CCIT Report #793 August 2011

Automatic Gain Control of Images Motivated by Human Vision

S. Furman, Y.Y. Zeevi

Abstract— Biologically-motivated Automatic Gain Control (AGC) scheme of processing along various image dimensions is presented. Images are represented in a multidimensional space that incorporates less investigated dimensions such as curvature, size, depth, convexity/concavity and more. Similarly to the effect of AGC on processing of intensity in vision, the proposed scheme for multidimensional image processing and computer vision enhances and emphasizes important image attributes along each dimension of the representation by adaptive nonlinear filtering. This achieves vision-like intelligent image processing and new powerful means for computer vision. The proposed AGC scheme is analyzed for its SNR characteristics, and for its action on several specific inputs. The results are compared with effects known from visual psychophysics, exhibiting reproduction of visual illusions. Finally, examples of applications in computer vision are presented. These include processing of HDR (High Dynamic Range) images, enhanced edge detection and interpolation of curves partly occluded during the acquisition process. Incorporating a generic neural network AGC scheme along all the visual dimensions, constitutes a universal, parsimonious and unified model that can span a multidimensional HDR, and yet be sensitive to fine details along all the dimensions. Implementation of the multidimensional AGC in image processing and computer vision may also contribute to the development of a metric for image space, and facilitate further development of new means for recognition and classification.

Index Terms—Computer vision, Computational models of vision, Filtering Enhancement, Projections, Multidimensional Image Representation, Size and shape, Depth cues, Neural nets Models.

1 Introduction

THE perceived image is quite different from the original image projected onto the retina. Some of the image features that are of great importance (biologically speaking) are enhanced, whereas other that are not significant are barely noticed or even ignored (i.e. suppressed). Many examples of this selective enhancement/suppression phenomenon exist. Usually they are referred to as "visual illusions" (See Fig. 1 for such examples), but all of them can be explained by the way the human visual system (HVS) generally processes visual information, implementing non-linear AGC mechanisms.

Understanding the organization and functioning of visual systems is obviously of great interest and importance in the field of image processing and computer vision because of its potential use in the design of intelligent systems that mimic biological vision (for such examples see [1] [2]). By matching image presentations to the known performance of the visual system, more meaningful and efficient communication can be achieved. After all, most of information generated for human consumption, is communicated with the human observer via the visual system as the final receiver. In yet another way, image processing modeled after the visual system may prove to be important in machine (computer) vision. And of course, now that visual prosthetics are becoming a workable reality [3], this understanding is essential. Moreover, such an understanding may lead to the development of an image metric accounting for human perception. This should contribute to further advancement of recognition and classification algorithms.

Each cone in the central fovea is connected to about 4000 cortical neurons [4]. The challenge to determine what are these 4000 processes, and what are the structure and function of this multidimensional representation, still remains outstanding.