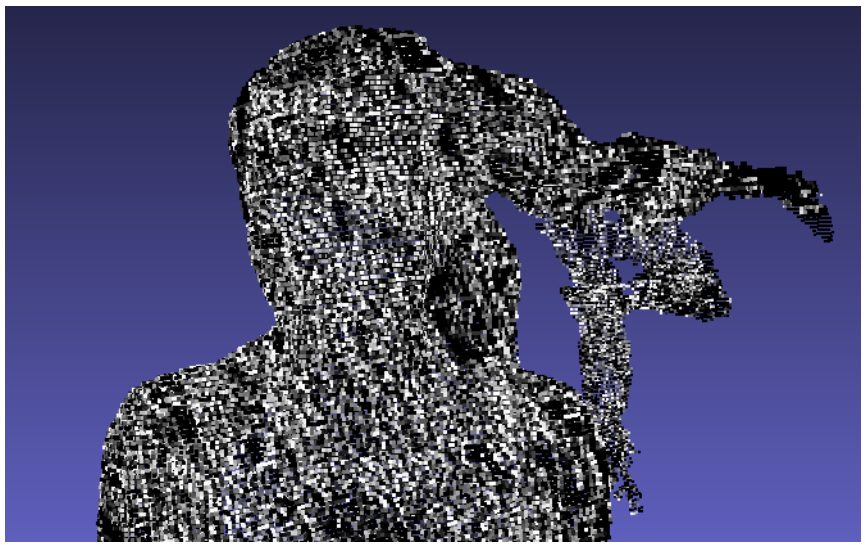
LBP


P=8, R=2
(a)
P=8, R=1
(b)
P=12, R=2
(c)
P=12, R=3
(d)

