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Performance Evaluation of Different Factors According to ROI Coding Methods in JPEG2000

Ho-Yong Kim*, Jong-Chae Shim**, Yeong-Geon Seo***

Abstract

Currently, the preferred processing of a user-centered ROI(Region-of-Interest) or a specific region of image to transmission and decompression of a full image is needed in different applications, specifically mobile applications. Here, we have to study how different factors affect ROI coding methods. Therefore, an application can select an ROI coding method and several parameters suitable for the environments. The ROI coding methods used in the study are Maxshift and Implicit and the parameters are tile size, image size, code block size, ROI importance and the number of lowest resolution levels. This study shows the experimental results between the different parameters and the two ROI coding methods.

Keywords : JPEG2000, ROI, EBCOT, Maxshift

1. Introduction

Visual image data is used in medical diagnosis, web browsing, image database and computer communication, and different applications[1]. As it needs a large amount of memories and high bandwidths to store and transmit the images, it must reduce an amount of data using data redundancy. Currently, a new image compression standard JPEG2000 has been developed to cope with the problem within the scope that does not decline the quality of the source image[2]. Especially, JPEG2000 offers the ROI coding method not offering in existing compression standards.

This method is made use of in the applications that should firstly transfer the specific region of image or user-centered ROI before the overall image is presented. The standard ROI coding methods are Maxshift[3], Implicit[4] and General scaling[3]. The non standard ROI coding methods are Maxshift-like[3], (G)BbBShift[5,6], PSBShift[7] and HBShift[8] which supplement Maxshift and General scaling, and Modified implicit[4], flexible and dynamic[9], fast ROI transcoding[10] and prioritized[11] which supplement Implicit method.

The new studies about ROI coding have been actively progressing like them. But, the studies which can apply the coding to an application are bounded to apply to the standard ROI coding methods using the default parameters. Therefore, our studies shows the criterions applying the parameters to a specific application in consideration of a classification table of ROI coding methods and the effects of the parameters.

2. Related studies

2.1 JPEG2000 image coding standards

JPEG2000 is a new image coding standard that uses state-of-the-art compression techniques based on wavelet technology. This is intended to provide low bit rates operation with rate-distortion and subjective image quality performance superior to existing

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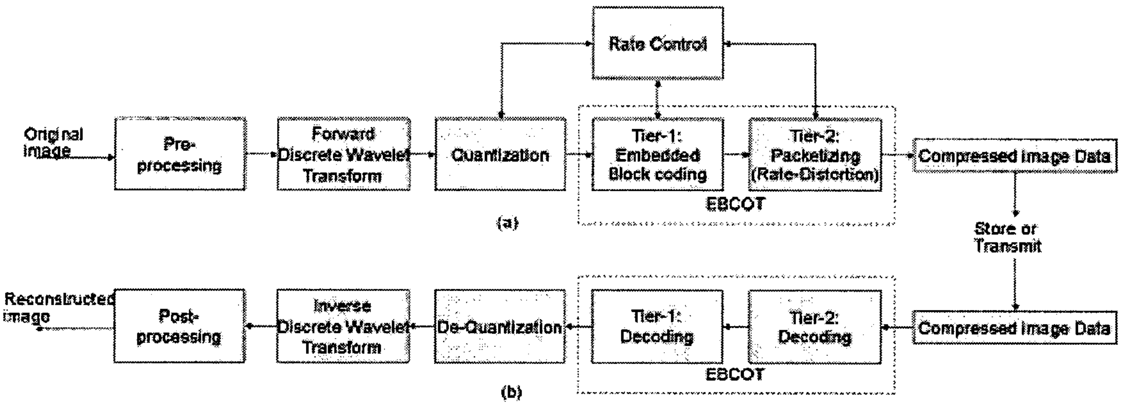
※ 제일저자(First Author) : 김호용
※ 교신저자(Corresponding Author) : 서영건
접수일:2006년07월05일, 심사완료:2006년09월07일
* 영진전문대학 컴퓨터정보기술계열
** 남해전문대학 컴퓨터 응용정보과
*** 경상대학교 컴퓨터 교육과
young@gsnu.ac.kr



