

Can biological solutions help computers detect symmetry?

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1- Motivation

1. Symmetry is an important visual cue for a wide range of biological organisms regardless of size and cognitive ability

2. The perception of symmetry is important for object processing by facilitating target recognition and identification

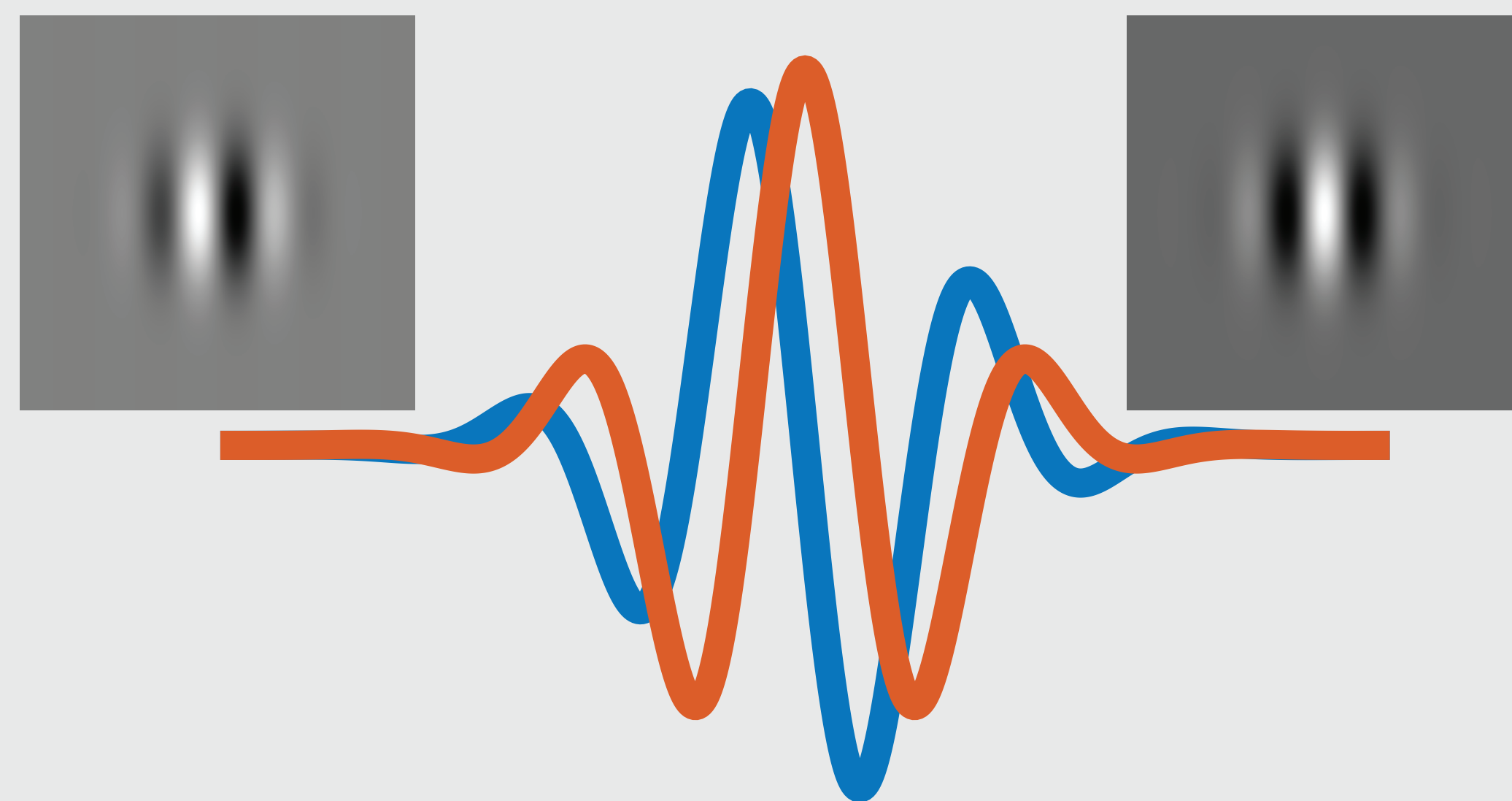
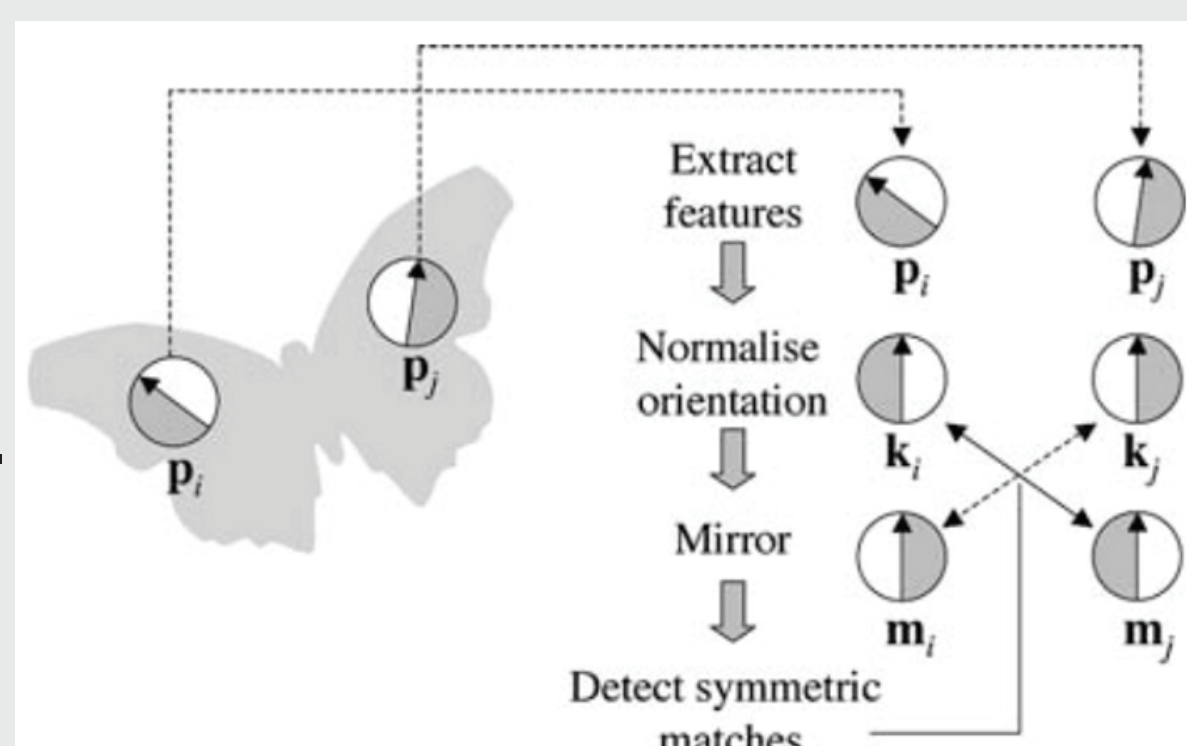
3. Although easy for humans, it is very challenging for computers (it has been proposed as a robust "captcha" -Funk & Liu; 2016).

