Title:

Can biological solutions help computers perceive symmetry?

Supervisor:

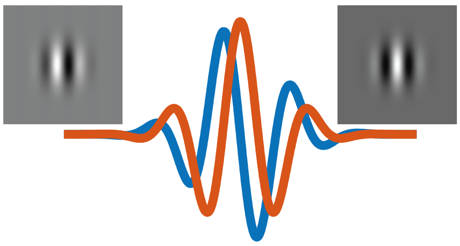
C. Alejandro Parraga (http://www.cvc.uab.es/~aparraga/)

Summary:

Although easy for humans, the perception of symmetry is very challenging for computers (it has been suggested as a robust "captcha" by Funk & Liu -CVPR2016). We propose using a set of biologically-plausible, cortically-based set of convolutional kernel operators to predict the ratings of symmetric images by human observers.

Extended abstract:

Symmetry is an important visual cue for a wide range of biological organisms regardless of size and cognitive ability. The perception of symmetry is important for object processing by facilitating target recognition and identification. Although easy for humans, it is very challenging for computers -it has been proposed as a robust "captcha" by Funk & Liu (CVPR2016).



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).

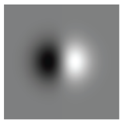
Current computational methods detect symmetric pairs of features and bond them, considering them simultaneously (Loy and Eklundh, 2006).

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

2

3

4



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

- Denoising: convolution with a small Gaussian (SD = 0.09 deg)
- Finding the edges along the preferred orientation using an odd-symmetric filter (first derivative of a Gaussian, SD= 0.28)
- Computing the continuous lines (CL) with an elongated Gaussian (even symmetric) oriented orthogonally to the preferred orientation.
- Convolving with a large odd-symmetric Gaussian (MI) to detect axis of symmetry. The output of this operator is null when both sided are identical.
- Calculating the symmetry lines $S = 0.5 * CL + 0.5 * (1 - MI)$

Results so far: Our results so far are encouraging. The current version of the biologically-inspired algorithm is able to reproduce the symmetry axis in many mirror-symmetric images. The next step would be to fix several shortcoming of the algorithm, e.g. to eliminate spurious results coming from homogeneous areas and texture, improve border-dependent artefacts, remove contrast-polarity dependency, etc.

To do: We expect the MSC candidate to be able to produce an algorithm capable of predicting symmetry ratings from human observers in natural images representing a large variety of cases. This will entail the application of computational learning algorithms to psychophysical data obtained from human subjects.

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)