

Towards Perceptual Quality Evaluation of Dynamic Meshes

Fakhri Torkhani

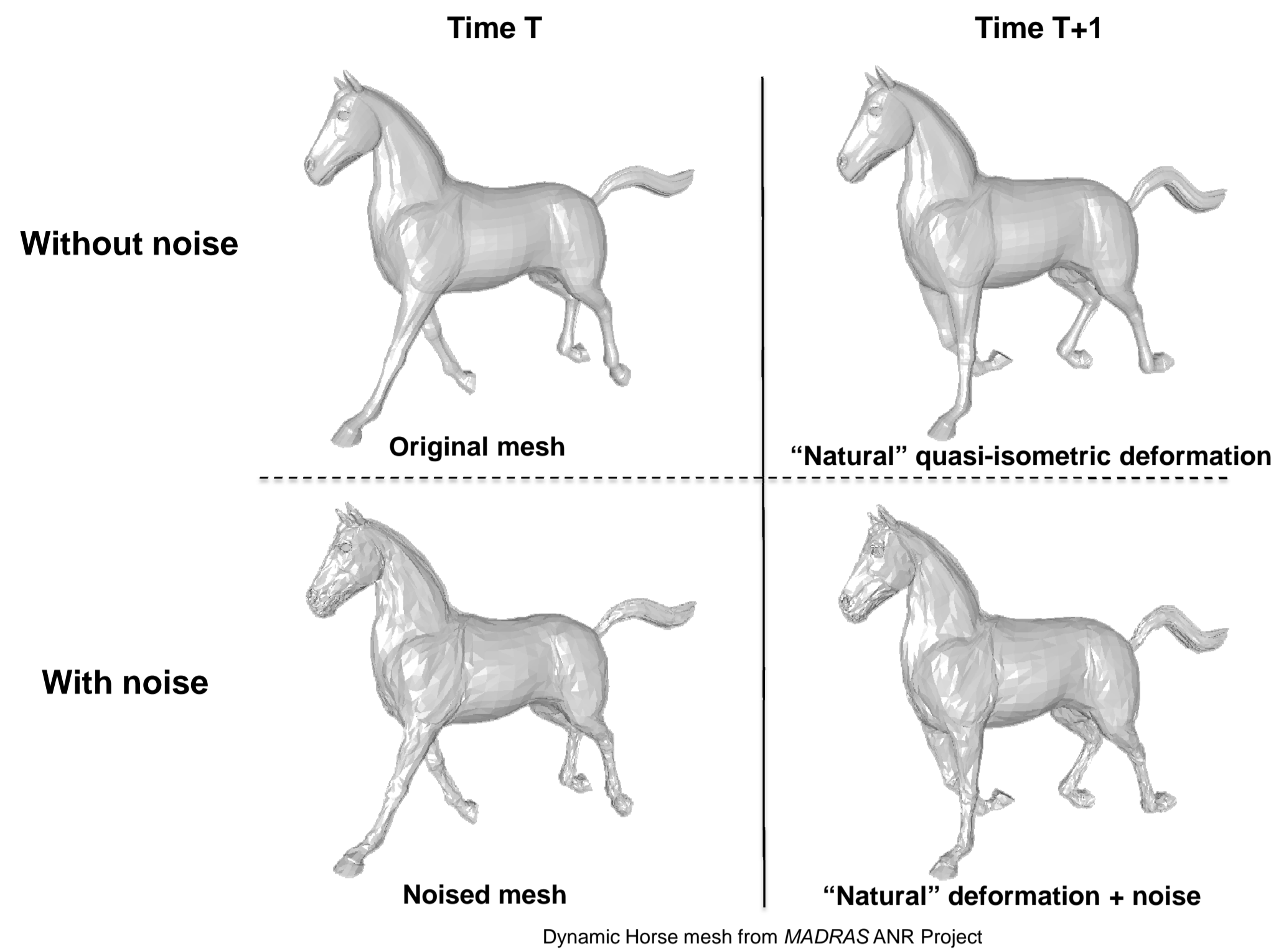
Kai Wang

Annick Montanvert

AGPIG Group, Gipsa-lab, CNRS UMR 5216, Grenoble, France

Grenoble
Images
Parole
Signal
Automatique

Motivation and objective

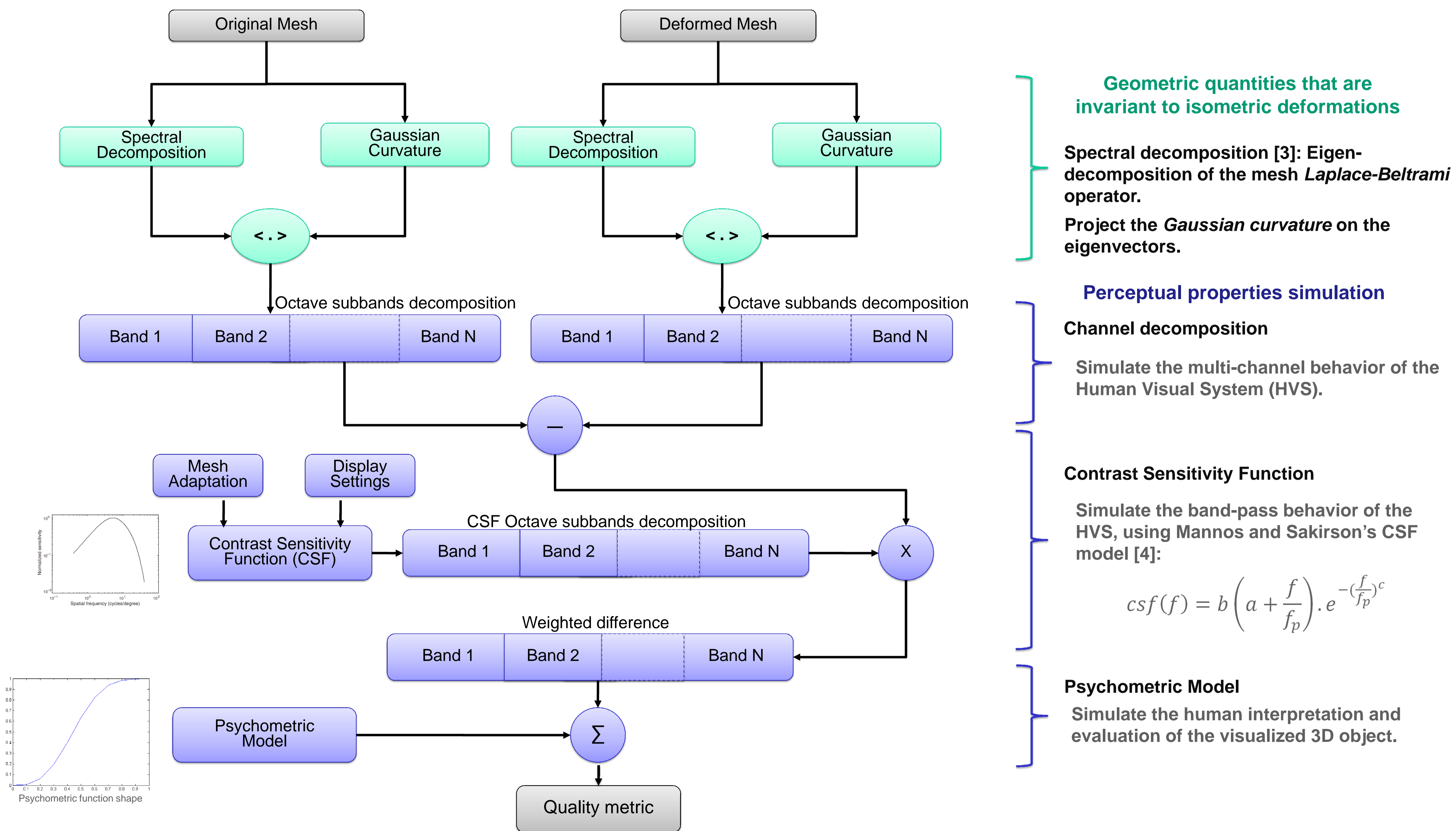


Like in the case of image quality assessment [1], metrics based on mesh geometric distances (e.g. Hausdorff distance and Root Mean Squared error) cannot correctly predict the visual quality degradation.

Recently, several perceptually-motivated metrics have been proposed (e.g. mesh structural distortion measure and roughness-based measures [2]). Those perceptual metrics work well on static meshes, but are less efficient on dynamic meshes because they may mistakenly evaluate "natural" deformations as of rather low perceptual quality.

We propose a metric for assessing perceptual quality of 3D meshes which integrate the characteristics of the human visual system and which is capable of distinguishing the natural deformation of animated meshes from deformations due to noise.

Method



Geometric quantities that are invariant to isometric deformations

Spectral decomposition [3]: Eigen-decomposition of the mesh Laplace-Beltrami operator.
Project the Gaussian curvature on the eigenvectors.

Perceptual properties simulation

Channel decomposition
Simulate the multi-channel behavior of the Human Visual System (HVS).

Contrast Sensitivity Function

Simulate the band-pass behavior of the HVS, using Mannos and Sakirson's CSF model [4]:

$$csf(f) = b \left(a + \frac{f}{f_p} \right)^{-c} e^{-\left(\frac{f}{f_p}\right)^c}$$

Psychometric Model