(Figure 1) JPEG2000 block diagram of (a) Encoder and (b) Decoder

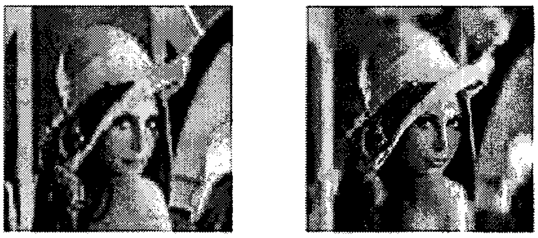
standards, without sacrificing performance at other points in the rate-distortion spectrum. Early results show a 20-30% compression efficiency improvement over JPEG. JPEG2000 addresses areas where JPEG fails to produce the best quality of performance, such as:

- -Low bit rates compression
- -Lossless and lossy compression in a single codestream
- -Seamless quality and resolution scalability, without having to download the entire file. The major benefit is the conservation of bandwidth
- -Large images: JPEG2000 will handle image size up to $(2^{32} - 1)$
- -Single decompression architecture
- -Error resilience for transmission in noisy environments- ROI coding
- -Improved compression techniques to control richer content and higher resolutions

2.2 ROI coding methods

2.2.1 Necessities of ROI

ROI coding is one of the main features of JPEG2000 and is the technology that firstly processes ROI than background(BG) in an image. This can be used in the applications that a specific region of the image has high importance than the other region of image. To support ROI coding, ROI must be encoded with high quality than BG and sent to a receiver with high priority. The merits of ROI image are not only to reduce the compression ratio and the transmission time but also to satisfy the different requirements of users and the efficient memory managements. (Figure 2) shows Lena image reconstructed by progressive image and ROI image in 0.125bpp.

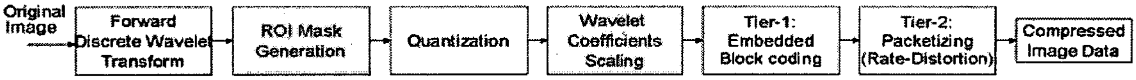


(a) (b)

(Figure 2) (a) Progressive image (b) ROI image

2.2.2 Tile-based ROI coding

If an image is large, the image is separated into non overlapped rectangular blocks and these blocks are encoded to reduce memory consumption. This processing is called a tiling and these separated blocks are called a tile. Because the compression is independently processed on each tile, ROI can be coded on unit of each tile instead of an overall image.



(Figure 3) The process of coefficient scaling-based ROI coding

This means that ROI tiles can be coded and decoded with higher quality than BG tiles. This is a simple ROI coding method which can be used in applications with the constraints of memory and hardware.

2.2.3 Coefficient scaling-based ROI coding

This method classifies ROI WCs(Wavelet Coefficients) and BG WCs of quantized WCs and makes BP(Bit-Plane) of ROI WCs shift by the importance of ROI. This belongs to the static ROI coding method defining the ROIs in encoding time. The process of general coefficient scaling-based ROI coding is in (Figure 3) and the decoding process is the reverse order of the step. Maxshift[3], scaling-based[3], Maxshift-like[3], (G)BbBShift[5,6] and PSBShift[7] belong to this method.

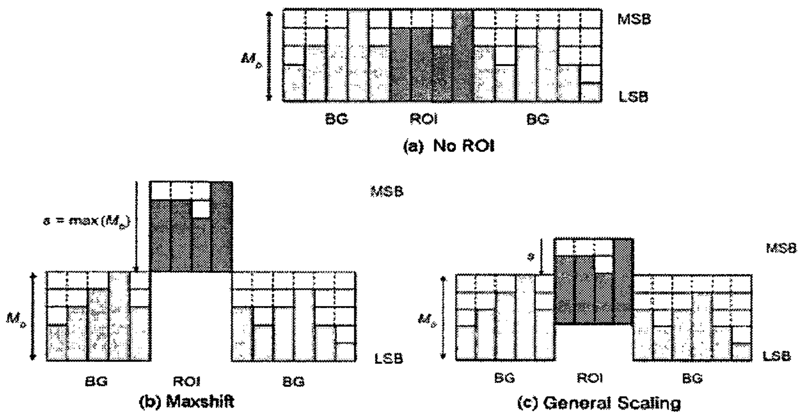
2.2.4 EBCOT-based coding

The method defining ROI in decoder is called by dynamic ROI coding and EBCOT-based coding belongs to this coding method. In EBCOT, each quality layer includes an arbitrary contribution degree from the embedded bitstream of CBs(Code Blocks), packets or precincts. So, emphasis of ROI is achieved by including the relatively high contribution degree about the quality layer of CBs, packets or precincts that should be reconstructed.

