

Multi-Distance Point Cloud Quality Assessment



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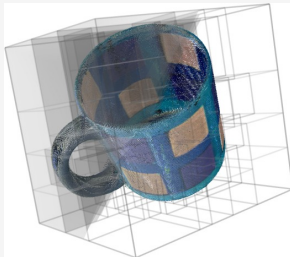
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Summary

- Point Cloud Quality Assessment
- Proposed Method
- Experimental Setup
- Results
- Conclusions

Point Clouds

- Point Clouds have points with 3D position information (x, y, z), color information (R, G, B), and possibly attributes such like transparency, time of acquisition, reflectance of laser, etc.

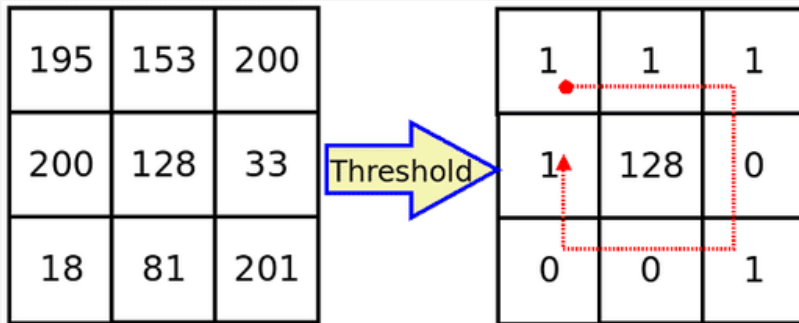


Point Cloud Quality Assessment

- Subjective Quality Assessment experiments - How humans perceive PC quality for different stimuli conditions
 - Experiments: Zhang et al., Alexiou et al., Javaheri et al., Zerman et al.
 - Psychophysical experiments with human participants are labor-intensive and time-consuming
- Objective Quality Assessment experiments - automatically predict visual quality
 - Objective Quality Metrics: Eg. Alexiou & Ebrahimi, Meynet et al., Torlig et al.
 - Based on point-to-point, point-to-plane or plane-to-plane spatial and texture distances. Also projection-based metrics which leverage standard 2D image metrics

Proposed Method

- Based on the scores of established metrics: Point-to-Point and Point-to-Plane, together with our Local Binary Pattern (LBP) approach.
- Objective Full-reference metric for PCQA



Default LBP for 2D images

$$\text{LBP}_R^N(P_c) = \sum_{n=0}^{N-1} \theta(P_n - P_c) \cdot 2^n, \quad (1)$$

where

$$\theta(u) = \begin{cases} 1 & \text{if } u \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

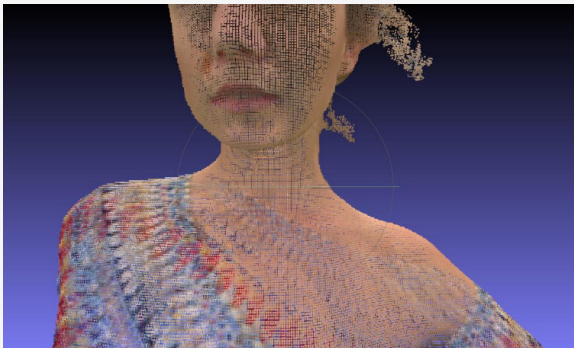
- Pixels are equally distributed in a dense 2D grid.
- Other LBP variants exists, eg. Rotation invariant LBP.

Proposed Method - Steps

- Voxelization
- PC LBP Feature Map (FM) creation
- FM histograms (reference vs test) distance calculation
- Regression algorithm - predicted MOS

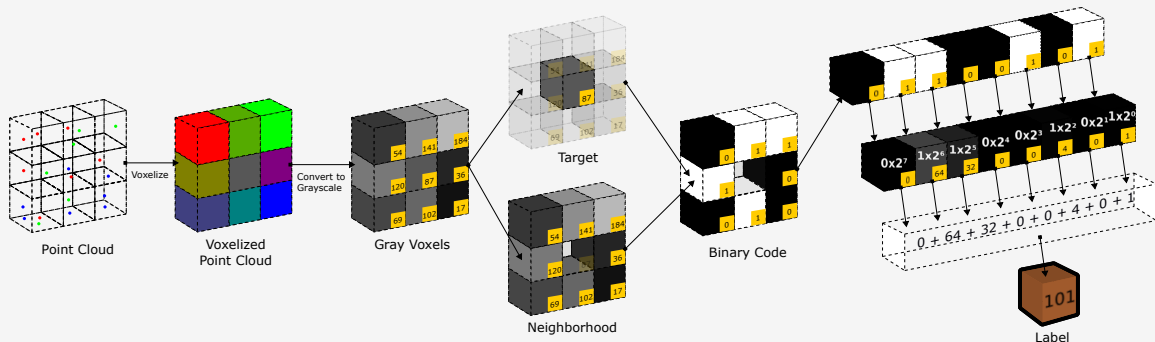
Proposed Method: Voxelization

- Points are sparsely distributed in the 3D space - problem of determining the neighborhood!
- Voxelization convert point(s) to discrete volumetric units (voxels)
- Details in: "Towards a Point Cloud Quality Assessment Model using Local Binary Patterns.", QoMEX 2020. (same authors of this paper).



