Sparse Templates-Based Shape Representation for Image Segmentation

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***Abstract*—We present a new approach to image segmentation based on sparse coverings of the image domain by shape templates. The basic idea is to formulate the segmentation problem as a sparse representation problem, utilizing new mathematical tools from l1-minimization and compressed sensing.**

Methods and Results

Given a large set of shape templates and a pre-segmentation, we are required to segment a noisy image where objects may overlap by taking into account prior knowledge about the shape of the objects and their parts. The parts may be partially occluded and the location and nature of occlusion is unknown. This can be modeled as a sparse error that affects only a few pixels in the input image while the "true" segmentation is represented as a sparse linear combination of the entire shape-templates training set.

Unfortunately, the shape dictionary - built by stacking all the training shapes and their translations to all pixel positions as column vectors - is not incoherent, but a truly redundant dictionary. As a consequence, all currently available theoretical recovery conditions predict a poor performance of the l1-minimization approach (i.e. exact recovery in the coefficient domain). However, we show empirically, see Fig. 2, that accurate recovery is possible for moderate sparsity of the basic templates and dense errors, similar to the work in [1].

We discuss the implications of these results on our application, and illustrate our approach on real world images, see Fig. 1, by numerical examples that employ large-scale convex programming.

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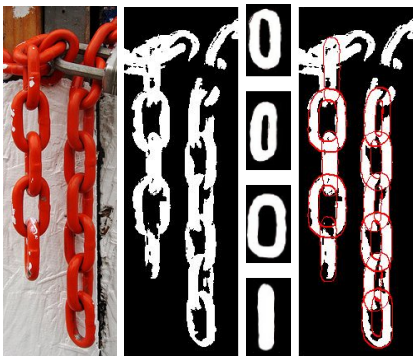

Fig. 1. Separating chain links from the background and from each other by convex optimization in terms of a sparse covering of the image by shape templates. The dictionary of shape templates was generated from four templates by translation, rotation and scaling. The approach presented in this work copes with a significant amount of overlapping templates and occlusion. *Left to right*: Original image, pre-segmentation using a thresholded distance to the color red as foreground indicator, shape templates used for segmentation, and the final result.

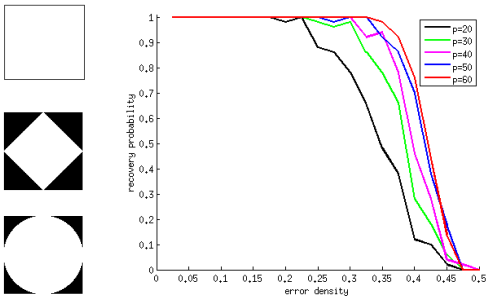

Fig. 2. The three templates (*left*) together with their translations build a dictionary. The true segmentation consisting of a sparse covering with only a few templates is recovered exactly. Recovery performance for increasing density of the error (including both salt and pepper noise and occlusion) improves with increasing image resolution (*right*).

References

[1] John Wright and Yi Ma. Dense error correction via l1-minimization. *IEEE Trans. Inf. Theor.*, 56:3540–3560, July 2010.