Coplanar Repeats by Energy Minimization, Supplemental Material

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1 Annotation-Assisted Repeat Grouping

The annotations provided by the 113 image dataset referenced in the paper are discussed in detail (available at http://ptak.felk.cvut.cz/personal/prittjam/bmvc16/coplanar_repeats.tar.gz). The annotations hierarchically segment the image into parts that (i) are scene planes (ii) are the union of scene planes that share the same vanishing line (iii) contain repeated content (iv) are the union of repeated content annotations that are distinctly different from other repeated content in the remainder of the image. In particular the repeated content annotations are specific to the type of symmetry exhibited by the repeat: namely annotations for translational and rotational symmetries are provided. In addition lattices are provided for translationally symmetric periodic repeats.

Individual salient features (*e.g.* Hessian Affine Keypoints or MSERs) are not grouped or annotated, so the annotations are feature agnostic, which is preferable since settings adjustments would invalidate such annotations. Rather, the annotations are used to assist a RANSAC-based inference algorithm to establish coplanar repeat groups. The annotations constrain the search for correspondences, which gives a much higher inlier percentage among tentative groupings that are inputted to RANSAC. Since the transform type is known from the annotations, the transform with the fewest required constraints can be used, which improves the probability of proposing a transform estimated from all-inliers. The vanishing line is estimated, and, depending on the annotation tag, either a translation or rotation and translation, which maps repeats onto each pointwise. The annotations are tagged so that the correct transformation can be estimated during annotation-assisted inference.

Even with this relaxed standard of annotation, it is impossible to group repeats at their highest frequency of recurrence. Depending on the features extracted, *e.g.*, corners of facade ornamentation may be detected, where only the windows were marked as repeated. Thus any performance evaluation must not penalize methods that correctly identify repeats that recur at higher frequencies than the annotations. Reflections and rotational symmetries, in particular, exacerbate this problem. Perhaps the most common example in the dataset are

window panes, which have axial symmetry, and if square, rotational symmetry. It is not practical to annotate all such occurrences (not just restricted to windows) in a large dataset. The annotations also group oversegmetnations of the image (*i.e.* superpixels in this context) into contiguous components of planes, sets of parallel planes and background surface. These annotations are not currently used in the evaluation, but would be useful for learning the regularization weights in the energy function.
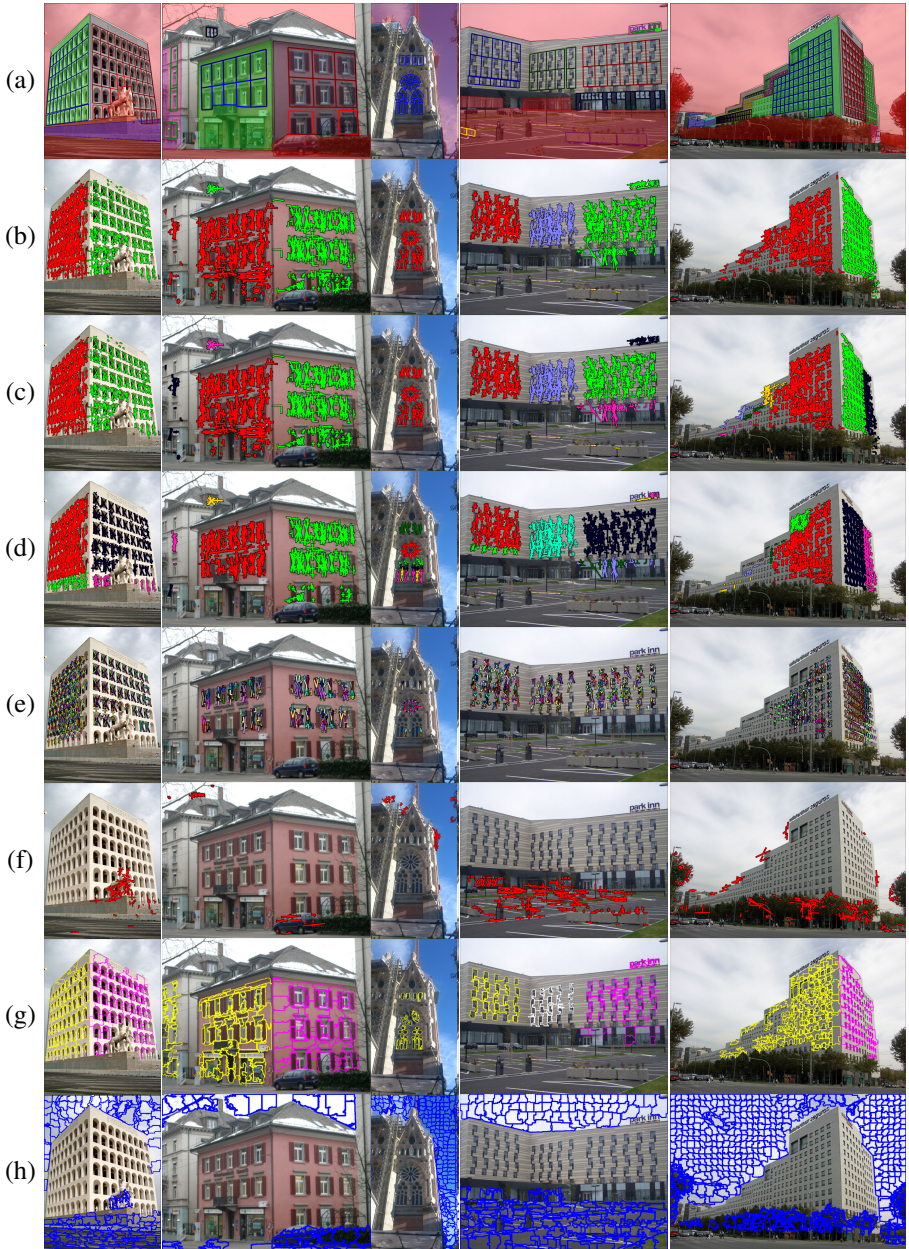
Figure 1: Annotations: (a) constraints coplanar repeat grouping, (b) vanishing line assignment, (c) plane assignment, (d) mutually distinct repeated content, (e) coplanar repeats found by annotation-assisted inference, (f) features on the background surface, (g) vanishing line assignment for regions, (h) regions on the background surface.