Robust Transmission of Progressive JPEG Image Coding in Wireless Communications

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Abstract - We present an error-robust progressive JPEG image compression scheme over wireless channels. It utilizes a resynchronization regulation technique to isolate erroneous blocks, and then corresponding error concealment techniques are applied to reduce the error damage.

1. INTRODUCTION

With the development of mobile communications, data transmission over wireless channels is getting more popular. However, there mainly exist two problems in current wireless communications, high error rate and limited bandwidth. Thus, error-robust transmission is necessary in an error-prone channel while the limited bandwidth makes the progressive coding desirable. With a progressive coding, users at the receiving end can browse the coarse image and stop receiving data at anytime to save bandwidth and time. The JPEG standard itself includes a progressive mode [1]. However, it is not mentioned how to support a progressive coding in an error-prone channel. Several techniques have been developed to enhance the error detection and correction capability for sequential JPEG [2]-[4]. In this work, we present a progressive and standard-compatible solution to robust wireless image transmission. It utilizes a resynchronization regulation technique based on the JPEG standard to isolate erroneous blocks, and then corresponding error concealment techniques are applied to reduce the error damage.

2. PROGRESSIVE JPEG

Two complementary progressive procedures, spectral selection and successive approximation, are defined in the Annex G of JPEG standard [5]. In spectral selection, the DCT coefficients of each block are segmented into different frequency bands and the bands are coded in separate scans. In successive approximation, the precision of the DCT coefficients is increased by one bit in each succeeding scan after the first scan. A codec can implement a full progression, which uses spectral selection within successive approximation. An allowed subset is spectral selection alone.

3. RESYNCHRONIZATION

The overall scheme we proposed is depicted in Fig. 1. Due to the use of the VLC, the erroneous compressed data usually can not be decoded correctly until the next resynchronization point, i.e., the next restart marker. Consequently, the restart marker provided by the JPEG standard plays an important role for error detection and error recovery in the error-prone environments. A misinterpreted restart marker generally results in much more serious image degradation than the errors in image data. It is a tradeoff in the choice of the occurrence frequency of restart makers. The less the restart makers are used, the longer the errors propagate. However, frequent restart markers result in substantial overhead in the rate and increased probability of errors occurring in markers.

To solve the above problem, we develop a scheme for the regulation of erroneous restart markers. The restart markers, which follow the JFIF convention of eight unique restart markers, are periodically inserted into the compressed bit stream at the encoder. The decoder preprocesses the received compressed bit stream to search for all restart markers in each scan. If a restart marker number is in the consecutive order with the previous one and the subsequent one, it is classified as a correct marker. Otherwise, we denote the number of detected erroneous markers between two correct markers as N_{find} and the number of desired markers for ordering continuity between two correct markers as N_{need}. Each segment with erroneous markers is classified as one of the following three situations and the corresponding regulation procedure is fulfilled.

(1) $N_{find} = N_{need}$. All erroneous markers are forced to change to the corresponding correct restart marker numbers.

(2) $N_{find} < N_{need}$. The lost restart markers are selected by searching the patterns with the minimum Hamming distance within the bit stream.

(3) $N_{find} > N_{need}$. Two possibilities are taken into considerations. If $N_{need} < N_{find} \leq N_{need} + 4$, the

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markers with the minimum Hamming distance to the desired ones are forced to be changed to the correct ones. Then the rest markers are skipped from the bit stream. On the other hand, if $N_{find} > N_{need} + 4$, one additional period of restart markers, i.e., 8, is added to N_{need} and this check procedure is executed recursively.

4. ERROR CONCEALMENT TECHNIQUES

After the regulation process of restart markers, each restart interval is identified. Certainly, errors may still exist in the entropy-coded segments and consequently error concealment should be performed in order to improve the image quality. We apply the error concealment on the minimum coded units (MCU's) within the corrupted restart intervals. For spectral selection, errors will propagate in certain bands of coefficients within this restart interval. The error concealment is carried out for each erroneous band by using the average coefficients of the same band from upper and bottom MCU's. For successive approximation, the erroneous MCU's are replaced by the estimates from the point transformed coefficients of the upper and bottom MCU's. Note that only the first scans of DC and AC coefficients are needed to perform error concealment for sufficiently good reconstructed quality. The errors existing in the scans of AC refinements are ignored. This resynchronization and error concealment scheme, which only needs simple arithmetic operations, exhibits very low complexity for real-time implementation.

5. EXPERIMENTS

The image *Suzie* is tested in the simulations. Table I shows the scan profile and PSNR values of the error-free case for spectral selection. Note that the first scan, i.e., DC coefficients, is most sensitive to the visual quality but inherently very susceptible to the channel disturbances because of the use of DPCM coding. Therefore, restart markers are added to the first scan more frequently and decreased progressively in the following scans. Table II lists the simulation results over a correlated Rayleigh fading model for the DECT system at 14-km/h speed. The proposed approach, i.e., regulation of restart markers (RRM) with error concealment (EC), achieves 5.1 to 7.1 dB PSNR improvements over the IJG strategy [6]. We also observe that most errors in the decoded images are concealed.

6. CONCLUSION

We have proposed an error-robust progressive JPEG image compression scheme over wireless channels. It utilizes a resynchronization regulation technique to isolate erroneous blocks, and corresponding error concealment techniques are applied to reduce the error damage. This coding scheme, which complies with the standard, exhibits very low complexity for real-time implementation. Our simulation results have also shown great improvements on the image quality.

REFERENCES

[1] W. B. Pennebaker and J. L. Mitchell, *JPEG Still Image Data Compression Standard*, New York: Van Nostrand Reinhold, 1993.

[2] W. Lam and A. R. Reibman, "Self-synchronizing Variable-length Codes for Image Transmission," *Proc. ICASSP*, vol. 3, pp. 477-480, 1992.

[3] M. E. Petsalis, M. R. Soleymani, and M. N. S. Swamy, "Effects of Errors and Error Recovery in Images Compressed by the JPEG Still Image Compression Standard Algorithm," *Proc. 1994 Canadian Conf. Electrical and Computer Engineering*, vol. 1, pp. 396-400.

[4] Y. H. Han and J. J. Leou, "Detection and Correction of Transmission Errors in JPEG Images," *IEEE Trans. Circuits and Systems for Video Technology*, vol. 8, no. 2, pp. 221-231, Apr. 1998.

[5] CCITT Recommendation T.81, *Digital Compression and Coding of Continuous-tone Still Images, Part 1: Requirements and guidelines*, 1992.

[6] Independent JPEG Group, JPEG Software Release 6A, Feb. 1996.

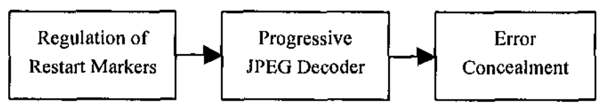

Fig. 1. The block diagram of the proposed scheme at the decoder.

TABLE I

SCAN PROFILE AND PSNR WITH ERROR-FREE

Spectral Selection	1	2	3	4
Ss-Se	0-0	1-4	5-11	12-63
Ah-Al	0-0	0-0	0-0	0-0
Encoded bits	3398	8875	9936	9704
Encoded bits with RM (Restart interval)	6195 (4)	10163 (8)	10575 (16)	10025 (32)
PSNR (dB)	25.18	28.67	32.27	37.74

TABLE II

PSNR FOR TRANSMISSION OVER DECT CHANNEL

Method \ Es/No (dB)	26	28	30
IJG	26.54	29.13	30.86
RRM	31.42	33.26	34.68
RRM + EC	33.66	34.95	35.94