Paying Attention to Symmetry

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Abstract
Humans are very sensitive to symmetry in visual patterns. Symmetry is detected and recognized very rapidly, and eye fixations are concentrated along the axis of symmetry or the symmetrical center of the patterns. This suggests that symmetry is a highly salient feature. Existing computational models of saliency, however, have mainly focused on contrast as a measure of saliency. These models do not take symmetry into account. In this paper, we discuss local symmetry as a measure of saliency. We developed a number of symmetry models and performed an eye-tracking study with human participants viewing photographic images to test the models. The results show that the symmetry models better match the human data than the contrast saliency model of Itti, Koch and Niebur [1]. This indicates that symmetry is a salient structural feature for humans, a finding which can be exploited in computer vision.

1 Introduction
Symmetry is a prominent visual feature in our daily environments. Symmetrical forms are have a high esthetic value. Faces with enhanced symmetry, for instance, are judged more attractive than the original faces [2]. It is also known that the human visual system is sensitive to symmetry. Symmetrical forms, especially when possessing multiple symmetry axes, are detected very rapidly [3]. Also recall and discrimination performances increase with symmetrical patterns [4]. Furthermore, humans interpret symmetrical regions as figure, and asymmetrical regions as background [5].

This sensitivity to symmetry suggests that symmetry is something that humans pay attention to, and can therefore be considered as a salient feature. If we look at the second column of figure 1, we indeed see that humans clearly have a preference to fixate on the centers of the symmetrical forms. Most existing models of saliency, however, are based on contrast (e.g., [1, 6]). Although these models are able to predict human eye fixations to some extend [6-8], they do not predict the attention to symmetry in figure 1 (third column).

This apparent deficiency in current vision models was the motivation for the present study. In this paper, we investigate the role of local symmetry in visual attention. We extended a number of symmetry operators to multi-scale saliency models. Furthermore, we performed an eye-tracking study to test the models, and compared the performance with the contrast saliency model of Itti et al.[1].

2 Methods
The symmetry models are based on symmetry operators proposed in [9, 10]. The basis of all models is the same: A symmetry kernel is applied to every pixel in the image. In the kernel, the presence of symmetry is checked for all possible symmetry axes. Symmetry is present if the gradients in the kernel are mirror symmetric with respect to the symmetry axes. These symmetry calculations are done on five different scales, to achieve scale invariance. The

Figure 1: Examples of images containing symmetrical forms. The second column shows the human fixation density map, the third shows the contrast saliency map, and the last shows our symmetry saliency map. The bright regions are the parts of the maps above 50% of its maximum. The preference of humans to fixate on the center of symmetry is correctly reproduced by our symmetry model, whereas the contrast model displays a wide non-specific saliency response.
The isotropic symmetry model is as described above. The radial symmetry model responds stronger to patterns containing multiple symmetry axes, and the color symmetry model uses color instead of luminance information.

To test the saliency model, we performed an eye-tracking experiment. 31 participants were shown 100 photographic images, and there eye gaze was recorded. The images were from five categories: images containing natural symmetries, animals, street scenes, buildings, and nature scenes.

3 Results

The resulting saliency maps of the symmetry models are compared with the human data by calculating the correlation coefficient. The results show significantly higher correlation for the symmetry models than for the contrast model of Itti and Koch. The performance of the symmetry models is similar to the inter-participant correlation, showing that the models predict the participant’s eye fixations similarly good as the fixations of other participants would.

4 Discussion

Our results show a significantly higher correlation for the symmetry saliency models than for the contrast saliency model. This suggests that humans pay attention to symmetry, and that symmetry can be considered a salient feature.

Our findings have potentially interesting applications in artificial vision systems. Specifically robots navigating in man-made environments containing many symmetrical patterns could benefit from our symmetry models to select interesting and useful visual information.

References