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DCC	Directional Cubic Convolution
DFDF	Directional Filtering and Data Fusion
FSIM	Feature Similarity Index
FV	Feature Vector
GM	Gradient Magnitude
HR	High Resolution
HVS	Human Visual System
LAZA	Locally Adaptive Zooming Algorithm
LR	Low Resolution
MBMA	Mapping Based Magnification Algorithm
MFV	Mapping Feature Vector
MHR	Mapping High Resolution
MLCP	Malaysian License Car Plate
MLR	Mapping Low Resolution
MSE	Mean Square Error
NEDI	New Edge Directed Interpolation
PC	Phase Congruency
PSNR	Peak Signal to Noise Ratio
SAI	Soft Decision Adaptive Interpolation
SSIM	Structural Similarity Index

ALGORITMA PEMBESARAN IMEJ BERDIGIT BAHARU BERDASARKAN INTERGRASI DI ANTARA KONSEP PEMETAAN DAN SINTESIS

ABSTRAK

Pembesaran imej adalah proses pembinaan semula imej resolusi tinggi (HR) dari versi resolusi rendah (LR). Proses pembesaran imej adalah salah satu proses penting yang digunakan untuk memenuhi keperluan manusia. Proses ini digunakan dalam beberapa aplikasi seperti dalam pengimejan perubatan, penderiaan jauh, mempertingkatkan butiran imej dan percetakan. Pada umumnya, algoritma pembesaran yang biasa menggunakan konsep penentudalaman. Walau bagaimanapun, algoritma pembesaran berasaskan penentudalaman ini mengalami masalah seperti kehadiran artifak-artifak yang tidak diingini dalam imej yang diperbesarkan seperti pinggir terhalang dan pinggir kabur. Artifak-artifak ini kebanyakannya muncul pada pinggir yang jelas. Oleh itu, selain menggunakan konsep penentudalaman, kajian ini memberi fokus kepada memperkenalkan algoritmapembesaran yang baharuberasaskan konsep sintesis. Disebabkan oleh konsep sintesis telah digunakan dalam algoritma sintesis tekstur berasaskan tampalan, pengubahsuaian kepada algoritma sintesis tekstur barasaskan tampalan perlu dilakukan agar dapatdigunakanuntuktujuan pembesaran imej. Pengubahsuaian yang dicadangkan menghasilkan algoritma pembesaran baharu yang dipanggil Algoritma Pembesaran Barasaskan Pemetaan (MBMA). Algoritma MBMA menggantikan setiap piksel imej LR dengan blok HRdua dimensi untuk membina imej HR. Algoritma yang dicadangkan pada asasnya direka untuk memelihara pinggir

yangjelas. Dua variasi cadangan MBMA diperkenalkan, iaitu MBMA_Average dan MBMA_Direct. Variasi MBMA yang dicadangkan telah dibandingkan dengan teknologiterkini pembesaran algoritma lain menggunakan 100 imej piawai dan 200 imej plat kereta lesen Malaysia (MLCP). MBMA_Average menghasilkan imej pembesaran yang lebih baik dengan pengurangan artifak yang tidak diingini (iaitu pengurangan pinggir kabur dan pinggir terhalang) berbanding dengan teknologi algoritma yang lain. Seterusnya, analisis kuantitatif menunjukkan bahawa MBMA_Average yang dicadangkan juga menghasilkan nilai yang terbaik dalam pengukuran PSNR, SSIM, MSE dan FSIM berbanding algoritma-algoritma tersebut.

NEW DIGITAL IMAGES MAGNIFICATION ALGORITHM BASED ON INTEGRATION OF MAPPING AND SYNTHESIS CONCEPT

ABSTRACT

Image magnification is the process of reconstructing High Resolution (HR) image from its Low Resolution (LR) version. Image magnification process is one of the most important processes that is used to fulfill human needs. This process is used in several applications such as in medical imaging, remote sensing, enhancing image details and printing. In general, the common magnification algorithms employ interpolation concept. However, these interpolation-based magnification algorithms suffer from the appearance of undesirable artifacts in magnified images such as edge blocking and edge blurring. These artifacts mostly appear around the strong edges.Therefore, instead of employing interpolation concept, this study focuses in introducing new magnification algorithm based on synthesis concept. As the synthesis concept has been used in patch based texture synthesis algorithms, a modification to the patch based texture synthesis algorithms has to be carried out in order to use it for the image magnification purpose. The proposed modification produces a new magnification algorithm called the Mapping Based Magnification Algorithm (MBMA). The proposed MBMA replaces each pixel in the LR image with a two dimensional HR block to reconstruct the HR image. The proposed algorithm is basically designed to preserve the strong edges. Two variants of the proposed MBMA are introduced, namely MBMA_Average and MBMA_Direct.The proposed MBMA variants have been compared with other state-of-the-art magnification algorithms by using 100 standard images and 200 Malaysian License Car Plate (MLCP) images. The

proposed MBMA_Average produces the best magnified images with less undesirable artifacts (i.e. less of edge blurring and edge blocking) compared with the other state-of-the-art algorithms. Furthermore, the quantitative analyses show that the proposed MBMA_Average also produces the best value of the PSNR, MSE, SSIM and FSIM measurements compared to those algorithms.

