THE ASSESSMENT OF COMPRESSION INDUCED IMAGE DEGRADATION.

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The introduction of image distortion during compression is of widespread concern, to the extent that it may influence the choice of codec and associated compression rate. The ability to quantify this image distortion (or reduction in exploitation potential) for particular applications is therefore highly desirable. The work presented at this conference represents part of a programme aimed at selecting a codec and compression rate automatically based on the exploitation potential of the input imagery and that required of the output imagery.

In the military domain, the quality or interpretability of reconnaissance imagery is normally measured using the National Imagery Interpretability Rating Scale (NIIRS). It consists of integral levels ranging from 0-9; higher values indicating a capability to support more detailed analysis. The assignment of NIIRS level is subjective and is driven by the requirements to detect, distinguish between, and identify specific imaged objects. If the particular object does not appear in the image, then an analyst must imagine it to do so and assess the image accordingly. A Civil NIIRS also exists. It is quantised down to tenths of a rating and includes a more general set of agricultural, cultural and natural features.

The performances of a number of metrics capable of quantifying image degradation have been evaluated on various imagery types [1]. Here we report on the application of JPEG, wavelet and VQ (vector quantisation) codecs, over a range of compression rates, to visible-band imagery, and, in particular, we examine the correlation between these metrics and the reduction in subjective NIIRS value. The assignment of NIIRS ratings is based on the March 1996 release of the IRARS (Imagery Resolution Assessments and Reporting Standards) committee's Civil NIIRS Reference Guide, and represents the consensus of opinion of a group of seven image analysts drawn from military intelligence centres across England.

In addition, we present a novel and straightforward method of graphical and scalar image quality measurement utilising integer wavelet transformations. The image is decomposed down to 3 levels using an S&P transform, as ultilised in the SPIHT [2] codec. It has been observed that the diagonal and edge transform-subbands are complementary in capturing blur and noise degradation caused by application of a codec to an original image. The measure can perform a similar function to the Hosaka [3] plot whilst not requiring segmentation and threshold parameters. By weighted summation, the graphical measure can be degenerated into a scalar quality measure. The scalar measure is found to present consistently high correlation with subjective image quality assessment using NIIRS.

The study used digital versions of the calibration images associated with the Civil NIIRS Scale. All of the scalar quality measures assessed in this study are bivariate, that is, they measure the differences between corresponding samples in the original image, f, and the (reconstructed) compressed image, f'. The study also evaluated graphical image quality measures, such as histograms and Hosaka plots, against the results. However, the dimensional inconsistency between the graphical measures and the NIIRS rating did not facilitate correlation.

Results have indicated that the following numerical image quality measures provide very good correlation with NIIRS ratings when applied to JPEG and particularly to both VQ and wavelet compressed imagery: Mean Square Error (MSE), Image Fidelity, Peak MSE and Normalised MSE. The unexpectedly high correlation between MSE and NIIRS degradation appears to negate much of the criticism of its low correlation with subjective assessment. These results support recent studies from academia [4] which found that the latter three of the above measures were amongst the best metrics in their subjective/numerical image quality correlation project.

It is apparent that the entire library of numerical measures used in this study were better able to reflect the NIIRS degradation in wavelet and VQ compressed imagery than they were for JPEG. This is due in part to the ability of wavelet and VQ compression to encode the imagery to produce an optimally minimised MSE image on reconstruction. The wavelet encoder produces embedded codefiles which ensure that recovered bits minimise optimally the MSE of the reconstructed image when decoded. Since MSE has been shown to provide a good correlation with NIIRS evaluation in this study, the use as a controlling parameter in the wavelet codec has been shown to provide a higher degree of correlation with the NIIRS assessment. In common with wavelet compression, VQ compression uses MSE to optimise the codebook generation during compression. At each level of compression, the algorithm optimises a codebook collection of model blocks using the Generalised Lloyd Algorithm (GLA) to minimise the MSE of the reconstructed image.

Image compression algorithms tend to introduce their own characteristic artefacts. For instance, at high compression rates JPEG and VQ introduce blocking artefacts whereas wavelet techniques tend to introduce blurring. Our analysts' order of preference was for JPEG, wavelet and then VQ. This is supported by the average NIIRS ratings, which indicate less perceived distortion using JPEG than wavelets except at low bit rates. The analysts expressed concern about the appearance of localised artefacts when viewing highly compressed wavelet compressed imagery and indicated that the artefacts could easily be misidentified as genuine image features in reconnaissance imagery. The analysts reported that, to a limited extent, they could look through the JPEG blocking artefacts.

References

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[4] A. M. Eskicioglu, P. S. Fisher. Image Quality Measures and their Performance, IEEE Trans. on Communications, Vol 43, No. 12, December 1995.