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).

The human visual system possesses low level operators capable (in theory) of detecting symmetric patterns embedded in complex images (Osorio, 1996, Kingdom, 2000).



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)

3- Method

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

1. Denoising: convolution with a small Gaussian (SD = 0.09 deg)

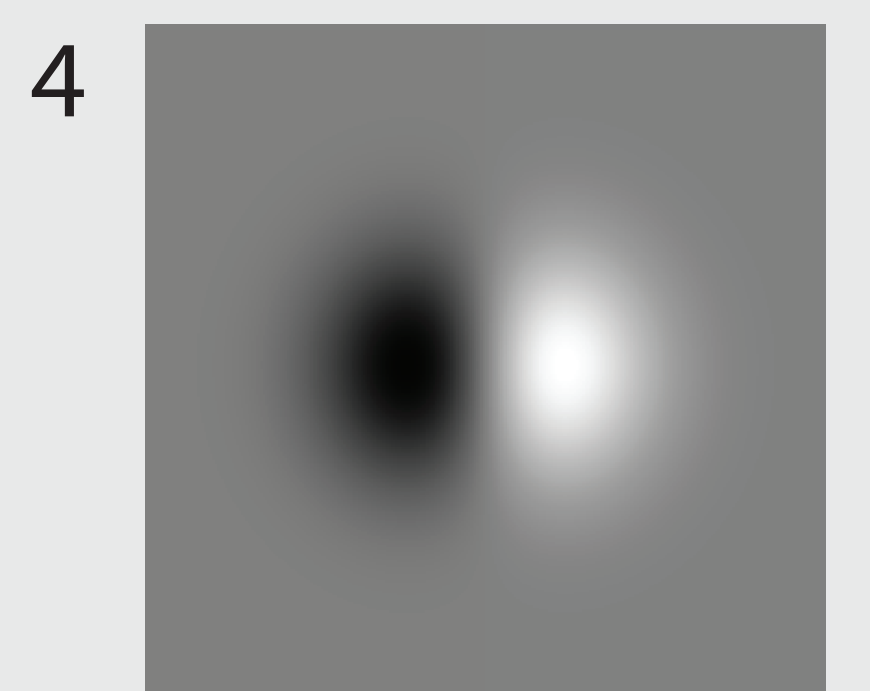
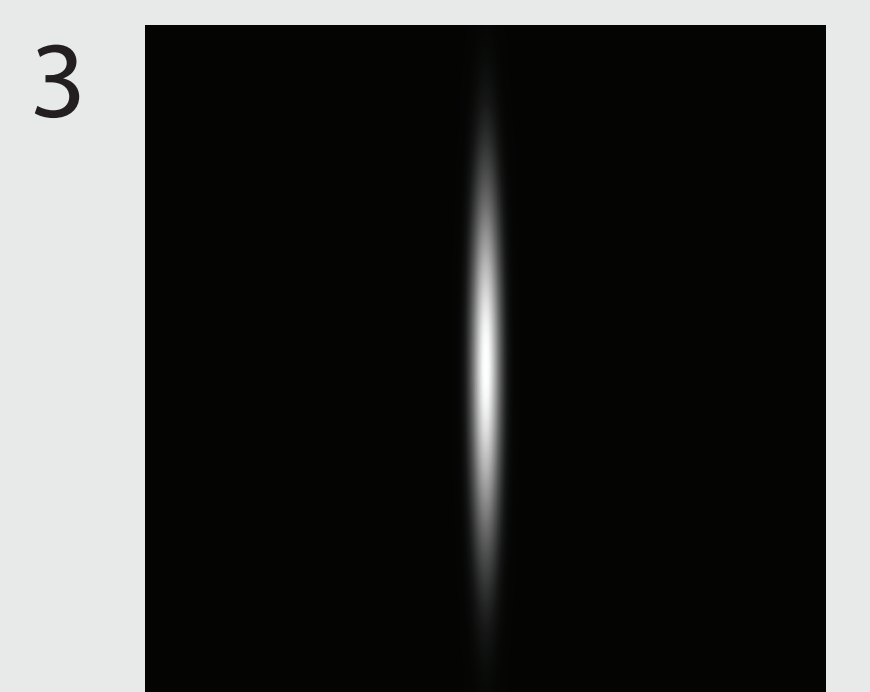
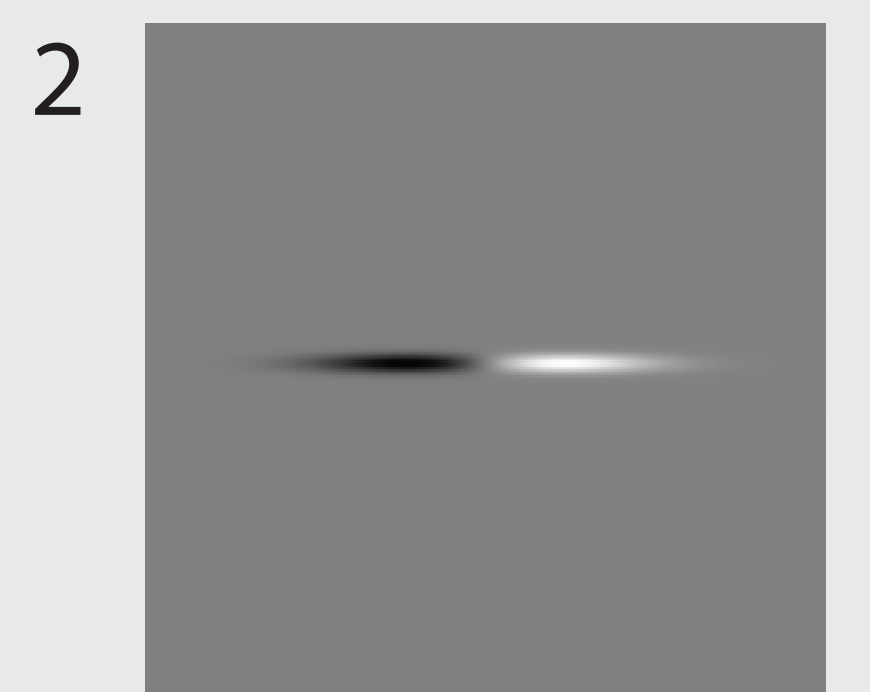
2. Finding the edges along the preferred orientation using an odd-symmetric filter (first derivative of a Gaussian, SD= 0.28)

3. Computing the continuous lines (CL) with an elongated Gaussian (even-symmetric) oriented orthogonally to the preferred orientation.

