Content-Based Tile Retrieval System

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Abstract

A content-based tile retrieval system based on the underlying multispectral Markov random field representation is introduced. Single tiles are represented by our approved textural features derived from especially efficient Markovian statistics and supplemented with Local Binary Patterns (LBP) features representing occasional tile inhomogeneities. Markovian features are on top of that also invariant to illumination colour and robust to illumination direction variations, therefore an arbitrary illuminated tiles do not negatively influence the retrieval result. The presented computer-aided tile consulting system retrieves tiles from recent tile production digital catalogues, so that the retrieved tiles have as similar pattern and/or colours to a query tile as possible. The system is verified on a large commercial tile database in a psychovisual experiment.

Motivation

- To ease content based browsing of tile catalogues (acquired in variable illumination).
- To find a similar replacement for broken tiles.

Task formulation:

- Retrieval of tiles with similar pattern and/or colours.
- Robustness to illumination conditions and noise.

Proposed Solution

- Texture representation by colour invariants (they detect structures with same luminance).
- Markovian textural features supplemented with LBP for inhomogeneous tiles.
- Colour representation using cumulative histograms.
- Size normalisation.

CAR Texture Model:

$$Y_r = \sum_{s \in I_r} A_s Y_{r-s} + \epsilon_r$$

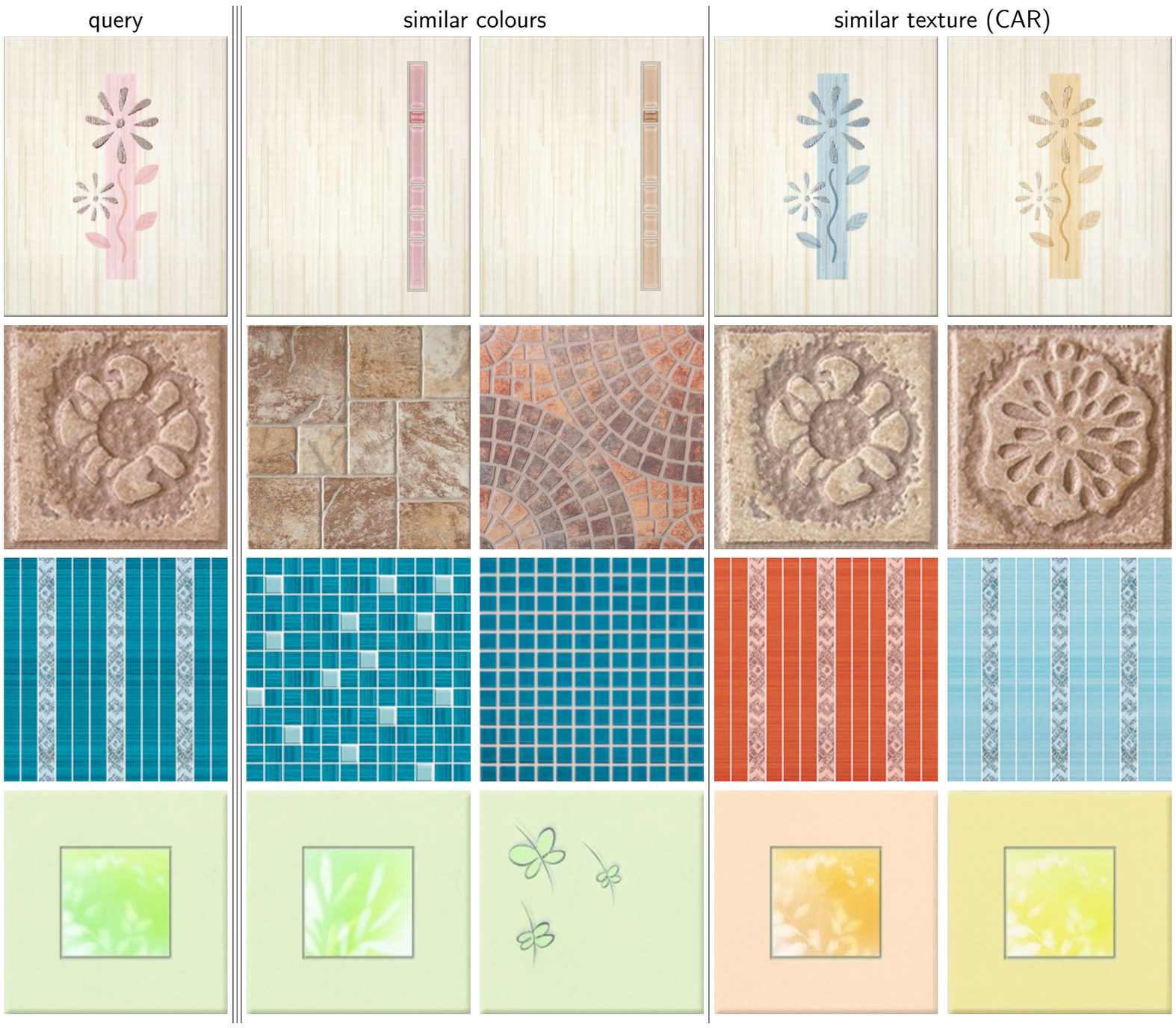
Y_r	vector of pixel values at texture position $r =$ (row, column)
I_r	contextual unilateral neighbourhood
A_s	**unknown** parameter matrices (diagonal)
ϵ_r	white noise with zero mean and with **unknown** diagonal covariance matrix