CHAPTER 1

INTRODUCTION

1.1 Background

In fact, most of the information received by human is in pictorial form. Thus, it is important to apply some operations on the image to get the required information. Image zooming is one of the most important operations in both human and computer vision fields. Zooming an image is the process of changing the number of display pixels per image pixel as well as in physical size (Kumar, 2009; Sharmal, 2012; Sharma1 and Walia, 2013). If the number of the pixels in the zoomed image is larger than the number of pixels in the input image, thus this process is defined as zoom-in or magnification process. On the otherhand, if the number of the new displayed pixels is smaller than the number of pixels in the input image, this is considered as zoom-out process (Abd El-Samie *et al*, 2013;Altunbasak,2010).

For the magnification process, a Low Resoultion (LR) image (i.e. the image that is generated from an imaging system with inadequate detectors (Yang and Huang, 2010)) a High Resoultion (HR) image (i.e. the image that contains more details at particular part in the LR image (Yang and Huang, 2010)) is constructed. This process is very important for specific applications including (but not limited) medical imaging (Salih and Ramly, 2002; Raveendran and Thoms, 2014),remote sensing(Jensen, 1996; DiBiase, 2007) and enhancing image details(Basque Research, 2013; Davis, 1998; Wittman, 2005).

1.2 Current Trend in Image Magnification Algorithms

Several magnification algorithms have been proposed by various researchers. These algorithms depend on using interpolation concept in magnifying the LR image and they can be defined as interpolation based magnification algorithms. Interpolation is the process of estimating the values of function at positions lying between its samples (Wolberg, 1996; Abd El-Samie *et al.*, 2013; Tripathi and Kirar, 2014). The estimation process is achieved by fitting a continuous function through the discrete input samples.

There is an inclusive list of different approaches for interpolation based magnification algorithms. This list can be divided into two approaches namely,adaptive and non-adaptive approaches. Most of adaptive and non-adaptive approaches result in a varity of undesirable artifacts (Atkins *et al*., 2001; Ouwerkerk, 2006; Altunbasak, 2010; Grover, 2014). These artifacts include edge blocking (Nallaperumal*et al*., 2006), edge blurring (Singhand Singh, 2013) and fail in preserving image details.

The non-adaptive algorithms treat all pixels equally and they are easy to be implemented. These algorithms include bilinear and cubic convolution. These algorithms are the simplest ones and they are preferred for their low complexity (Thevenaz *et al*., 2000; Giachetti and Asuni, 2011). However, they suffer from the inability to adapt to varying local structure of the LR image. Furthermore, these algorithms tend to cause undesirable artifacts such as blurring and blocking around edges (Amanatiadis and Andreadis, 2009).

Recently, numerous adaptive interpolation algorithms have been presented in the literature. These algorithms struggled to overcome the shortcomings of the non-adaptive algorithms. Adaptive interpolation algorithms depend on what they are interpolating based on certain information extracted from the structure of the image including edges and smooth areas (Kim, 2014,Li and Orchard, 2001). These algorithms can be classified as edge-adaptive interpolation, statistical learning-based interpolation, optimal recovery based interpolation and transform domain interpolation (Altunbasak, 2010).

The edge directed interpolation algorithms take into account the edge information in the LR image either explicitly (Chen *et al*., 2005) or implicitly (Li and Orchard, 2001; Giachetti and Asuni, 2011; Zhou *et al*., 2012). The subjective quality of the magnified images using these algorithms is improved with higher computational cost. Furthermore, the magnified images have sharper edges than magnified images using the non-adaptive algorithms. However, edge directed algorithms usually cause artifacts in complex edges such as in textures (Amanatiadis and Andreadis, 2009).

The statistical learning-based interpolation algorithms based on the observation that pixels can be classified to different spatial context classes such as edges of different orientation and smooth textures. Then an interpolation filter is designed for the selected class to get the interpolated image (Altunbasak, 2010). These algorithms are considered as the most effective interpolation algorithms since the magnified image has superior visual quality with sharper edges than many other algorithms. However, these algorithms have difficulties dealing with texture areas (Altunbasak, 2010).

The Adaptively Quadratic Interpolation Algorithms (AQUA) are based on specifying the local quadratic signal class from local image patches and then applying optimal recovery to estimate the unknown points. While the AQUA works well for small interpolation factors, the magnified image is deteriorated when interpolating by larger factors (Altunbasak, 2010).

The transform domain interpolation algorithms focus on the use of Wavelet Transform(WT) and Discrete Cosine Transform(DCT) in decomposing the image into specific frequency bands, then process each band separately. The magnified image