Simulate the human interpretation and evaluation of the visualized 3D object.

Results

Type of deformation	Weighted Contrast difference	Our perceptual Quality metric	MSDM	Hausdorff distance
Low noise	1.9080	0.1036	0.2229	0.0006
Medium noise	3.6322	0.5291	0.4372	0.0019
High noise	6.8425	0.9970	0.5534	0.0033
Quasi-isometric deformation	1.8195	0.0891	0.4380	0.1530
Movement + low noise	2.0758	0.1267	0.4998	0.1527
Movement + medium noise	3.5824	0.5132	0.5772	0.1521
Movement + high noise	6.6650	0.9954	0.6327	0.1514

Some quality/distance evaluation results on Horse, the reference model being the first mesh in the sequence.

Our metric considers a nature quasi-isometric deformation as of very high quality ($Q \approx 0.1$), and its value increases as the noise amplitude increases.

The proposed metric is experimentally more efficient than the mesh structural distortion measure (MSDM) and the Hausdorff distance.

Future work

Integrate more Human Visual System properties
Validate the metric based on subjective experiments

References

- [1] Z. Wang and A. Bovik. Modern Image Quality Assessment. Morgan & Claypool Publishers, 2006.
- [2] G. Lavoué and M. Corsini. A comparison of perceptually-based metrics for objective evaluation of geometry processing. IEEE Trans. on Multimedia, 12(7): 636-649, 2010.
- [3] B. Lévy and H. Zhang. Spectral mesh processing. In Proc. of SIGGRAPH Asia Course Notes, 2009.
- [4] J. L. Mannos and D. Sakirson. The effects of a visual fidelity criterion on the encoding of images. IEEE Trans. on Information Theory, 20(4): 525-536, 1974.

Contact

fakhri.torkhani@gipsa-lab.grenoble-inp.fr
kai.wang@gipsa-lab.grenoble-inp.fr
annick.montanvert@gipsa-lab.grenoble-inp.fr