Discovering Texture Regularity as a Higher-Order Correspondence Problem

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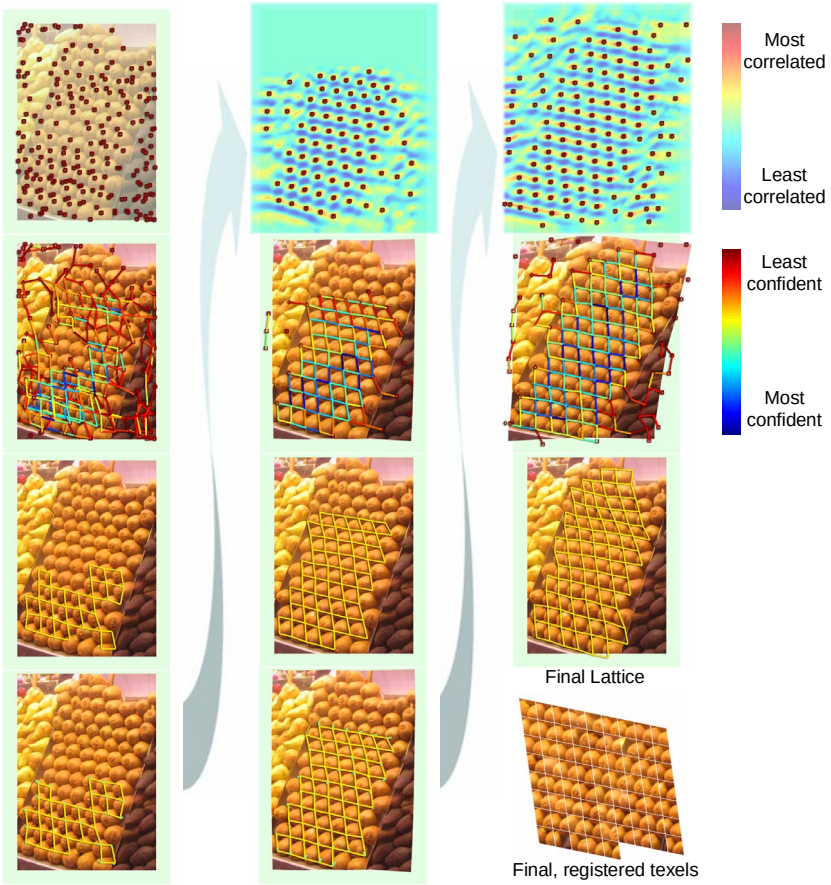
We propose an iterative, higher-order feature matching algorithm to discover the lattices of near-regular textures in real images. The lattice of a near-regular texture identifies all of the texels as well as the topology among the texels. Our algorithm finds a plausible lattice by alternatively constructing a lattice from potential texels and then using the lattice to propose texels.

Algorithm Outline

1. Propose texels with MSER and correlation
2. Assign neighbors with higher-order matching
3. Refine lattice by enforcing topological constraints
4. Remove geometric distortions and iterate



Texel Proposal

For the first iteration, we use MSER to find several hundred interest points and treat those as potential texels.

For later iterations, we correlate each texel in our lattice with its local neighborhood and sum the results at the appropriate offsets. Peaks in this correlation map become our potential texels for the next iteration.

Picking the Best Lattice

We choose the best lattice through several iterations and random initializations based on the A-score. This score maximizes for lattices which have many texels that align well.

$$\text{A-score} = \frac{\sum_{i=1}^{m} std(T_1(i), T_2(i), \ldots, T_n(i))}{m * \sqrt{n}}$$

n is the number of texels,*m* is the number of pixels in each aligned texel *Tn*.

Assigning Neighbors

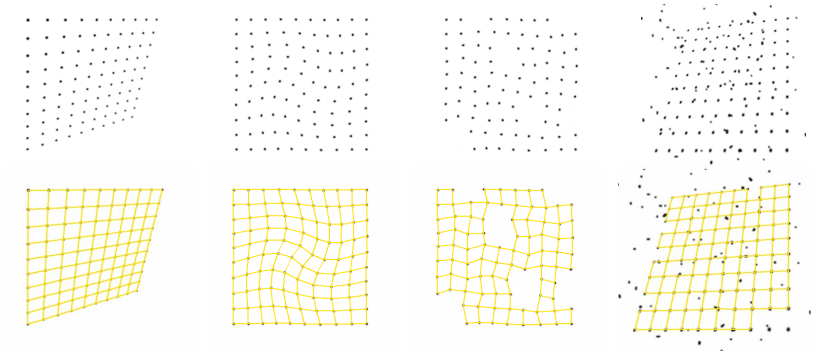
We construct a lattice by assigning neighbors to potential texels. We perform two successive assignments (for each direction of repetition) such that:

Each assignment connects visually similar texels.
Each assignment is as short as possible.
Pairs of assignments are geometrically similar.

By giving affinity for pairs of geometrically similar assignments, we avoid having to explicitly estimate the scale or direction of regularity in the texture. The assignment method will discover it on its own.

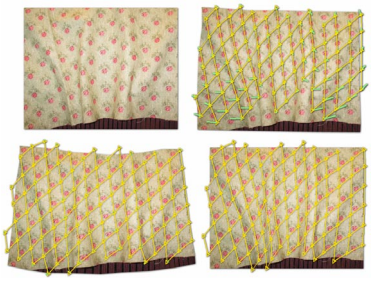
Since the optimal assignment under these second-order constraints is NP-hard to find, we approximate the optimal higher-order assignment with Leordeanu and Hebert, ICCV 2005.

Below are several lattices constructed with higher-order matching in a single iteration.

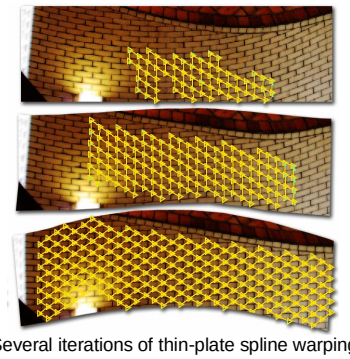


Iterative Unwarping

We use a regularized thin-plate spline to invert any distortions present in the texture. This helps the algorithm extend the lattice into regions that might otherwise be too distorted.



Clockwise from upper left: Input texture, warp after second iteration, lattice after 9 iterations, and lattice on original image.



Several iterations of thin-plate spline warping.

Source code available upon request. All textures are available from the CMU Near-regular Texture Database. This research is supported in part by an NSF fellowship to James Hays and NSF grants IIS-0099597, CCF-0541230, NSF OISE-0527138, and Microsoft Research Asia.