Here are Implicit[4], Modified implicit[4], flexible and dynamic[9], fast ROI transcoding[10] and Prioritized[11]. Implicit method is the standard of JPEG2000 part 1, and if ROI WCs are included in CB, it regards as ROI CB. Hence, it causes the problem that BG WCs included in ROI CB must also take precedence. To cope with this problem, Modified implicit[4] truncates k LSBs(Least Significant Bit-planes) of the BG WCs included in the ROI CB.

2.3 Necessities of the best ROI coding method

Because the ROI coding supplies a good tradeoff between the image quality and compression ratio, it can satisfy the user



(Figure 4) Comparison of Maxshift and General scaling

<Table 1> Comparisons of the ROI coding methods

division	method	std.	shape of ROI	static/ dynamic	control of importance	multi ROI	ROI shape coding	processing unit	lossy?	pub. date
coef. scaling -based	①Maxshift	1	arbitrary	static	X	X	X	WC	O	2000
	②Scaling based	2	rec.&ellip.	static	O	O	O	WC	O	2000
	③Maxshift-Like	1C	arbitrary	static	O	X	X	WC	X	2001
	④(G)BbBShift	No	arbitrary	static	O	X	X	WC	O	2002
	⑤PSBShift	No	arbitrary	static	O	O	X	WC	O	2003
	⑥HBShift	No	arbitrary	static	O	O	X	WC	O	2004
EBCOT -based	⑦Implicit	1	polygon	dynamic	O	O	X	CB	O	2000
	⑧Proposed implicit	1C	arbitrary	dynamic	O	O	X	CB/WC	X	2005
	⑨flexible and dynamic	1C	polygon	dynamic	X	X	X	precinct	O	2002
	⑩fast ROI transcoding	1C	polygon	dynamic	O	O	X	packet	X	2005
	⑪prioritized ROI	1C	polygon	dynamic	X	O	X	packet	O	2004

requirements in different applications. But there does not exist the best ROI coding method applicable in all applications. The reason is that the requirements of each application are different, ROI coding methods have their merits and demerits in their own ways and there exist a number of ROI parameters influencing ROI coding performance. In order to offer the best service, it needs to select and apply ROI coding methods and ROI parameters suitable for a specific application.

3. The comparison of ROI coding methods

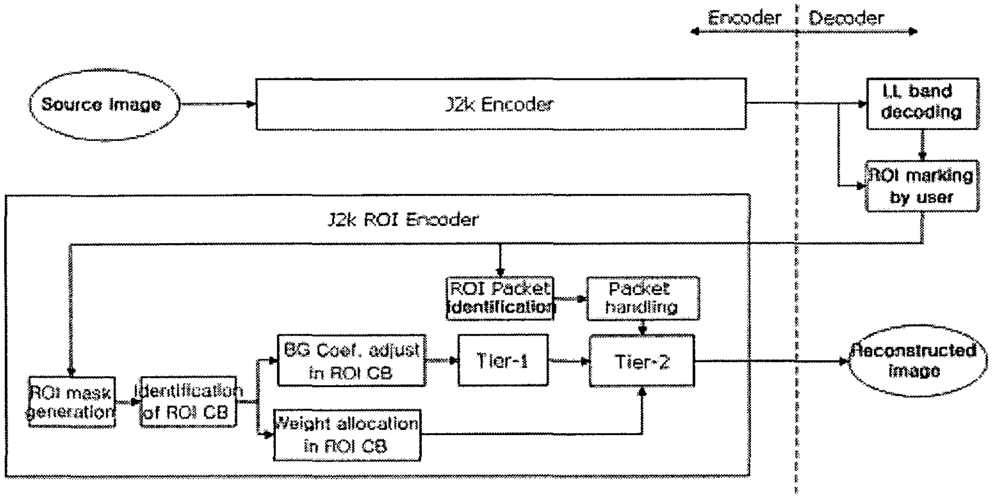
In this chapter, we classify ROI coding methods suitable for several requirements through the comparison of them and introduce some parameters influencing ROI performance.

