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Image Super Resolution and Enhancement Using E-spline

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Abstract: E-splines (Exponential spline) polynomials represent the best smooth transition between continuous and discrete domains. As they are constructed from convolution of exponential segments, there are many degrees of freedom to optimally choose the most convenient E-spline, suitable for a specific application. In this paper, the parameters of these E-splines were optimally chosen, to enhance the performance of image zooming and interpolation schemes. The proposed technique is based on minimizing the total variation function of the detail coefficients of the E-spline based wavelet decomposition. In zooming applications, the quality of interpolated images are further improved and sharpened by applying ICA technique to them, in order to remove any dependency. Illustrative examples are given to verify image enhancement of the proposed E-spline scheme, when compared with the existing approaches.

Key words: Image de-noising, interpolators, E-spline functions.

1. Introduction

During the past decade, there have been an increasing number of papers devoted to the use of polynomial splines in different signal processing applications [1-3]. B-spline polynomials, is a class of these polynomial splines that find extensive applications in many engineering applications. In Ref. [4], a complete analysis for a B-spline PR (perfect reconstruction) frame work with a derivation for the scaling and wavelet functions was presented. However, as they are constructed using Haar functions, there is no much degree of freedom to use in optimizing the performance of some signal processing applications like the design of digital interpolators. On the other hand, E-splines (Exponential splines) enjoy a unique feature of being able to convert from analog to digital applications. This is crucial in several signal processing applications such as differential operators, fractional delays, interpolators and sampling rate converters [5-6]. Moreover, E-splines have many degrees of freedom if they are optimized in a specific application, as they are constructed from the convolution of exponential segments with different rates.

In Ref. [7], a preliminary application for the usage of E-splines in image zooming and interpolation was presented. In this paper, it is proposed to use E-splines in enhancing the performance of image de-noising as well as image zooming schemes. In denoising applications, the proposed denoising technique is based on total variation function minimization [8-9]. Using a recently developed E-spline wavelet decomposition [10-14], the E-spline parameters as well as the thresholding levels of the E-spline detail coefficients are optimally chosen to minimize the total variation of the E-spline detail wavelet coefficients. In image zooming applications, E-spline based interpolators are used in image interpolation. In this case, the parameters of E-spline polynomials are chosen to boost the high frequency detail energy of

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