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Filter design of composite trade-off filter with support regions to obtain invariant pattern recognition with defocused images

Asticio Vargas[a,*], Juan Campos[b], Cesar San Martin[c], Nestor Vera[c]

[a] *Departamento de Ciencias Físicas, Universidad de La Frontera, Av. Francisco Salazar 01145, Temuco, Chile*

[b] *Departamento de Física, Universidad Autónoma de Barcelona, Edificio Cc, E-08193 Bellaterra, Barcelona, Spain*

[c] *Departamento de Ingeniería Eléctrica, Universidad de La Frontera, Av. Francisco Salazar 01145, Temuco, Chile*

Abstract

The discrimination capacity (DC) measures the ability of the filter in a pattern recognition problem to discriminate the target against other objects in the input scene. If the input scene is degraded by a defect of focus, then the DC is degraded and the pattern recognition process is worse. In this paper, we present a methodology based in the selection of ring frequency bands and in the design of the trade-off filters taking into account these frequencies to obtain several information channels. The information of all the channels is fused by means of the addition of all the channels and the geometric mean of them. Also individual channel analysis is shown. The influence on the DC and SNR of the added white noise in the input image is presented.

Keywords: Discrimination capability; Pattern recognition; Filter design; SDFs filters; Image processing; Defocused images; Sub-band decomposition

1. Introduction

In pattern recognition problem, the filter design has been a very important development area. The success of the recognition process strongly depends on the

*Corresponding author.

E-mail addresses: avargas@ufro.cl (A. Vargas), juan.campos@uab.es (J. Campos), csmarti@ufro.cl (C.S. Martin).

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used filters, so many filters have been proposed each one optimizing some quality criteria or solving a determinate task. The start point of some of these tasks is the quality of the input image to be processed. So, depending on the kind of the degradation, the solution to obtain better results will be different. For instance, if the input image presents rotation in plane, a filter based on circular harmonic decomposition permits to obtain invariant results [1].

There are problems that cannot be solved by the use of only one filter being necessary the use of several filters which give multiple information channels each one with their own information. In the literature several architectures have been proposed to optically implement multichannel filtering. Yu et al. [2] proposed a technique to perform multiple correlation that uses a scanning grating displayed on a spatial light modulator (SLM) where the orientation of the grating is sequentially varied. Sheng et al. [3] and Mendlovic et al. [4] proposed a multichannel optical processors for implementation of the wavelet transform. The replicas produced by the pixelated structure of the spatial light modulators have been used to implement a multichannel pattern recognition [5] and Gabor-wavelet transform [6]. In [7] the design of a gray-level computer generated hologram filter for multiple-object correlation is provided. The impulse response (IR) of this filter is the combination of the IR of several filters spatially disjoined which permits the implementation of a multichannel process. Some times the input image appears distorted or degraded. Then especial filters are needed for pattern recognition. For instance, Chang et al. [8] have proposed a new method for pattern recognition that is invariant under changes of position, orientation, intensity and scale. It is based on the centroids of objects.

A common degradation that appears in the input scene is the defect of focus. To obtain a less sensitive process to the degradation introduced in the input scene by a defect of focus of the imaging system we have used [9] a Laplacian pyramidal decomposition over the input scene. A sub-band image set is obtained, each sub-band image is used to perform a correlation process with a POF filter. In this way a multichannel process is carried out. By means of a non-linear combination of the information provided by all channels invariance against the defocus can be obtained. Due to the restriction between the central frequency band and the width of the Laplacian filter, better results are obtained when annular preprocessing filter [10] is used.

In this paper, we propose the design of a trade-off SDF filter in annular regions of support to obtain an effective and robust process invariant to defocus degradation in the input scene. We will study the behavior of the method when only a filter or the combination of all the channels is used. In Section 2, we give an overview of the out of focus effect on the correlation process, and why regions of support of annular shape are selected. In Section 3, the filter design is described. Finally, in Section 4 several experiments are carried out to study the behavior of the proposed method. Then in Section 5 we present the conclusions.

2. Effect of the defocus on correlation process

In most of the cases the input scene to be analyze in a pattern recognition problem is acquire by means of an optical system. In the acquisition step the input scene may