Restoration of interlaced images degraded by variable velocity motion

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Abstract. An interlaced composition of odd and even subimage fields is a very common video formation technique. Motion degradation is an inherent problem in portable imaging systems, such as airborne imaging, mobile phones, robots, etc. When relative motion between the interlacing camera and the scene occurs during imaging, two distortion types degrade the image: the edge “staircase effect” due to shifted appearances of objects in successive fields, and blur due to scene motion during each field exposure. In contrast to other previous works that dealt with only uniform velocity motion, here we consider a more general, realistic, and complicated case, in which the motion velocity is not necessarily uniform. The motion in each field and the displacement are assumed to be space invariant. Since conventional motion identification techniques used in other works cannot be employed in the case of variable velocity motion, a new method for identification of the motion from each field is used, and different point spread functions are identified for each field. The restored image is achieved by deblurring each field separately, and then realigning the fields. Results of motion identification and image restoration for various motion types are presented and analyzed for simulated and real-degraded images.

Subject terms: motion deinterlacing; motion blur; composite frame; displacement vector estimation; motion optical transfer function; image restoration; blur identification.

Paper 020473 received Oct. 28, 2002; revised manuscript received Apr. 14, 2003; accepted for publication May 23, 2003.

1 Introduction

A scanning process with interlace of the order 2 is common in most video sequence acquisition systems. Interlaced imaging was developed originally to increase the frame (field) rate without enlargement of the required bandwidth of the channel, and is still common today. These imaging systems usually produce their pictures by sequentially superimposing the odd and even fields of each image.

If relative motion between the camera and the object occurs, the interlaced image is degraded by two effects: the typical “staircase effect” and motion blur. The edge staircase effect (or “comb effect”) is due to the changes of the object’s location during the period between the instants of exposures of two successive fields. The blur results from relative motion between the camera and the scene during the exposure of each field. These phenomena are explained in Sec. 2.

Techniques that considered compensation of the motion effect on interlaced images (sometimes referred as motion-compensated deinterlacing) are designed to convert interlaced images to progressive image format. Most of these techniques use several frames to estimate the field displacement caused by the motion and usually ignore motion blur. When the blur effect is ignored, the motion that occurs only between frames can be determined by the motion displacement vector (DV), which is the distance between the locations of the same point in two successive fields. A DV estimate can be used to realign the fields. However, a restoration method is incomplete when it takes into account only the field displacement restoration but ignores the blur caused by motion during the nonzero exposure time. Analysis of motion blur and motion blurred image restoration methods can be found in the literature.

A recent work for restoration of motion distorted composite frames considered both the staircase and blur effects. The two fields of the interlaced image were realigned using the DV estimated from the interlaced image. Assuming uniform velocity motion during the exposure, and knowing the exposure duration, the blur extent was directly calculated from the DV and used to restore the image from the blur effect (deblurring). The deblurring operation could be carried out, since for a uniform velocity motion, the point spread function (PSF) required for this operation is completely determined by the blur extent and direction. However, in most of the cases a uniform velocity motion during the exposure cannot be assumed.

In this work we propose a restoration technique that is not restricted to uniform velocity motion during exposure. Since the fields are acquired at different points in time, a variable velocity motion forms a different blur effect (PSF) in each of the fields. The motion is also assumed to be space invariant, which means that the blur effect is similar across the field and also the displacement between the fields is spatially similar. Such a situation usually occurs when the relative motion is caused by an angular motion of