LOSSY COMPRESSION OF MEDICAL INFRARED IMAGES

G. Schaefer* and S.Y. Zhu**

* School of Computing and Informatics, Nottingham Trent University, UK
** Applied Computing, University of Derby, Derby, UK

Gerald.Schaefer@ntu.ac.uk
S.Y.Zhu@derby.ac.uk

Abstract: With the increasing use of thermal infrared imaging for medical purposes factors concerning the storage and transmission of thermograms need to be addressed. Since lossless compression methods achieve only fairly poor compression ratios, we present a lossy compression algorithm for thermograms based on a set of standardised views and regions and JPEG2000's ability of region of interest coding.

Introduction

In recent years there has been a resurgence of interest in the application of infrared thermal imaging in medicine due to improvements in camera technology and the promise of reduced costs [1]. Due to this increased use factors concerning the storing of thermal medical images have become an issue with one of the most prominent of these factors being the storage space used by the images. Hence, in order to reduce the demands on hardware resources, compression of the data is necessary. In general there are two categories of image compression algorithms: lossless techniques which preserve all information and lossy algorithms which sacrifice some of the visual quality to gain in terms of compression rate. For medical images typically lossless techniques are employed so as to make sure no image features are remove or distorted. However, lossless image compression achieves only a compression ratio of up to about 1:4 [2, 3] which is in stark contrast to lossy techniques that provide compression with ratios up to 1:100.

In this paper we apply the recently released JPEG2000 compression standard [4, 5] to thermal medical images. We utilise the lossy mode of JPEG2000 together with its ability of Region of Interest (ROI) coding [6] which allows certain parts of an image to be coded at a different (higher) quality than the rest. The ROIs are obtained following recent work conducted at the University of Glamorgan which defines a set of standard views for thermal medical imaging together with a series of interest regions within each of the views [7]. Coupling these with JPEG2000 allows high quality coding of thermal images with compression rates far beyond the ability of lossless algorithms.

Methods

JPEG 2000

Much effort has been spent on what finally became the new JPEG2000 image compression standard [4, 5]. At its heart is the usage of a wavelet transform which allows multi-resolution representation and more efficient coding compared to other transforms such as the discrete cosine transform employed in the previous JPEG standard [8]. Furthermore, JPEG2000 not only allows images to be coded with clearly better visual image quality compared to its predecessor, it also addresses a series of other issues. Unification of lossless and lossy compression modes, robustness to bit-errors to allow image transmission over noisy channels and provision of regions of interest (ROIs) are only some of those features that have been incorporated into the new standard and that also make it especially interesting for the coding of medical imagery.

Region of interest coding in JPEG2000

Often some parts of an image are more important than others. For such purposes JPEG2000 offers Region of Interest (ROI) coding [6] which allows users to define certain areas in an image to be coded with higher quality and less distortion compared to the rest of the image (i.e. the background). Two types of ROI coding methods are provided by the standard: maximum shift and a generic scaling based ROI coding. Both techniques place ROI associated bits in higher bitplanes by downshifting the bits of background coefficients from most significant bitplane to least significant bitplane so that ROI coefficients can be coded first in the following embedded bitplane coding. As any scaling value is supported, the generic scaling based method allows fine control on the relative importance between the region of interest and the background. On the other hand, the different wavelet subbands must have the same ROI definition, which is not desirable in some applications. The Maxshift method can be considered as a particular case of the generic scaling based method where the scaling value is so large that there is no overlapping between background and ROI bitplanes. Therefore, the ROI's shape is implicitly encoded and arbitrarily shaped

ISSN: 1727-1983 © 2005 IFMBE

ROI coding can be supported. Moreover, it can flexibly treat separate wavelet subbands differently.

Standard views and regions of interest

In an attempt to standardise the capture of medical infrared images and in order to build an atlas and database for the temperature distribution of the skin in human subjects a series of standard views have been defined in [7]. In total 27 standard views comprising regions of the human body that are likely to show significant temperature changes in case of physiological effects due to disease have been specified. Also, for each view one or more regions of interest comprising certain anatomical areas or regions useful for analysing the temperature distribution therein have been defined. Figure 1 gives two example views (right leg in lateral view; right arm, anterior view) and their regions of interest (lateral hip, medial knee, and lateral ankle respectively anterior forearm, medial elbow, and anterior upper arm).