$$Z_r = [Y_{r-s}^T : \forall s \in I_r]^T, \qquad \gamma = [A_s : \forall s \in I_r]$$

Colour Invariants:

- trace: tr A_s, $s \in I_r$,
- eigenvalues: $\nu_{s,j}$ of A_s, $s \in I_r,\ j = 1, \ldots, C$
- α_1: $1 + Z_r^T V_{zz}^{-1} Z_r$
- α_2: $\sqrt{\sum_r (Y_r - \gamma Z_r)^T \lambda^{-1} (Y_r - \gamma Z_r)}$
- α_3: $\sqrt{\sum_r (Y_r - \mu)^T \lambda^{-1} (Y_r - \mu)}$

μ	mean value of vector Y_r
λ, V_{zz}	texture statistics, details in the article
C, K	number of spectral planes, pyramid levels



Tile catalogue from `http://sanita.cz`.

Psychophysical Experiment

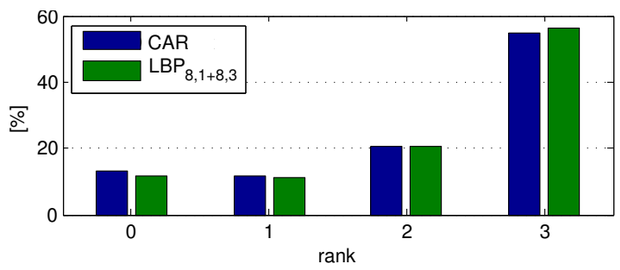
Blind ranking of the first two retrieved tiles:

- ranks: 0 = dissimilar, 1 = little similar, 2 = quite similar, 3 = similar
- database with 3301 tile images
- 34 volunteers, 133 evaluated queries

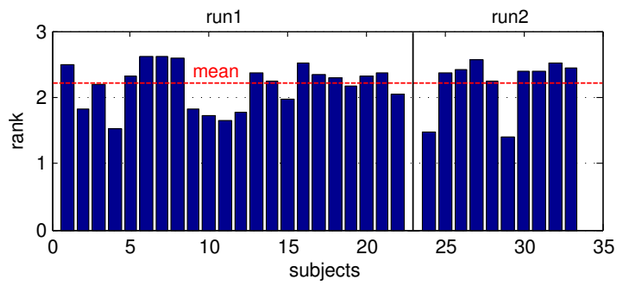
Averaged subject evaluated quality of texture retrieval methods:

	CAR	$\text{LBP}_{8,1+8,3}$
run 1	2.21 ± 0.64	2.22 ± 0.65
run 2	2.23 ± 0.62	2.21 ± 0.57

Ranks given by subjects:



Subjects' average ranks:



Conclusions

- ⊕ Separate representation of colour and texture.
- ⊕ Detection of patterns with same luminance.
- ⊕ Texture description by CAR features and LBP (complement visual characteristics).
- ⊕ Robust to illumination variations.
- ⊕ Fast.
- ⊕ Perceptually evaluated.

Demo at
http://cbir.utia.cas.cz/tiles/