Paper Summary: “Discrete Texture Traces: Topological Representation of Geometric Context”

This paper introduces an invariant representation of image patches against spatial deformations and occlusions. Dynamics such as viewpoint changes or variations of deformable objects bring about non-affine deformations which pose great challenges in detection, recognition and tracking applications. A representation invariant to such dynamics is needed for unhindered research in these application domains. Previous representation techniques had often come up based on the Euclidean distance as the major metric in the image domains. This metric fails in the deformation of curved object surfaces where the actual Euclidean distance between two points are very weakly related to the image Euclidean distance. The topological and neighborhood structure of the image pixels, however, are preserved and that is what this paper built its approach on. Guidance of topological nature is independent of smooth deformations of the underlying space and therefore trails arising from such representations are invariant to homeomorphic deformations.

Earlier literatures have often assessed local parameters of transformations which is not required here. Neither is the detection of key points required to compute a descriptor at any location in this method. This quasi-invariant representation further goes on to tackle the incremental tracking problem. The problem boils down to modeling a description of how to get to location X_2 from location X_1 in terms of image texture and topology alone. The authors start by describing the trace properties in continuous-space images and then arrives at its discrete approximation – the *Discrete Texture Traces (DTTs)*. The continuous curve between X_1 and X_2 is approximated by quantizing two features – the neighborhood orientation into angular bins and image locations into discrete labels. A sequence of <*location label, angular bin*> pairs make up the discrete trace from X_1 to X_2. Mathematically, the paper introduces *attributed adjacency matrices*, which are sparse matrices, to establish the existence of these sequences. Finally, image patches are generated by modelling all discrete texture traces, starting from an arbitrary point in the patch, that have the target location in their feasible set. Once the set of traces, say M, has been ascertained from the source reference images, querying is done for the target location in a deformed image by computing the subset of M in the target image whose feasible sets contain the target location. For experimental evaluation a confidence of the target location is determined which is the ratio of the size of the computed subset to M.

The method has been evaluated by comparison with Geodesic Intensity Histograms (GIH). The first evaluation considers images perturbed with Gaussian noise, in-plane rotations, scale and smooth non-affine deformations. Images perturbed with occlusion, in and out-plane rotations and illumination changes are used to evaluate the incremental tracking application of DTTs. The performance metric is the ratio of the number of correct key point matches to the total number of key points defined. A set of 20 images from the PASCAL VOC 2010 database were perturbed for the experiment. The only scenario where the GIH outperformed the DTT was for large smooth deformations and this has been attributed to GIH’s strict invariance to smooth spatial perturbations. DTTs in incremental tracking falls short on accuracy when there is not enough texture on the target object. Apart from this the proposed method does quite well even when incremental updating is removed.

In conclusion, the paper has been written quite well with a very interesting idea of topological invariance to deformation. The problem has been clearly laid out and the idea effectively communicated. Section 3.2 could have been made simpler to understand. Figures and graphs were quite intuitive and Section 7 gave a very apt summary of the entire paper.