# Modelling symmetry perception with banks of quadrature convolutional Gabor kernels

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## 1- Motivation

1. Mirror symmetry is a property most likely to be encountered in animals than in medium scale vegetation or inanimate objects.

2. The perception of symmetry assists higher-level visual processing that is crucial for survival and has an importan role in aesthetic judgement.

3. Although easy for humans, it is very challenging for computers (it has been proposed as a robust "captcha" -Funk & Liu; 2016).

## 2- Background

The exact mechanism of symmetry detection is not understood. Several fMRI studies have shown that symmetrical shapes activate specific higher-level areas of the visual cortex (Sasaki et al.; 2005) while a large body of psychophysical experiments suggest that the perception of symmetry is critically influenced by low-level mechanisms (Treder; 2010). Current computational methods detect symmetric pairs of features and bond them, considering them simultaneously (Loy and Eklundh, 2006). In this work we attempt to find plausible low-level mechanisms that might form the basis for symmetry perception. Our simple model is made from banks of (i) odd-symmetric Gabors (resembling edge-detecting V1 neurons); and (ii) banks of larger odd- and even-symmetric Gabors (resembling higher visual cortex neurons), that pool signals from the 'edge image'. As reported previously (Akbarinia et al, ECVP2017), the convolution of the symmetrical lines with the two Gabor kernels of alternative phase produces a minimum in one and a maximum in the other (Osorio; 1996), and the rectification and combination of these signals create lines which hint of mirror symmetry in natural images.

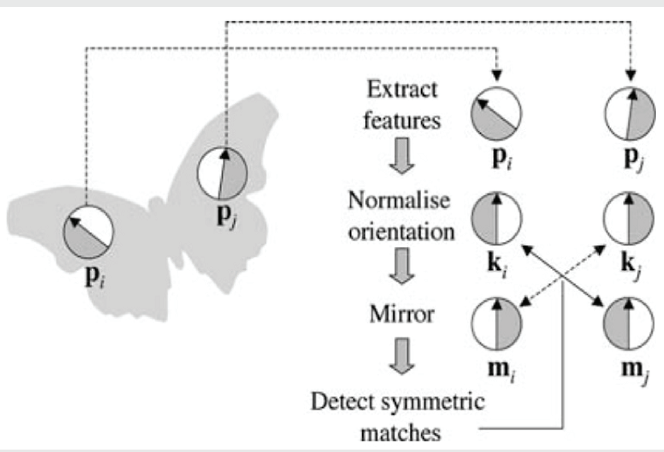


Illustration of a feature extraction approach from Loy and Eklundh (2006)

