A Psychophysical Evaluation of Texture Degradation Descriptors

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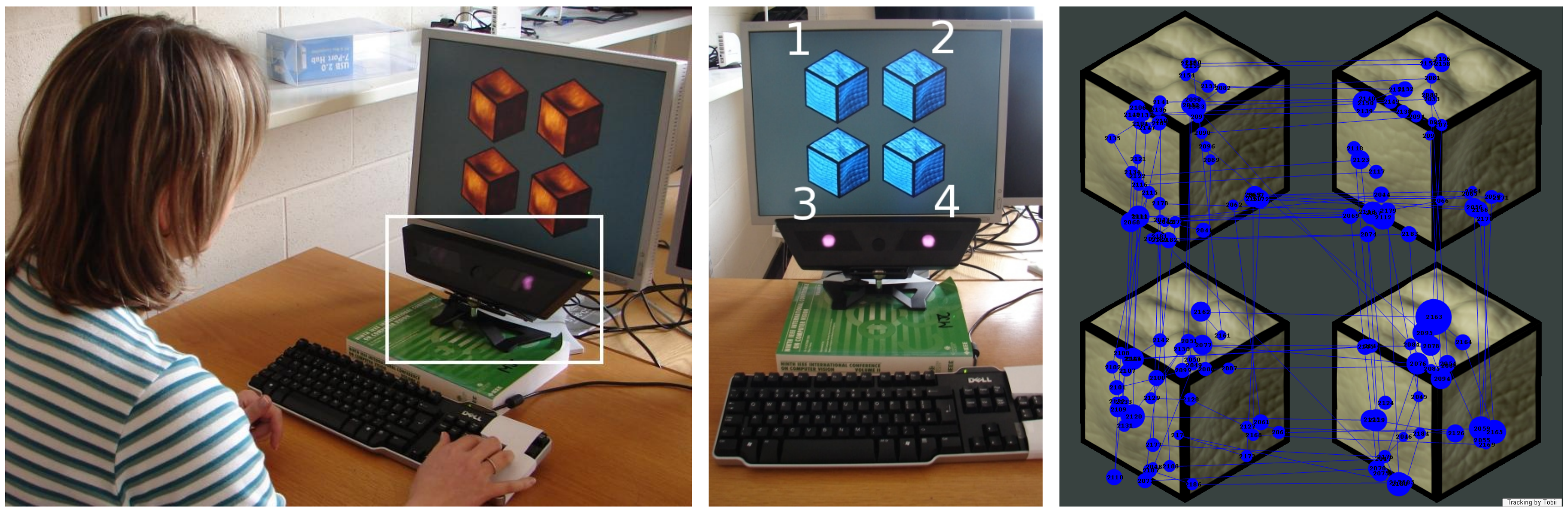
Abstract

Delivering digitally a realistic appearance of materials is one of the most difficult tasks of computer vision. Accurate representation of surface texture can be obtained by means of view- and illumination-dependent textures. However, this kind of appearance representation produces massive datasets so their compression is inevitable. For optimal visual performance of compression methods, their parameters should be tuned to a specific material. We propose a set of statistical descriptors motivated by textural features, and psychophysically evaluate their performance on three subtle artificial degradations of textures appearance. We tested five types of descriptors on five different textures. We found that descriptors based on a two-dimensional causal auto-regressive model, have the highest correlation with the psychophysical results, and so can be used for automatic detection of subtle changes in rendered textured surfaces in accordance with human vision.



Setup of the psychophysical experiment, example stimuli image, and recorded gaze fixation pattern.

Motivation

- Image compression methods use predefined parameters to control output quality.
- How to set the parameters automatically to achieve high compression and good perceptual quality?

Our goal: Find computational texture degradation descriptors with responses highly correlated with human perception of these degradations.

Texture Degradation Descriptors

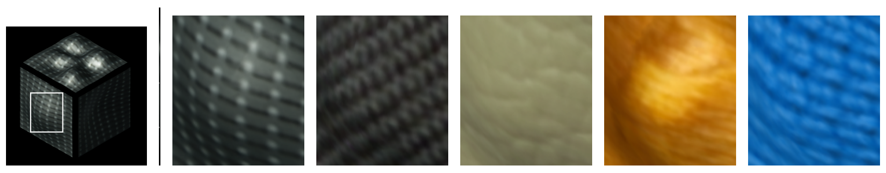
Motivated by standard texture features:

- structure similarity index (SSIM),
- visual difference predictor (VDP),
- local binary patterns (LBP),
- Gabor features (GF),
- causal auto-regressive model (CAR).

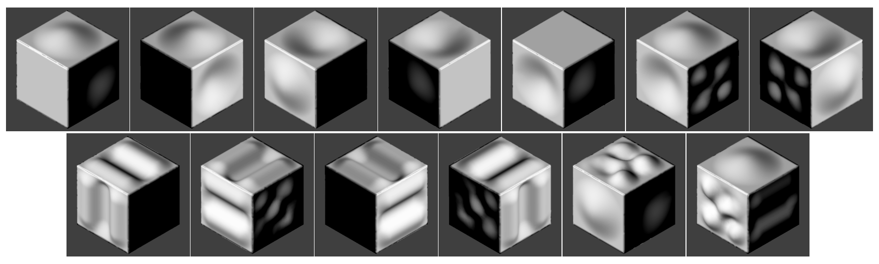
Test Data Design

- view & illumination dependent textures (Bidirectional Texture Function), 5 samples:

alu fabric leather wood wool



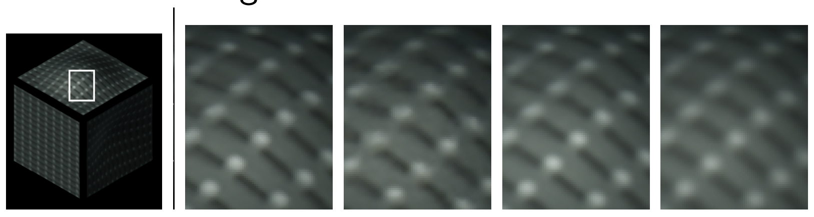
- different illumination directions & shapes,