3.1 Comparisons of ROI coding methods

<Table 1> shows ROI coding methods. In standard field of the table, ①, ② and ⑦ are the standard methods, ④, ⑤ and ⑥ are not compatible with the standard, and the others are compatible with it. The shape of ROI is closely related to the processing unit of it. Coefficient scaling-based coding methods support the arbitrary shape because of processing the ROI by the unit of WC. However, ②supports only rectangular and elliptical shapes of the overhead of ROI shape coding. EBCOT-based methods support polygonal shapes because of processing it by the unit of CB. However, ⑧ supports arbitrary shapes. ROI importance is an important degree of ROI compared to BG. The dynamic range in coefficient scaling-based method is small in the order of ③②, ⑤④⑥, ①. However, that in EBCOT-based is zero.

3.2 Criterion selecting the ROI coding method

This problem is the same as how well a selected ROI coding method satisfies the requirements of the application. In this paper, we made a classification table of ROI coding methods by the requirements. The classifications are static ROI or dynamic ROI, the ROI importance, the real time application and the multiple ROIs, and these are the



(Figure 5) EBCOT-based ROI coding

typical requirements of the ROI application.

Most applications need only static ROI coding, but in case of being not aware of ROI in encoding it needs a dynamic ROI coding that is useful in an interactive application. In real time of static ROI, ③ which deletes BPs is the most excellent and ②is the most inferior because of ROI shape coding. In that of the dynamic ROI, ⑨⑩is the most excellent because of processing it by the unit of packet or precinct based on reconstruction, the next is ⑦⑧ which processes by the unit of CB, and lastly ⑪is the most inferior owing to processing the control of the ROI importance. In multiple ROIs of static ROI, ②⑤⑥ offers with the diverse importance degrees and ①③④ does with a same degree. In those of the dynamic ROI, only ⑨offers with a same degree and the others do with the diverse degrees.

3.3 ROI parameters

The ROI parameters influencing the ROI coding performance are a tile size, a wavelet filter type, a count of quality layers, a CB size, a count of ROI, an ROI size, a shape and position of ROI and an importance of ROI. The smaller the tile size is, the fewer the count of DWT decomposition levels and CB size and the less the coding performance of ROI, since the blocking artifacts occur.

The wavelet filter type may affect the efficient ROI size because there is a relation to the count of WC used on DWT. The affection increases when more count of the decomposition levels is used. Also, because of the duplication of basis function of wavelet, ROI WC may affect several samples in the whole resolution. Therefore, the reconstruction of ROI WCs can be included in BG neighbored on ROI.

<Table 2> A classification of ROI coding methods by the requirements

requirement	static ROI	dynamic ROI
ROI importance	①, ②③④⑤⑥	⑨, ⑦⑧⑩⑪
real time	③, ①④⑤⑥, ②	⑨⑩, ⑦⑧, ⑪
multiple ROIs	②⑤⑥, ①③④	⑦⑧⑩⑪, ⑨

If CB size is small, the count of CB increases and then there is a demerit which is to code more CBs. But, there is a merit which the spatial locality is excellent. This phenomenon will appear more clearly on EBCOT-based method which manages the ROI by the unit of CB.

The shape and position of ROI are less important because the ROI coding of coefficient scaling-based method is coded in WC level. Therefore, they are useful for encoding a small size of ROI or a complex shape of ROI. Since the ROI coding of EBCOT-based method is coded by the unit of CB, it is useful for encoding the polygonal shape of ROI. The importance of ROI helps naturally transfer from ROI to BG. In case of having the high ROI importance in low-bit rates, the results that decrease the whole image quality may be incurred because the quality of BG is so inferior. To complement this problem, most ROI coding methods are applying the importance of ROI about low subbands of DWT decomposition level.