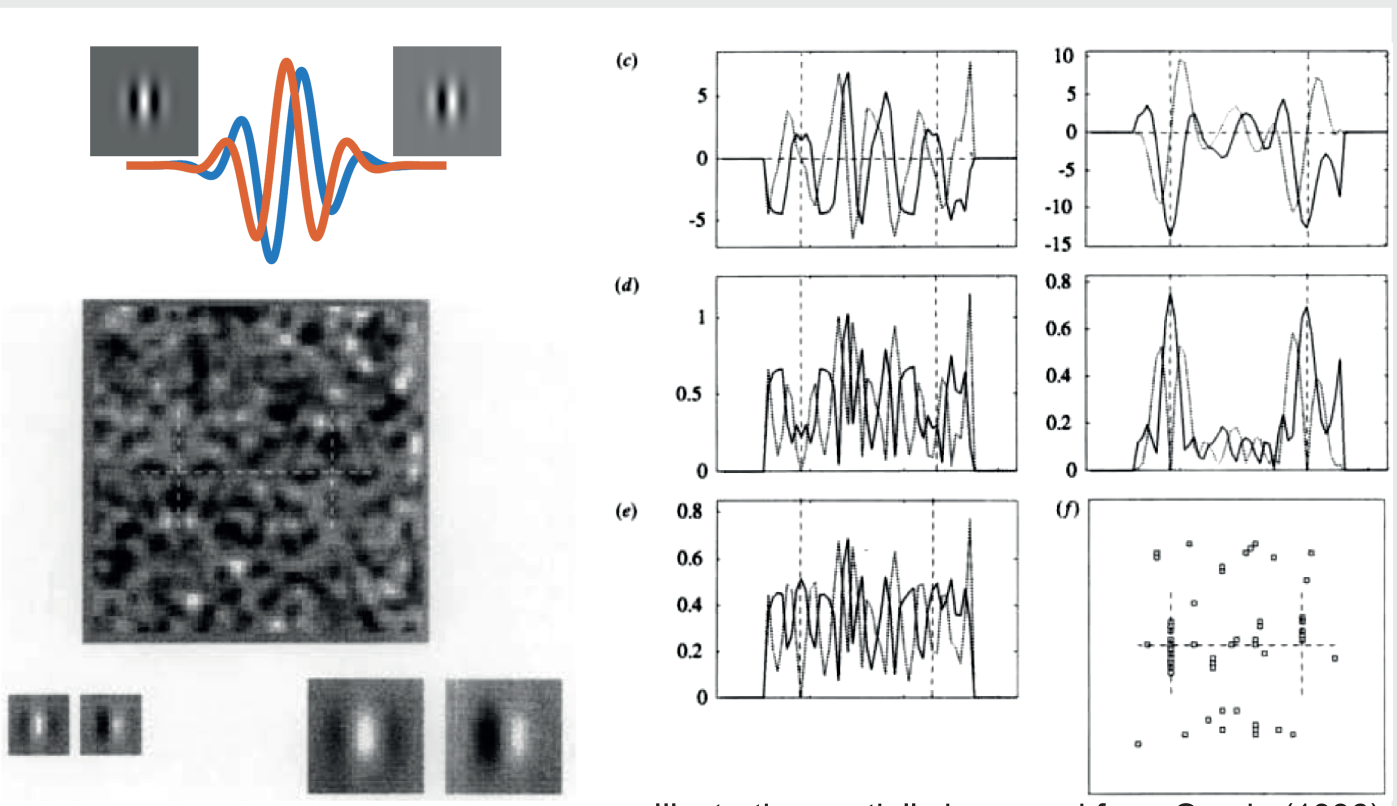
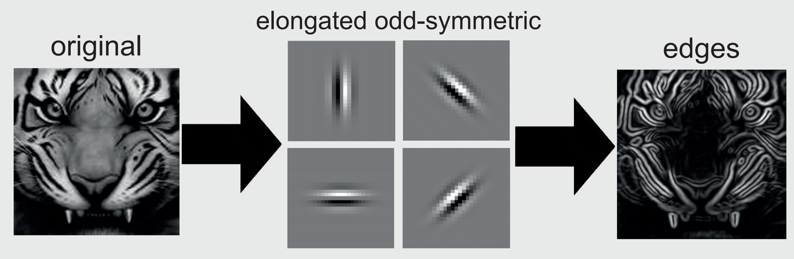


Illustration partially borrowed from Osorio (1996)

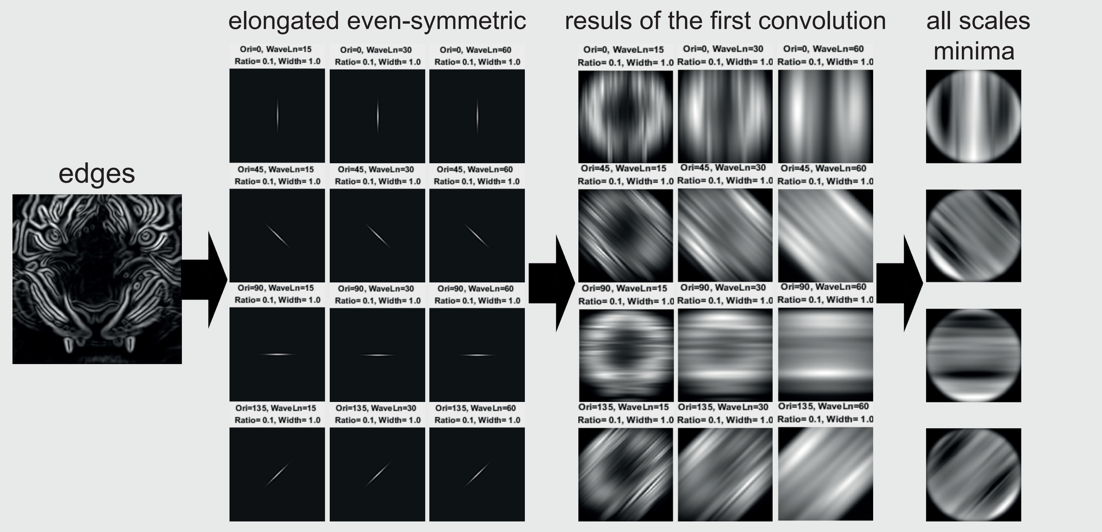
## 3- Method

We constructed a biologically-inspired symmetry detector from simple even- and odd-symmetric operators as follows:

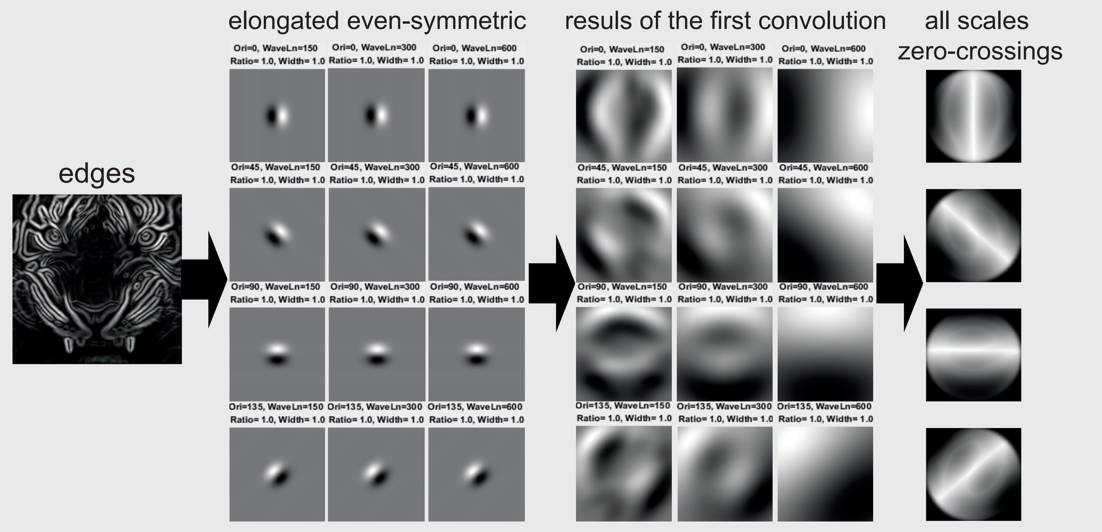
Step 1. We found the edges by meansof an elongated odd-symmetric filter (small StdDev) in 4 orientations.



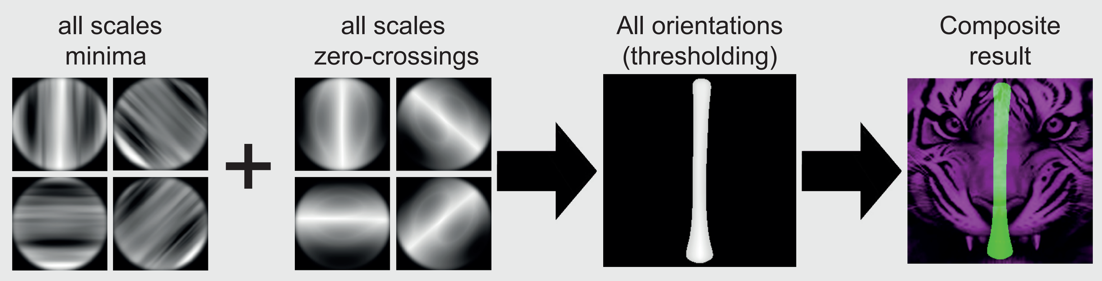

Step 2- We convolved the "edges image" with a bank of elongated even-symmetric Gabors in n=4 orientations. We combined all scales and inverted the results (minima became maxima).




Step 3. We convolved the "edges image" with a bank of larger odd-symmetric Gabors. The output of this operator is null (zero-crossing) when both sided are identical.