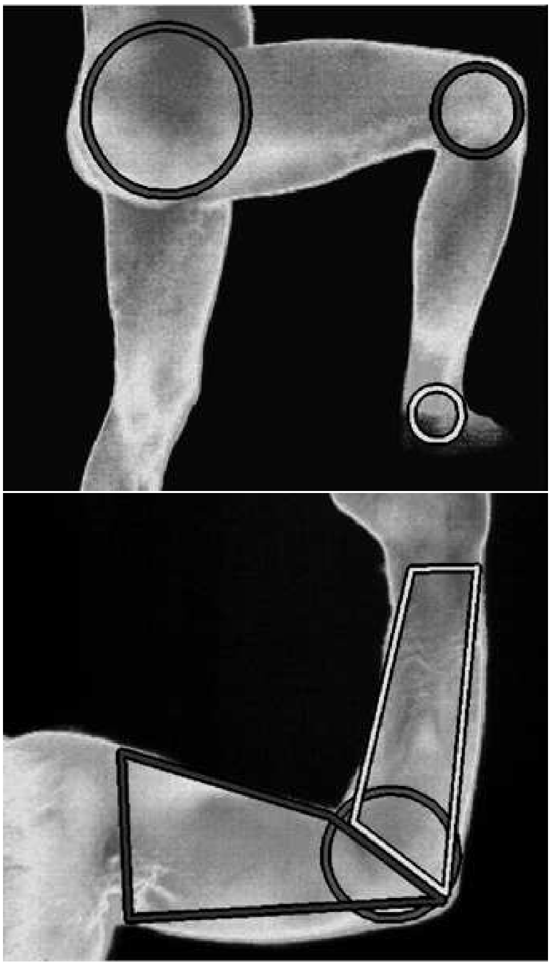

Figure 1: Examples of regions of interest defined in [7] for *right leg, lateral* (top) and *right arm, anterior view* (bottom) views.

JPEG2000 ROI coding for thermal images

Since JPEG2000 supports region of interest coding and the standardisation process from [7] defines such regions for each possible view we simply couple these to provide good quality lossy compression of thermograms. First, the type of view of a thermal image is identified. Then, one or more of the regions of interest that have been defined for that view are selected as the ROIs for the compression algorithm. JPEG2000 compression is then applied so that the ROI are preserved at much better quality compared to the background.

Results

Examples of the performance of the proposed technique are given in Figures 2 and 3. Figure 2 shows an image of *right leg, lateral* view together with its compressed counterparts, encoded using JPEG [8] and the method proposed above. Compression ratios were 1:39 for JPEG and 1:40 for JPEG2000, i.e. the latter is slightly more compressed. Regions of interest were defined around the *medial knee* and *lateral ankle* areas (for simplicity of implementation the smallest bounding rectangles of those regions were choses as ROIs) and the Maxshift ROI algorithm applied. Figure 2 also provides the error images, that is the difference image between the original and the compressed version, for both algorithms. In order to make the difference more visible a gamma function with $\gamma = 0.5$ was applied to enhance the contrast. Figure 3 shows another example based on an image in *right arm, anterior* view. JPEG2000 ROI coding was applied with the ROI spanning both the *anterior forearm* and *medial elbow* areas. Again, standard JPEG compression was applied for comparison, and the error images for both methods are provided.

Discussion

From the examples given above it is clear that the proposed method provides an effective method of lossy image compression while preserving certain areas of interest with near lossless quality. This is particularly demonstrated by the error images which are nearly black (i.e. no error) around those areas selected (despite the contrast enhancement). In contrast, standard JPEG compression encoded to the same compression rate shows errors in all parts of the image including those regions which are more important for clinical purposes.

