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Object-based quality evaluation procedure for fused remote sensing imagery

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ABSTRACT

Satellite sensors usually provide two types of data: panchromatic and multispectral images which are characterized by their high spatial resolution and high spectral resolution respectively. In this context, the fusion techniques or pansharpening consist of merging these different aspects to obtain a fused (or pan-sharpened) image with high spatial and spectral resolutions.

In this paper, a new quality assessment scheme for pan-sharpened remote sensing imagery is proposed. The methodology described extracts the segments of the images to constitute the basic elements of the measuring quality methodology. This new strategy overcomes traditional pixel-based perspectives, approaching an evaluation by human observers. The results of its application to a set of fused images show that an object-based assessment is consistent in terms of quality determination of both the spectral and spatial properties of remote sensing images.

1. Introduction

Very-high resolution satellites provide a panchromatic band with a high spatial resolution and several multispectral bands but with a lower spatial resolution. In this context, the fusion of remote sensing imagery or pan-sharpening consists of combining the spatial information of the high spatial resolution image and the panchromatic image (PAN) to the high spectral resolution image and multispectral image (MS) [1,2]. The challenge of this process is to obtain a pan-sharpened or fused image (FUS) which preserves the spectral fidelity of the MS image but containing the high frequency information of the PAN image [3,4].

To this purpose, many pan-sharpening algorithms have been described in the literature, trying to produce an FUS image that matches the spectral and spatial features of MS and PAN images, respectively [5–8]. At this point, a quality evaluation of pan-sharpened images plays an important role in benchmarking different algorithms, as well as providing an improvement tool for them [9].

However, a quantitative quality assessment of pan-sharpened images constitutes a complex and challenging issue [1]. In fact, the aim is to combine the spatial and spectral evaluation in a single indicator which aligns with the qualitative evaluation. However, these evaluations can be addressed as two different problems. On the one hand, a full-reference quality evaluation (PAN versus FUS) and, in the other hand, a semi-reference quality evaluation (MS versus FUS) [2,10].

In this work, a new methodology is described for assessing the quality of pan-sharpening images. This novel method is founded on obtaining the objects in the image to be used as the core element of the quality assessment, in contrast to the usual procedures based on pixels.

This paper is structured as follows: First, the related works on quality assessment of pan-sharpened images are briefly reviewed. The proposed assessment procedure is described in Section 3, as is the data used to test this new methodology. Section 4 shows

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Fig. 1. Multispectral images: (a) Geoeye, (b) Ikonos, (c,d) QuickBird.

several examples of the results obtained after the application of the object-based evaluation. Finally, the main conclusions of this work are stated in Section 5.

2. Related works

Although it is noteworthy that scientific papers rarely address the measurement of image quality from an object approach, many pixel-based approximations can be found in the literature that try to solve this problem. In fact, image quality assessment is an active field of research with significant attention in the fields of image processing, visual and machine learning [11,12].

As regards the pan-sharpening quality evaluation, researchers usually make use of quality indicators extensively used in image processing which are mainly based on distances between the grey levels of the pixels of images. As an example, a Minkowski distance in the order of 2 is used to calculate the median square error (MSE) or the ERGAS indices [13,14], the dot product used by the Single Angle Mapper index (SAM) [15,16] or the cross correlation (CC) [7,17] on the computation of the Zhou Index [18,19]. Other authors calculate image statistics to establish a quality assessment as the Q, Q4 or SSIM indices do [20–22] or implement a quality assessment based on a comparison with input data (QNR) [23].

As has been said, the aforementioned approaches are pixel-level based and tend to give a unique scalar as a overall quality indicator. Nevertheless, two assumptions underlie this focus. First, this perspective assumes that image quality is homogeneous throughout the FUS image. This fact is particularly difficult to meet in remote sensing imagery because of the large amount of data and consequently the variety of cover that can be presented on the image. Second, the element used to evaluate the quality, the pixel, lacks meaning in terms of human evaluation. In other words, the qualitative evaluation cannot be analyzed as a simple pixel comparison.

In order to avoid the aforementioned drawbacks, we present a object-based quality evaluation procedure for remote sensing imagery in this paper. The image objects are obtained by segmenting the FUS image. These data are propagated through the PAN and MS images for comparison purposes. An overall quality map can be derived as a distance to the characteristics of the ideal object.