A ROTATIONAL ROBUST SIFT-BASED DESCRIPTOR

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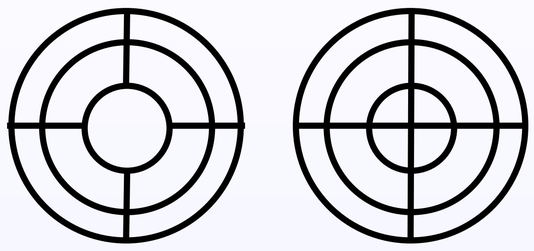
1. Abstract

Image descriptors are widely adopted structures to match image features. SIFT-based descriptors are collections of gradient orientation histograms computed on different feature regions. To achieve rotation invariance, feature patches are usually rotated in the direction of the dominant gradient orientation.
The sGLOh and sGLOH+ are new SIFT-based descriptors, which avoid to rotate the feature patch before computing the descriptor vector.
The proposed descriptors have been compared with the SIFT.

2. Descriptor grid

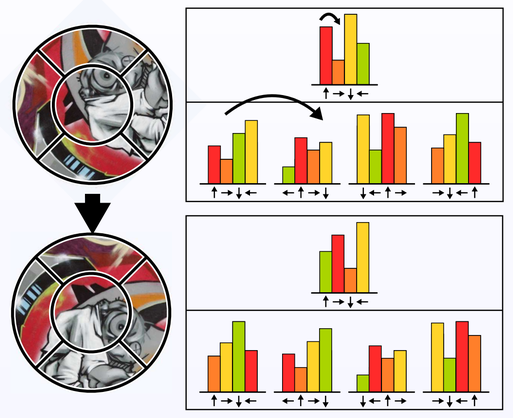
The sGLOH descriptor is a modification on the GLOH descriptor [1], which avoid to rotate the feature patch before computing the descriptor since predefined discrete orientations can be easily derived by shifting the descriptor vector.



The descriptor grid is made-up of circular rings centered on the feature point, equally distributed along m directions. The final descriptor vector H is obtained by concatenating the gradient orientation histograms, obtained by Gaussian kernel density estimation.

3. Discrete rotation

The rotation of the descriptor by a factor αk where $\alpha = \frac{2\pi}{m}$ is given by a cyclic shift of the block histogram inside a ring.



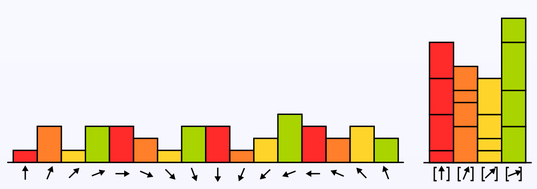
The distance between two feature H and $\overline{H}$ is

$$\widehat{d}(H,\overline{H}) = \min_{k=0,\dots,m-1} d(H,\overline{H}_{\alpha k})$$

where $d(\cdot,\cdot)$ is a common distance measure like L_1 or L_2 and each descriptor vector has been normalized to unit length.

4. Orientation refinement

A further variant of the sGLOH descriptor, called sGLOH+, computes a small orientation refinement on the patch before obtain the descriptor vector.
Instead of estimate the dominant orientation on the whole range $[0, 2\pi[$ (left image), the dominant orientation is computed using modular arithmetic on the range $[0, z[$, where $z = \frac{2\pi}{m}$ (right image).



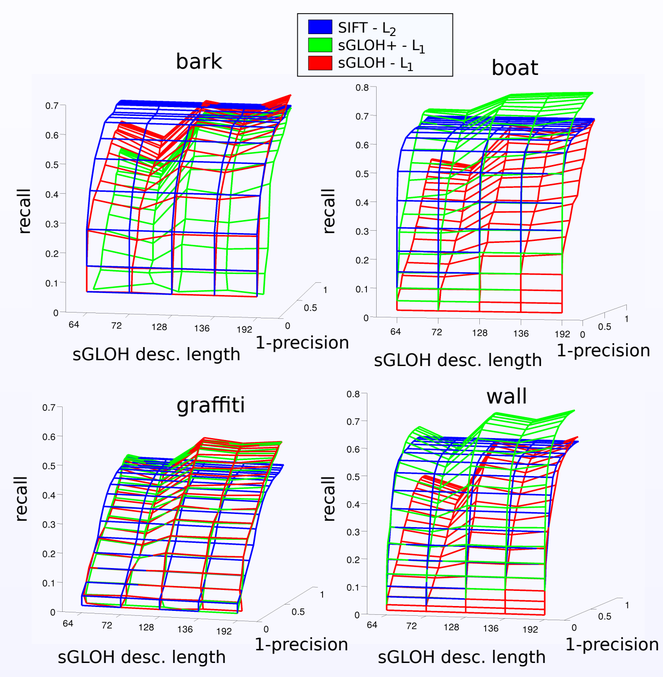
Since in this case the range of possible orientations is more costrained, the accuracy of the matching process increases. Moreover, in the case of bad dominant gradient orientation estimation, the error is bounded by $[0, \frac{\pi}{m}]$, using the distance measure $\widehat{d}$.

5. Test setup

The sGLOH and sGLOH+ descriptors have been compared with the SIFT descriptor on the well known Oxford database. The same experimental setup described in [1] has been used, while keypoints have been extracted with the Harris-Z detector [2] which provides stable features.
The sGLOH and sGLOH+ descriptors have been tested for different grid settings, obtaining descriptors of length $l = 64, 72, 128, 136, 192$. The SIFT descriptor length was fixed to 128. The best distance measures between L_1, L_2 have been used for each descriptor: the sGLOH and the sGLOH+ perform best on the L_1, while the L_2 distance was used for the SIFT.

6. Results

The obtained results are comparable or better than those obtained by SIFT (blue surface). Only in the case of the bark sequence, SIFT performs better, but only for really high precision.



Moreover, sGLOH+ (green surface) seems to perform better than sGLOH (red surface) in most cases, especially when the precision is low, underlining the validity of the dominant orientation refinement introduced.

References

[1] K., Mikolajczyk, C., Schmid, A Performance Evaluation of Local Descriptors, in *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 2005

[2] F., Bellavia, D., Tegolo, C., Valenti, A non-parametric scale-based corner detector, in *19th International Conference on Pattern Recognition (ICPR 2008)*, 2008