Conclusions and further work

An effective image compression algorithm for medical infrared images has been presented. JPEG2000's ability of region of interest coding together with a consistent and concise definition of standardised views and regions allow lossy compression to performed in such a way that those areas defined to be clinically

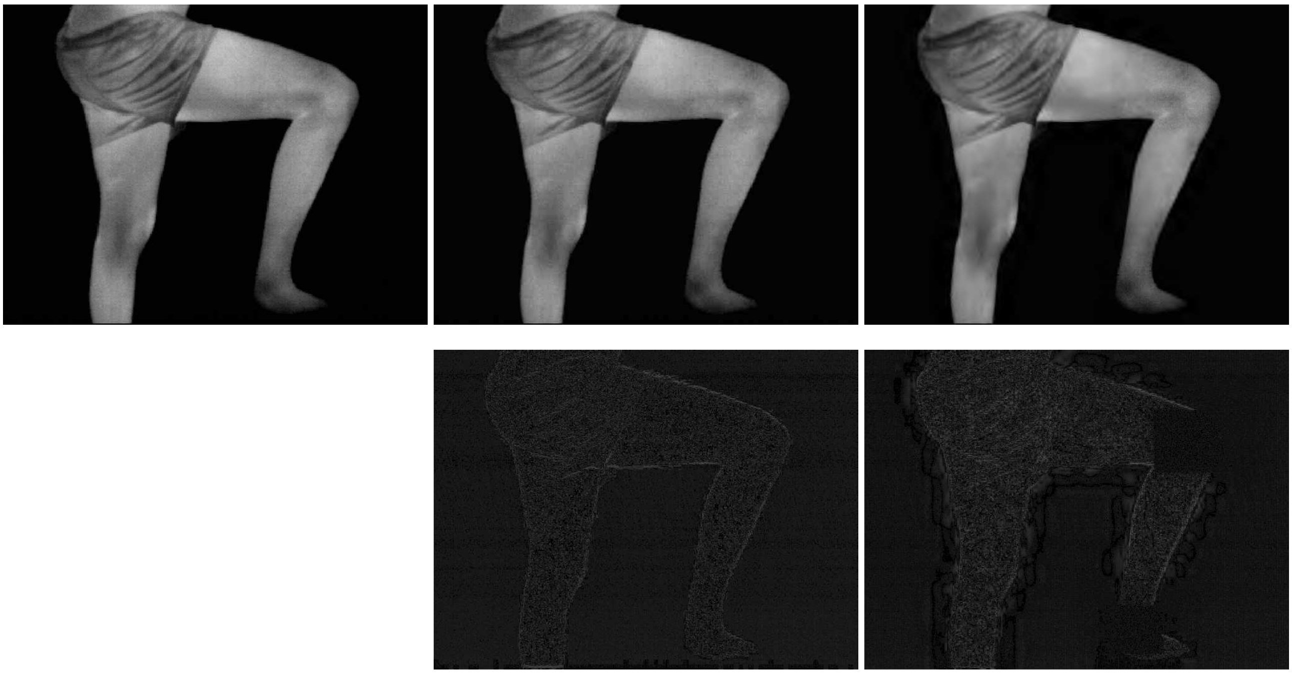

Figure 2: Original image of *right leg, lateral* view (top left) together with version compressed using JPEG (top middle, CR = 1:39) and JPEG2000 with ROI coding (top right, CR = 1:40). The bottom row shows contrast enhanced error images for the two compressed images.