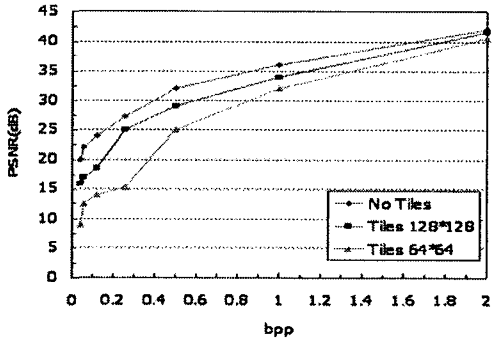
<Table 3> Images for experimentation

picture	resolution	type
Barb	512 X 512	natural
Mountain	640 X 480	natural
Library	464 X 352	complex
Boat	512 X 512	natural
Satellite	1417 X 793	aerial
France	672 X 496	complex

4. Experiments and evaluations

In this chapter, we experiments empirically to define the effects for ROI parameters using the standard ROI coding methods. The experimental result is an average of values got from 6 images.

All images are represented with gray image (8bpp), and if the image is a layered progressive, the bit rates are set from 0.03125bpp to 2bpp. This compression rate means from 256:1 to 4:1. Other parameters are that the decomposition is 5-level DWT, the lowest level is included in ROI, the layer is 20, and the remainders are set up by default values.

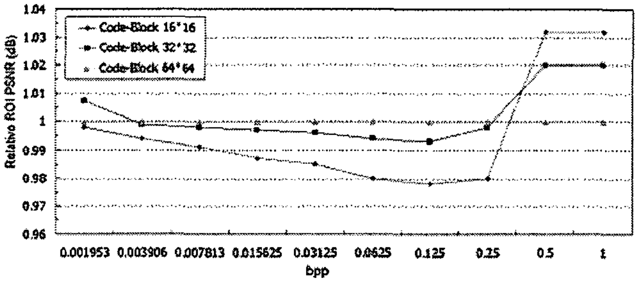


(Figure 6) Performance with tile size

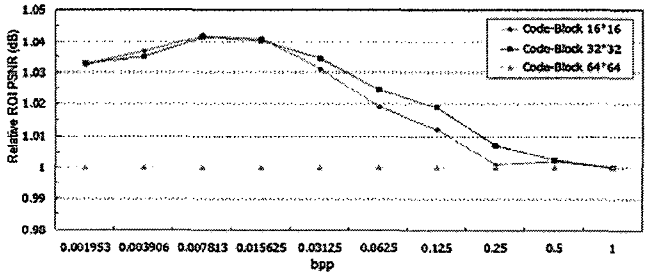
(Figure 6) shows the performance evaluation according to the change of tile size. The smaller the tile size is, the lower the compression efficiency. Especially in low bit rates, compared to the image compressed on one tile, it decreased by about 5dB on 128 X 128 tiles and about 10dB on 128 X 128 tiles.

(Figure 7) shows the performance evaluation according to the change of CB in two methods. (a) shows that the ROI performance of a big CB(64 X 64 pixels) is superior to that of a small CB in low bit rates. In case of using a small CB, comparatively the performance is beginning to improve in high bit rates(0.5 and 1bpp). The reason is why the overhead to code the count of increasing CB is bigger than that to do the spatial locality of ROI. But ROI in high data rates is lossless regardless of CB size.

(b) shows that when the CB size is 32 X 32, the performance is clearly superior to that of the other sizes. The reason is why the overhead to code the count of CB which

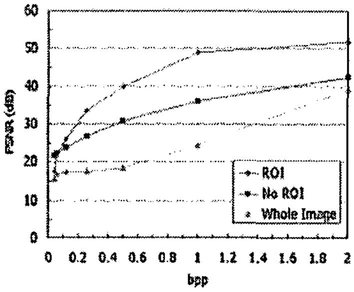


(a) Maxshift Method

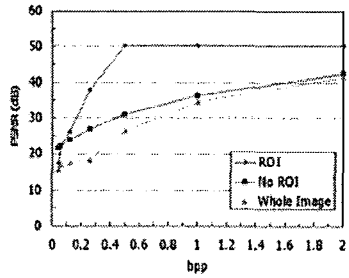


(b) Implicit Method
(Figure 7) Performance with CB size

increases during processing the ROI by the unit of CB is comparatively low.