- Three filters to simulate effects of texture compression:

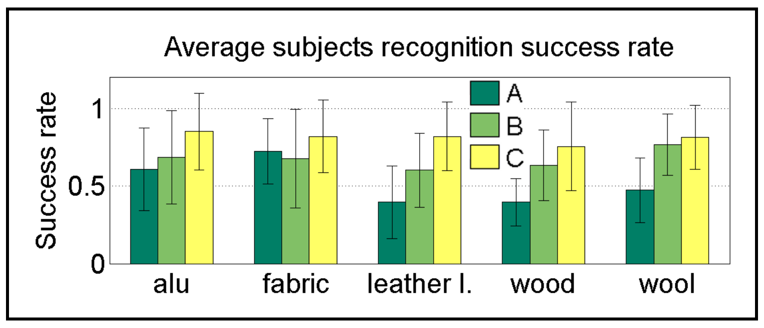
A - illumination/view directions downsampling to 50%
B - spatial filtering (averaging by kernel 3×3 pixels)
C - spatial filtering (averaging by kernel 5×5 pixels).

orig. **A** **B** **C**



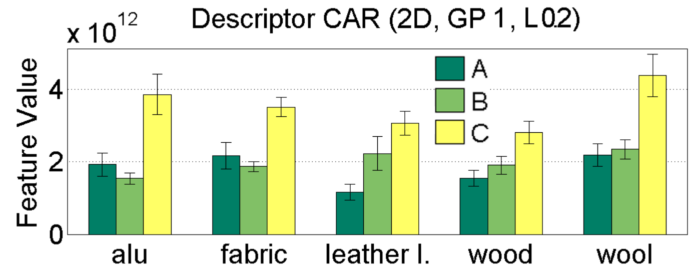
Psychophysical Experiment

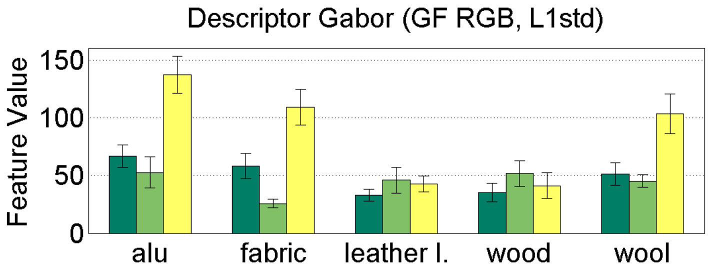
- eye-tracking of 12 paid subjects
- 195 stimuli images: quad of cubes, one has modifed texture by one of the filters (A,B,C)
- **Task:** find the modified cube.
- **Outputs:** responses accuracy (67%) & gaze fixations statistics (62 916 fixations longer than 100 ms).

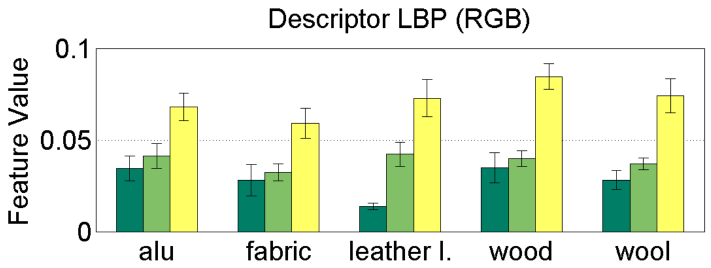


Descriptors' Responses

Dissimilarity between original images and degraded images (filters A,B,C):







Perceptual Evaluation of Descriptors

Correlation coefficients between average subjects responses (i.e. columns of the framed graph) and responses of individual descriptor's (i.e. columns of the descriptors graphs):

tested descriptors	correlation R		feature size
SSIM, 11×11	**0.125**		
VDP, p>75%	**0.107**		
VDP, p>95%	0.097		
$LBP_{8,1+8,3}$	0.610		512
$LBP_{8,1+8,3}$, RGB	**0.712**		1536
GF	0.569		48
GF, RGB	**0.578**		144
Opponent GF	0.322		252
	$L_{0.2}$	FC_3	
CAR GP 1, 2D	**0.787**	0.777	195
CAR GP 2, 2D	0.752	0.710	390
CAR GP 1, 3D	0.542	0.550	177
CAR GP 2, 3D	0.552	0.517	354
CAR GLP 2, 2D	**0.714**	0.654	390
CAR GLP 2, 3D	0.362	0.360	354

$R_{X,Y} = \frac{E[(X-\mu_X)(Y-\mu_Y)]}{\sigma_X \sigma_Y}$ correlation coeficient,
GP . . . Gaussian pyramid,
GLP . . . Gaussian-Laplacian pyramid.

Conclusions

- CAR and LBP have the best performance in detection of subtle texture differences with respect to human judgements.
- Pixel-wise metrics (SSIM, VDP) are not translation invariant, i.e. not suitable.

Application: Visual performance optimization of texture compression and rendering methods.

S+SSPR 2010, Cesme, Izmir, Turkey