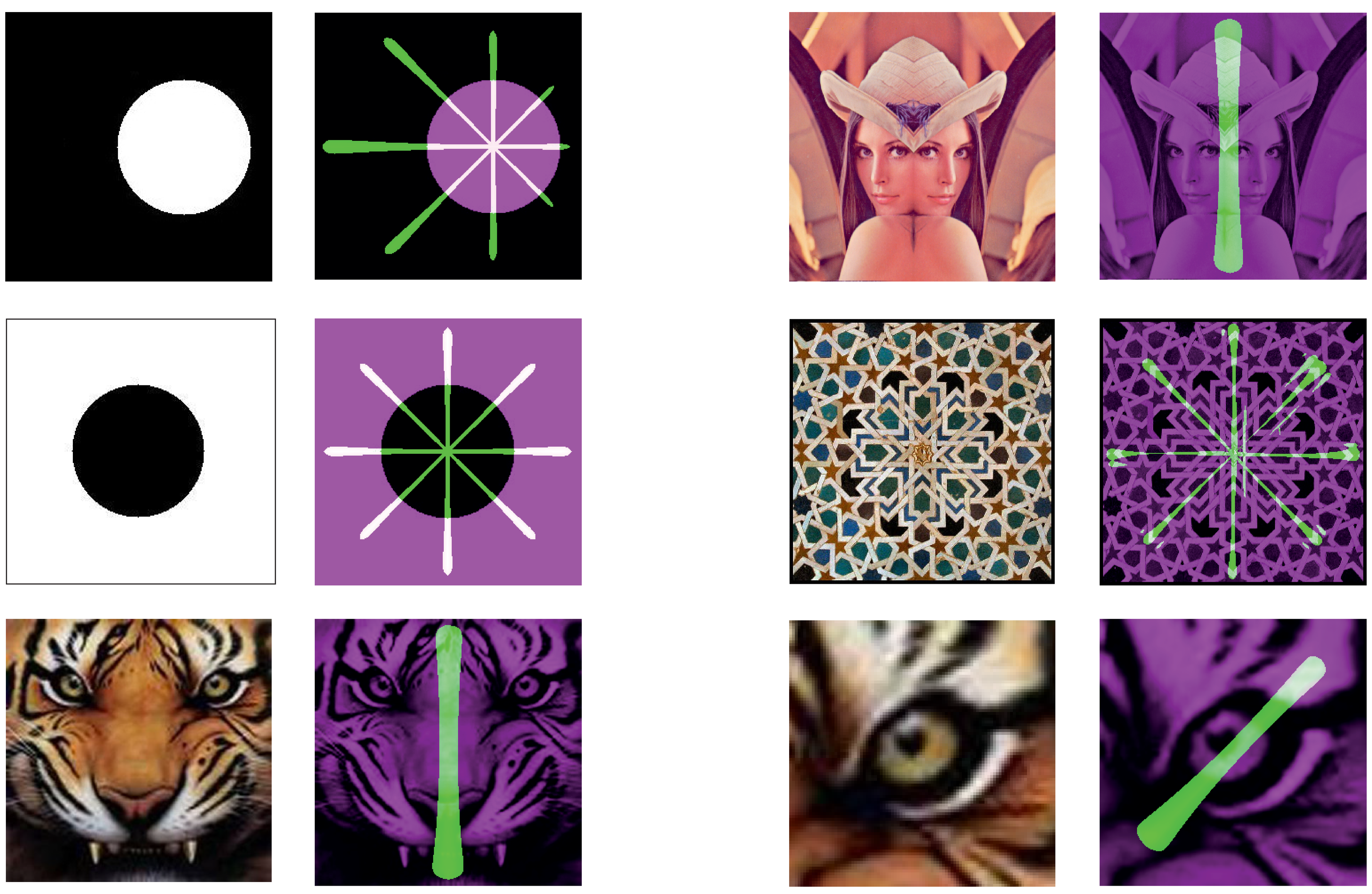

Step 4. We calculated the symmetry lines by combining the outputs of step 2 and 3 for all orientations and selected the largest values (thresholding).




## 4- Results

The method seems to works well for several exemplary images. It is robust to contrast changes and positional shifts. We only tested 4 orientations and a few spatial scales and adjusted the Gaussian sizes manually. The relative differences in size between the banks of Gaussians in step 2 and step 3 are important and seem vary for each case. The same applies to the percentage of pixels used in the thresholding (step 4). These issues are likely to be solved by implementing a machine learning layer. However, our results shows that low-level neurons in the HVS have the capabilities to address the problem at least for simple mirror-symmetry cases.

Exemplary results



## 5- Acknowledgements, etc.

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**References**

Funk & Liu (2016) CVPR; Rainville & Kingdom (2000) Vis Res 40(19); Osorio (1996) Proc Royal Soc B 263(1366); Loy & Eklundh (2006) ECCV; Treder (2010) Symmetry 2(3); Kondra and Petrosino (2013) CVPR.