Proposed Method: LBP for Point Clouds

- LBP descriptor to PC: nearest N voxels as the neighboring elements P_n
- Neighborhood is visited from closer to farther 8 voxels
- Feature Map (FM) containing PC LBP labels

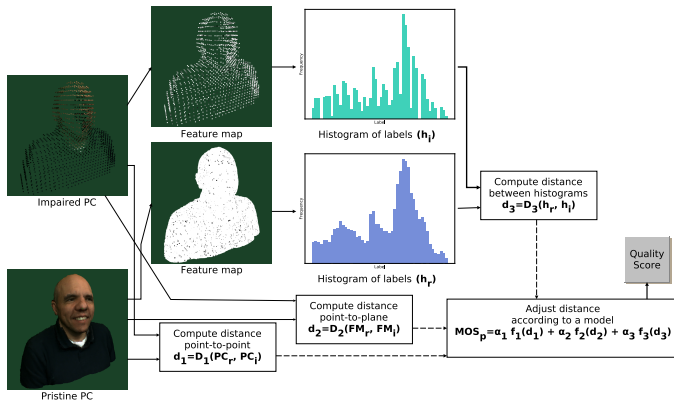


Proposed Method: Regression and Final Score

- Third-degree polynomial function as a regression algorithm
- a_1 , a_2 , and a_3 were found using a least squares method
- $f(x) = x$
- $d_1 = po2point_{MSE}$ and $d_2 = po2plane_{MSE}$
- d_3 is the distance between reference and impaired LBP FM histograms

$$MOS_p = a_1 \cdot f_1(d_1) + a_2 \cdot f_2(d_2) + a_3 \cdot f_3(d_3) \quad (3)$$

Proposed Method: Block diagram



Experimental setup: datasets / subjective scores

- 3 datasets containing reference and impaired PCs and subjective scores - Torlig 2018 (UnB), Alexiou 2019 (UnB&EPFL) and Cruz 2019 (UBI&UC&UNIN).
- We compared our proposal to publicly-available PCQA methods: po2point_{MSE} , $\text{PSNR-po2point}_{MSE}$, $\text{po2point}_{Hausdorff}$, $\text{PSNR-po2point}_{Hausdorff}$, Color-YCbCr_{MSE} , $\text{PSNR-Color-YCbCr}_{MSE}$, $\text{Color-YCbCr}_{Hausdorff}$, $\text{PSNR-Color-YCbCr}_{Hausdorff}$, po2plane_{MSE} , $\text{PSNR-po2plane}_{MSE}$, $\text{po2plane}_{Hausdorff}$, $\text{PSNR-po2plane}_{Hausdorff}$, Plane-to-plane, pl2plane_{MSE} , pl2plane_{RMS} , proj_{PSNR} , proj_{SSIM} , proj_{MSSIM} and proj_{VIP} .

Experimental Results

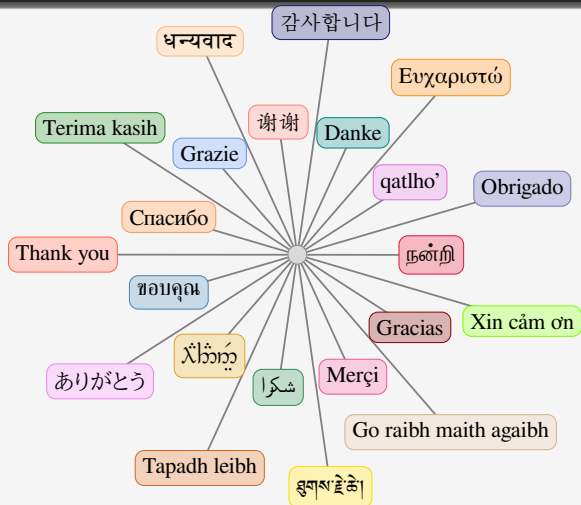
- Calculated PCC, SROCC and RMSE of metrics with 3 datasets.
- Our proposal is best for two datasets and second best for one dataset, and presents a more consistent performance across all datasets.

Table: Performance of the proposed metric compared to second-best metric.

DB	Variant	PCC	SROCC	RMSE
UnB	Proposed	0.903	0.903	0.532
	<i>po2point</i> _{Hausdorff}	0.859	0.805	0.633
UBI&UC& UNIN	Proposed	0.884	0.910	0.653
	Color-YCbCr _{MSE}	0.860	0.890	0.707
UnB&EPFL	Proposed	0.797	0.799	0.838
	<i>po2point</i> _{MSE}	0.800	0.868	0.839
	<i>po2plane</i> _{MSE}	0.768	0.891	0.895

Conclusions

- Novel PCQA method based on a multi-distance approach mixing established PC metrics (Point-to-point and Point-to-plane) and the statistics of a variant of the LBP texture descriptor
- Promising results with strong performance when compared to other metrics



Questions?

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<http://www.ene.unb.br/mylene/databases.html>