(a) 1/4 rectangular ROI, 32*32 CB

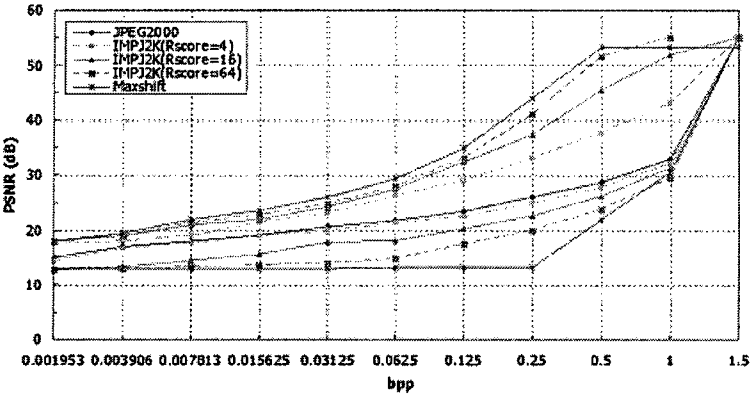


(b) 1/8 rectangular ROI, 32*32 CB

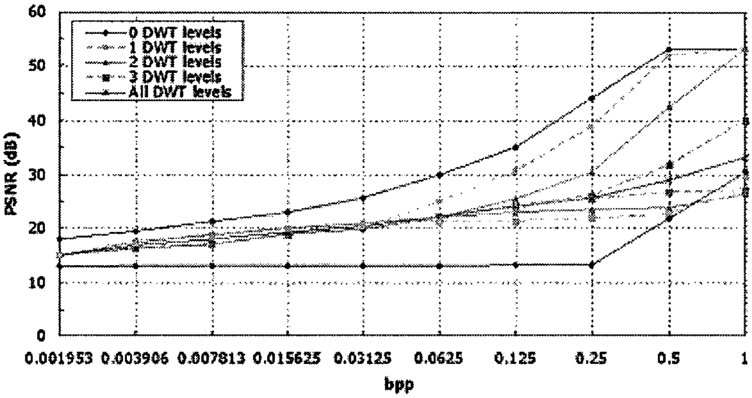
(Figure 8) Performance with ROI size

In (Figure 8), we use Maxshift method and the ROI centered on the image, and the ROI sizes are 1/4 andl/8 rectangular shapes of the whole image with CB size 32 X 32. The smaller ROI size is, the lower the bit rates receiving the whole ROI. PSNR of ROI in low bit rates (<0.125bpp) is lower than that of BG when the ROI size is big (>1/8), because of the overhead for ROI coding.

(Figure 9) shows that the bigger ROI importance, the bigger the difference of performance between ROI and BG. In low bit rates, the higher the ROI importance, the less the difference of performance of PSNR among ROIs, and however, that among BGs become larger. If the count of subband of the decomposition levels regarded as ROI increases, the quality of BG to be reconstructed is higher. But the performance of ROI is influenced by high data rates. Extremely, if all resolution levels are included in ROI, that is the same as not encoding ROI.



(Figure 9) Performance with ROI importance



(Figure 10) Performance when all coefficients of each decomposition level are regarded as ROI

5. Conclusion

Since there does not exist the best ROI coding method suitable for all applications, it needs to select the parameters and coding methods satisfying the requirements of an application. In order to do this, we proposed the methods selecting the parameters to apply anROI coding method in JPEG2000 by the experiments about ROI parameters and the classification table of ROI coding methods according to the requirements. In our future studies, we will experiment one or more complicate parameters.

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김 호 용

1985년 : 울산대학교 공학사
1987년 : 숭실대학교 석사

1990~1991년 : 한국과학기술원 시스템공학연구소
1991~1995년 : 현대자동차
1996~현 재 : 영진전문대학
컴퓨터정보기술계열 조교수
관심분야 : 데이터베이스, 데이터 압축

심 종 채

1987년 : 경상대학교 학사
1995년 : 중앙대학교 석사
2002년 : 경상대학교 전자계산학과 박사

1987년 : (주)정원시스템 SE
1989~1998년 : 호남석유화학(주) 전산실
1998~현재 : 남해전문대학 컴퓨터응용정보과 교수
관심분야 : 데이터베이스, 멀티미디어, 가상대학

서 영 건

1987년 : 경상대학교 학사
1989년 : 숭실대학교 석사
1997년 : 숭실대학교 박사

1989~1992년 : 삼보컴퓨터
1997~현재 : 경상대학교 컴퓨터교육과 부교수
관심분야 : 멀티미디어통신, 영상인식,JPEG2000