# Bilateral Symmetry Detection via Symmetry-Growing

Minsu Cho
http://cv.snu.ac.kr/~minsucho
Kyoung Mu Lee
kyoungmu@snu.ac.kr

Computer Vision Lab.
Department of EECS, ASRI,
Seoul National University, Korea
http://cv.snu.ac.kr/

A variety of symmetries occur in nature, living organisms, and manufactured artifacts, and provide humans with pre-attentive cues that enhance object recognition. Despite the long history of the research, the recent performance evaluation [6] shows that we are still short of a robust and widely applicable symmetry detector. The symmetry detection methods can be broadly classified into global and local feature-based methods. Global methods [5] treat the entire image as a signal from which symmetric patterns are inferred, but are limited to detecting a single incidence of symmetry, and also greatly influenced by background clutters. On the contrary, local feature-based methods [2, 4] use local features such as edges, contours, boundary points, and regions to detect symmetry by grouping symmetric sets of local features. Their main advantage is to more efficiently detect local symmetries against background clutters in images that are not globally symmetric. However, they are largely influenced by feature detection step, and cannot exploit further information beyond the detected features.

In this work inspired by the recent match-growing approaches [1, 3] in object-recognition, we propose a novel and robust method for localizing and segmenting bilaterally symmetric patterns from real-world images. On the basis of symmetrically matched pairs of local features, the method gradually expands and merges confident local symmetric region matches by exploiting both photometric similarity and geometric consistency via our symmetry-growing framework. It overcomes the limitations of the previous local-feature based approaches by efficiently exploring the image space beyond the detected symmetric features. Multiple clusters of consistent symmetric feature pairs are directly detected in our growing process without conventional voting procedure of the Hough transform or RANSAC in the local feature-based methods [2, 4].

A brief overview of our approach is illustrated in Fig. 2. Given an image of Fig. 2(a), we aim to detect and segment all the bilaterally symmetric patterns and infer their quasi-dense correspondences within the symmetric patterns. First, we extract local invariant features from the given image as shown in Fig. 2(b). Second, using the appearance around the detected features and its mirrored features, we obtain potential symmetric matching pairs of features [4] as in Fig. 2(c). Third, starting from singleton symmetry clusters each containing a single symmetry match, we simultaneously expand and merge the symmetry clusters by exploring the image space in our symmetry-growing framework. Our algorithm gradually grows reliable symmetry clusters as shown in Fig. 2(e)-(f), where the dots with the same color represent features in the same cluster. Finally, the reliable symmetric patterns grown well enough are chosen as in Fig. 2(h), where the detected symmetry is indicated by the convex hull of the features.

The basic building block of our symmetry-growing is *symmetry propagation* illustrated in Fig. 1. Suppose that a local symmetry match $M_i = (R_a, R_b)$ and its neighboring region $R_c$ are given. Then, using the reflective transformation $T_i$ from $R_a$ to $R_b$, a new match $(R_c, R_d)$ is generated by propagation and refinement as shown in Fig. 1(b) and (c). If the propagated symmetry match has high similarity in appearance, it is accepted and the cluster containing the support match expands. Each cluster holds its own *expansion layer* which provides the neighboring regions for the symmetry propagation. It consists of a set of local regions in the overlapping circular grid which covers the image plane as shown in Fig. 2(d). Our symmetry-growing algorithm simultaneously performs intra-layer expansions and inter-layer merges in a multi-layer framework. Thus, it effectively avoids the adverse effect of outliers and detect multiple symmetry patterns with dense correspondences.

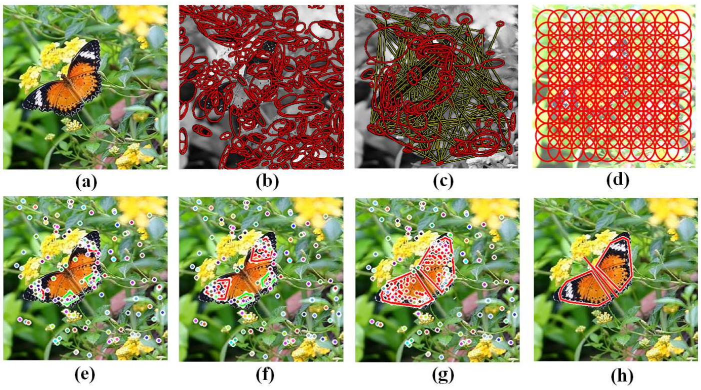

Figure 2: Overview of our symmetry-growing approach.

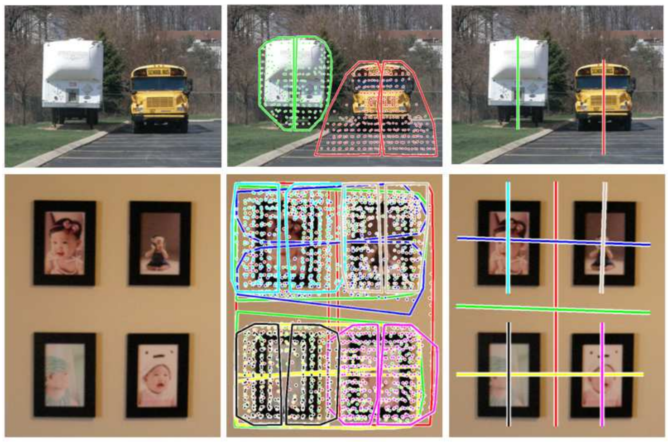
Figure 3: Symmetry detection examples on the dataset of [6].

The experimental evaluation on the full dataset of [6] demonstrates that our method successfully detects and segments multiple symmetric patterns from cluttered real-world images, and clearly outperforms the state-of-the-art methods in accuracy and robustness. Two examples of our results are demonstrated in Fig. 3, where input images, segmented symmetric regions, and their symmetry axes are shown. Different symmetry clusters are indicated in distinctive colors.

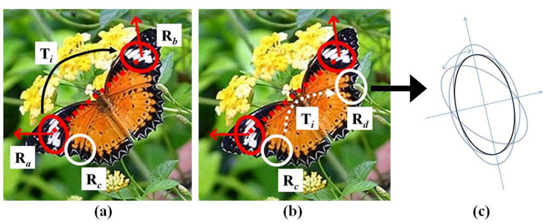

Figure 1: Symmetry Propagation (a) Support match $M_i = (R_a, R_b)$ and a region $R_c$. (b) Propagation of the region $R_c$ by $M_i$. (c) Refinement.

[1] Minsu Cho, Young Min Shin, and Kyoung Mu Lee. Co-recognition of image pairs by data-driven monte carlo image exploration. *ECCV*, pages IV: 144–157, 2008.

[2] Hugo Cornelius, Michal Perd'och, Jiří Matas, and Gareth Loy. Efficient symmetry detection using local affine frames. *SCIA*, pages 152–161, 2007.

[3] Vittorio Ferrari, Tinne Tuytelaars, and Luc Gool. Simultaneous object recognition and segmentation from single or multiple model views. *IJCV*, 67(2):159–188, 2006.

[4] G. Loy and J. O. Eklundh. Detecting symmetry and symmetric constellations of features. *ECCV*, pages II: 508–521, 2006.

[5] G. Marola. On the detection of the axes of symmetry of symmetric and almost symmetric planar images. *PAMI*, 11:104–108, 1989.

[6] Minwoo Park, Seungkyu Lee, Po-Chun Chen, Somesh Kashyap, Asad A. Butt, and Yanxi Liu. Performance evaluation of state-of-the-art discrete symmetry detection algorithms. *CVPR*, 2008.