4. Convoluting with a large odd-symmetric Gaussian (MI) to detect axis of symmetry. The output of this operator is null when both sides are identical.

5. Calculating the symmetry lines

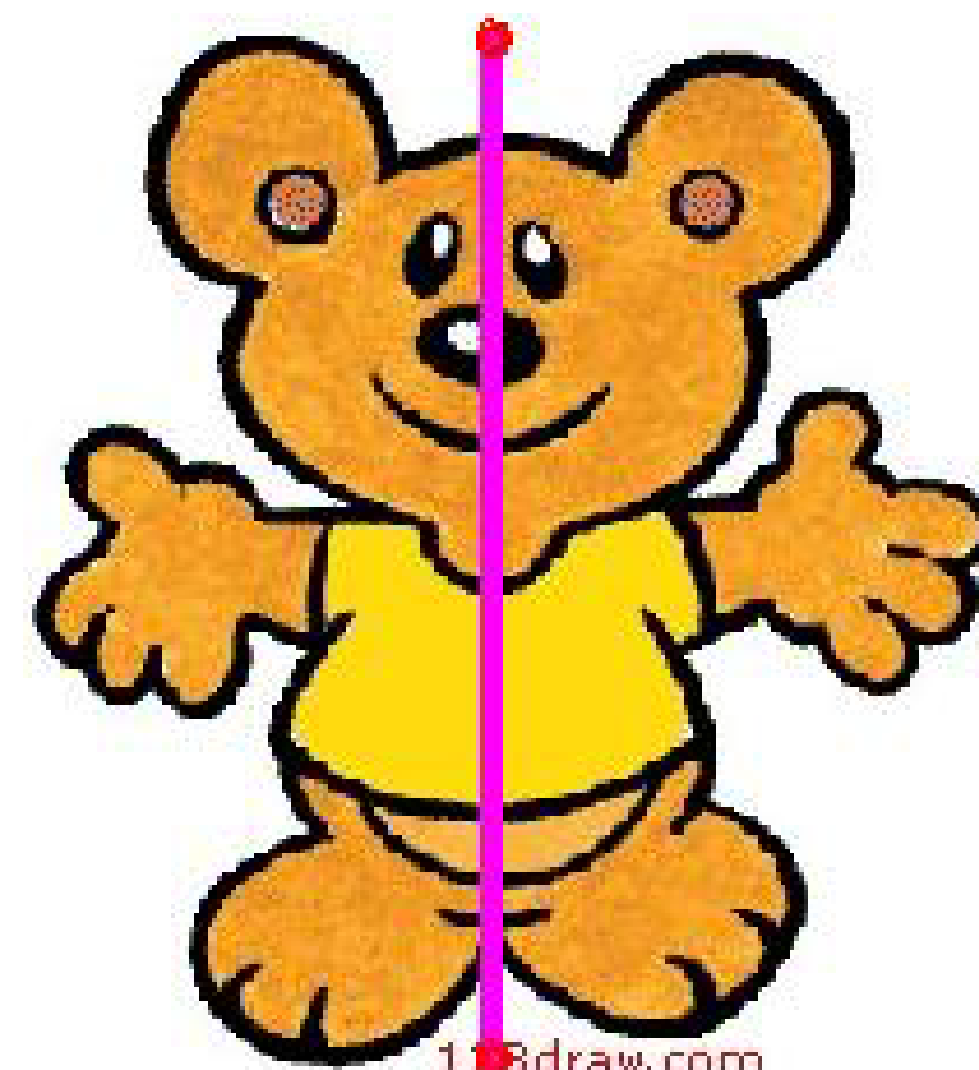
$$S = 0.5 * CL + 0.5 * (1 - MI)$$



4- Results

The main problem consists of eliminating spurious results coming from homogeneous areas and texture. However, our results show that this method is worth exploring in the future.

Ground truth (drawn by observers)



Our results