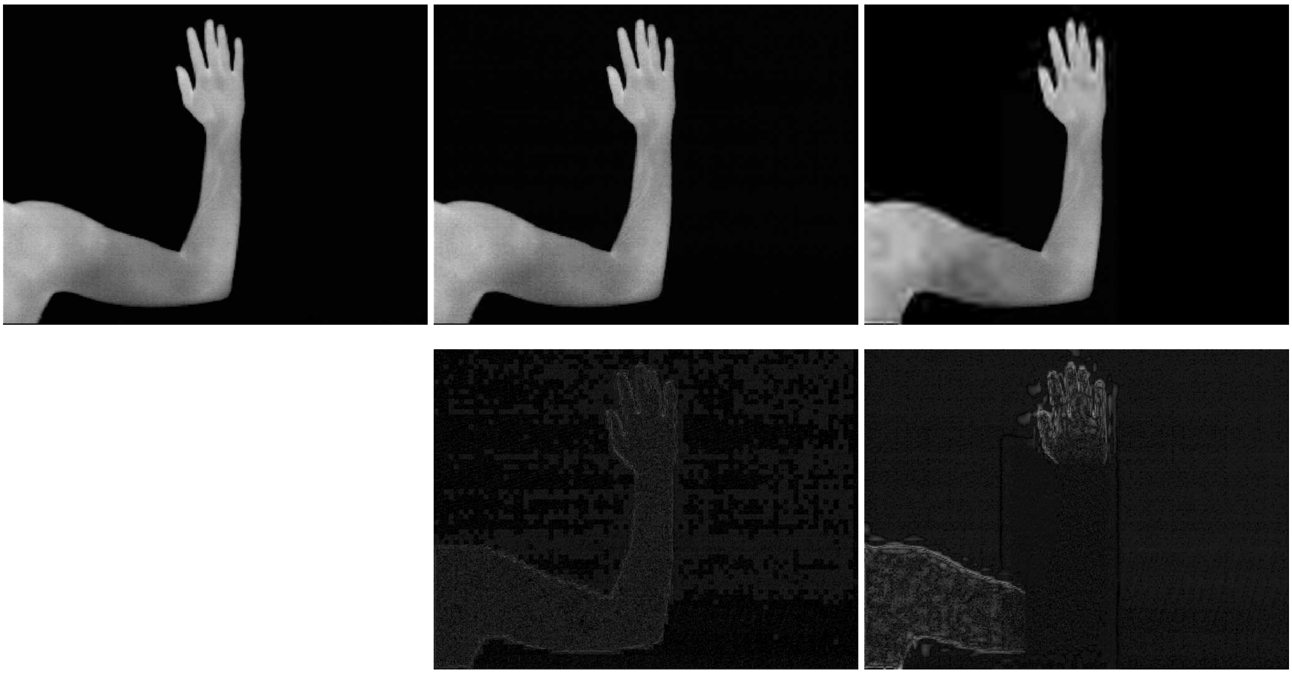

Figure 3: Original image of *right arm, anterior* view (top left) together with version compressed using JPEG (top middle, CR = 1:39) and JPEG2000 with ROI coding (top right, CR = 1:40). The bottom row shows contrast enhanced error images for the two compressed images.

important are encoded with higher quality compared to the background. Currently, we are in the process of evaluating our method on a large dataset of thermal medical images [2].

References

[1] B.F. JONES. A re-appraisal of infrared thermal image analysis for medicine. *IEEE Trans. Medical Imaging*, 17(6):1019–1027, 1998.

[2] G. SCHAEFER, R. STAROSOLSKI, and S.Y. ZHU. An evaluation of lossless compression algorithms for medical infrared images. In *27th IEEE Int. Conference Engineering in Medicine and Biology*, pages 1125–1128, 2005.

[3] R. STAROSOLSKI, G. SCHAEFER, and S.Y. ZHU. Performance evaluation and optimisation of lossless image compression algorithms applied to medical infrared images. In *Medical Image Understanding and Analysis*, 2005.

[4] ISO. JPEG2000 image coding system. *ISO/IEC FCD 15444-1 JPEG2000 Part I Final Committee Draft Version 1.0*, 2000.

[5] M. RABBANI and R. JOSHI. An overview of the JPEG 2000 still image compression standard. *Signal Processing: Image Communication*, 17(1):3–48, January 2002.

[6] J. ASKELOF, C. LARSSON, and C.A. CHRISTOPOULOS. Region of interest coding in JPEG 2000. *Signal Processing: Image Communication*, 17(1):105–111, January 2002.

[7] E.F.J. RING, K. AMMER, A. JUNG, P. MURAWSKI, B. WIECEK, J. ZUBER, S. ZWOLENIK, P. PLASSMANN, C. JONES, and B.F. JONES. Standardization of infrared imaging. In *26th IEEE Int. Conference on Engineering in Medicine and Biology*, pages 1183–1185, 2004.

[8] G.K. WALLACE. The JPEG still picture compression standard. *Communications of the ACM*, 34(4):30–44, 1991.

ISSN: 1727-1983 © 2005 IFMBE