

A Proposal of a Homeostatic Regulation Mechanism for a Vision System

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Abstract. In this work, we propose the introduction of a homeostatic regulation mechanism in a vision system. This homeostatic mechanism takes charge of controlling the luminance, white balance, contrast and size of the object of interest in the image, using naive methods except for the contrast, for which we have implemented a method that avoids the hill climbing search for the best focus position. We carry out some experiments in order to test the possible increase of the performance in a face detection application.

1 Introduction

Homeostasis is defined as "a relatively stable state of equilibrium or a tendency toward such a state between the different but interdependent elements or groups of elements of an organism, population, or group". The state of equilibrium is normally related to the survival of the organism in an environment. Thus, organisms have regulation mechanisms, generally referred as to homeostatic regulation, in order to maintain this state of equilibrium.

The concept of homeostasis as autoregulation mechanism has been included by some authors in systems that have to develop their activity in complex and changing environments. In robotics we find some examples in the AuRA architecture [1], or in the work of Hsiang [2]. The role of the homeostatic mechanism has been also studied by Damasio [3] from an emotional point of view. He called primary emotions, to the ones which are in charge of taking decisions about the individual survival, so they are part of the homeostatic regulation mechanism. The idea of primary emotions as homeostatic regulation has been used by some other authors like Velasquez [4] who introduces the concept of *drive releasers* in his Cathexis architecture.

Since the introduction of the Active Vision paradigm, vision systems include perception strategies which are controlled by the interaction with the environment when a specific goal is pursued. Thus, we can consider the introduction of

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a homeostatic regulation in such vision systems since they share the fact that a goal has to be achieved (survive) in a changing environment and they have to adjust their behaviors to get the best performance in the whole time.

2 A homeostatic regulation mechanism for a vision system

The performance in most of the computer vision systems relies heavily on the quality of the images supplied by the acquisition subsystem. In computer vision applications where the environment E is completely controlled, the set of camera parameters δ that define the quality of the image can be initially tuned to get the best performance. If the environment changes to E' , for example due to different lighting conditions, the performance of the system will be maximum for another set of camera parameters δ' . So if the system have no internal mechanism to detect this change, its performance will drop because it will continue using the initial parameter set δ and we must rely on an external agent to readjust the parameter set to δ' .

In the introduction, the concept of homeostatic regulation was presented as a mechanism to increase the survival opportunities of an agent in a changing environment. We can adopt the same concept to keep the performance of a vision system as high as possible when the environmental conditions change, endowing the vision system with a homeostatic regulation mechanism.

To our purposes we consider that the variables that affect to the image quality are the contrast, luminance, size of the object of interest and the white balance. For each of these variables, a homeostatic regime is defined and it is maintained by means of adjusting the camera parameters to keep the values of the variables within the homeostatic regime. Below we describe in a few words the algorithms used for control each variable.

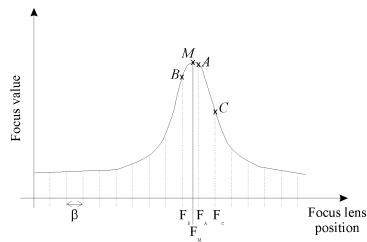


Fig. 1. Autofocus algorithm (first phase)

Luminance It is controlled by dividing the image into five different regions similar to the proposed by Lee et al. [5]. These five regions allow us to get different autoexposure strategies according to the nature of the object of interest giving different weights to the average luminance in each region. We have tested three different strategies for auto exposure that we have called as uniform, centered and selective.

Contrast A focused camera gives sharp images hence the acquired image has a high contrast, we use a autofocus algorithm for regulating the contrast of the images. Since the study of complex focus measures is out of scope of this work, we choose a passive focus technique with a measure which exhibits a

maximum when the image is at best focus proposed by Nanda and Cutler [6]. The AF algorithm we have developed starts with a run along the complete range of focus lens positions with a step β (Fig. 1). Due to the discretization effect of the focus positions, the maximum value A is found at F_A whereas the actual maximum is M at position F_M . To estimate the value M , a quadratic function f_F is computed from points (F_B, B) , (F_A, A) and (F_C, C) and the maximum of f_F is taken as an estimation of M . Thus, we avoid to use slow hill-climbing techniques around the point A .

White Balance For applications based on color it is necessary that it has a certain constancy because depending on the light source temperature the same color appears different in the image. To deal with this fact dynamically we have adopted the *Grey World* [6] assumption which tries to make the amount of green, blue and red in the image equal, by adjusting the red and blue gain parameters.

Size In this case we are interested in keeping constant the aspect ratio of the object in the image. To accomplish it the zoom of the camera is increased or decreased.

3 Experiments

To test the introduction of the homeostatic regulation in a vision system we are going to use a face detection application as test bed. This application utilizes the architecture EN-CARA [7] which is based on the concatenation of naive classifiers whose inputs are weak clues about the presence of a face in the image. We compare the performance of the system with changing environmental conditions. The performance is measured as the number of frontal faces detected.

Figure 3 shows the obtained results with the homeostatic regulation mechanism. The experiments were carried out with a person in front of the camera. After a while some lamps were switched off and then they were switched on to restore the initial illumination conditions. Previously to the experiment, camera parameters were adjusted to achieve a good performance.

In figure 3 is observed that lamps were switched off when 150 images were acquired and then switched on after the acquisition of 320 images. Unlike the experiments carried out without a homeostatic mechanism¹, the number of faces detected when the lamps were switched off is greater and both the luminance and white balance is restored using the parameters of the camera after a transitory time period.

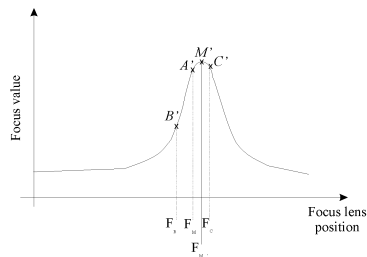


Fig. 2. Autofocus algorithm (second phase)

¹ See an extended version of this work in <http://mozart.dis.ulpgc.es/~javier/javier-publications.html>

4 Conclusions

In this paper, we have initially presented a discussion about the suitability of including a homeostatic regulation mechanism in a vision system that operates in a non controlled environment. Then we identify some variables to be controlled and we have proposed the architecture of a simple homeostatic mechanism to maintain them near a set point, called homeostatic regime. This homeostatic mechanism includes a two phase autofocus method based on the fitting of a quadratic function that avoids a hill climbing search to find the best focus position. In the experiments carried out with a face detection application we have found that the number of faces detected is greater when the homeostatic mechanism is activated than when it is not.

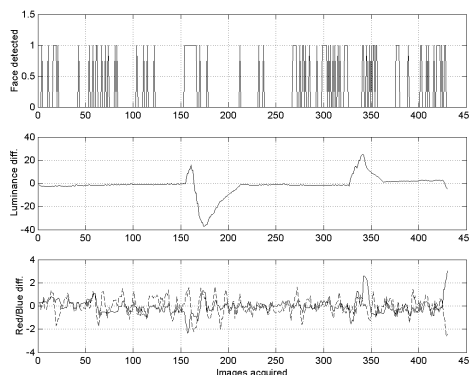


Fig. 3. Face detection with homeostatic control

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