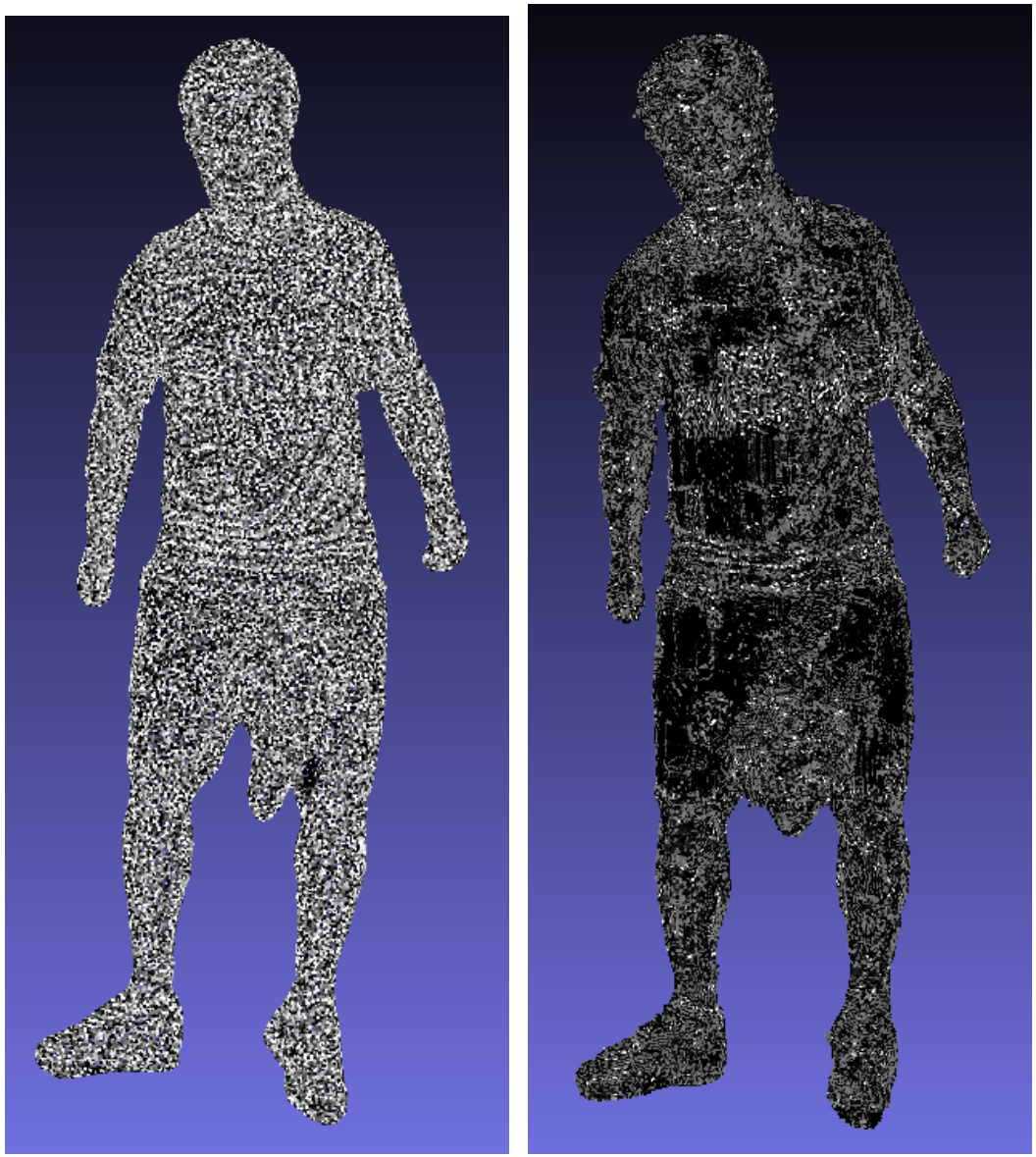

Input Image
Output LBP Image
23
16 + 4 + 2 + 1 = 23

Feature PC

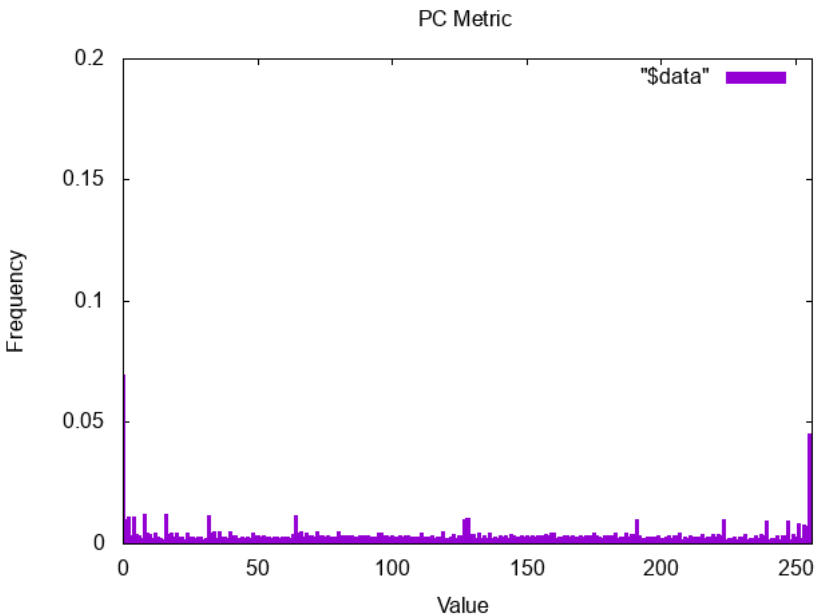


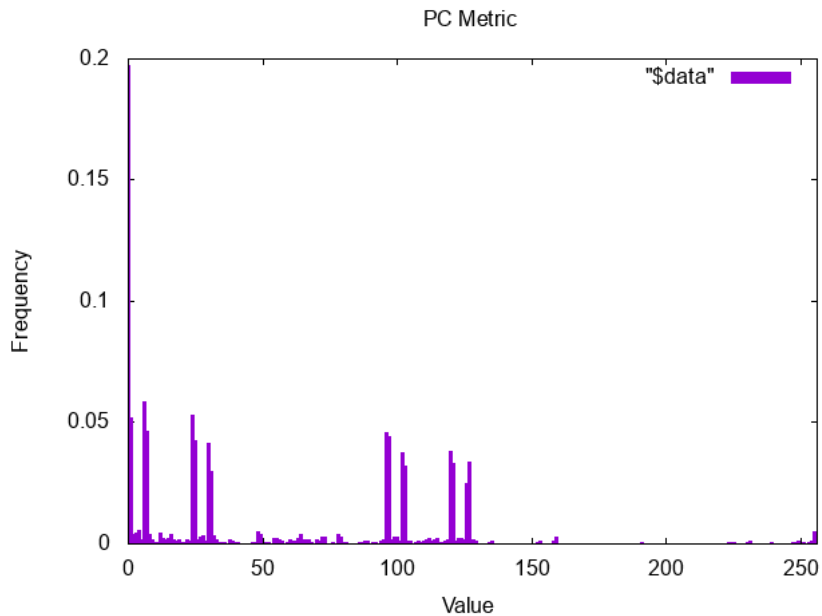


Feature PC



LBP labels histogram





Objective Volumetric Video Quality Assessment

Calculate histogram difference

- Make the difference of reference PC and degraded PC
- Correlate obtained values (Pearson, Spearman) to subjective scores of evaluation with humans

Calculate histograms euclidean differences

longdress	hidden	0.0000000000
longdress	octree08_jpeg010	0.0969154340
longdress	octree08_jpeg050	0.0713802897
longdress	octree08_jpeg090	0.0548819815
longdress	octree09_jpeg010	0.1238553797
longdress	octree09_jpeg050	0.0670966377
longdress	octree09_jpeg090	0.0505155374
longdress	octree10_jpeg010	0.1643708341
longdress	octree10_jpeg050	0.0649983822
longdress	octree10_jpeg090	0.0464406376

Calculate correlation

TODO: Calculate Pearson and Spearman correlation methods between the scores of subjetive evaluations with our results of the difference between histograms.

Questions?

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http://www.gpds.ene.unb.br/rafael