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＊＊Abstract＊＊

・Discrete Cosine Transform (DCT) in JPEG is one of the effective image coding methods that add a quantization method based on human visual characteristics to the orthogonal transform.

・JPEGの離散コサイン変換（DCT）は，直交変換に人間の視覚特性に基づく量子化法を加えた有効な画像符号化方式の一つである．

・Since the bases set of Discrete Cosine Transform (DCT) in JPEG considers the statistical characteristics of the image, that is a problem that the quality of the encoded image deteriorates in the area of local features when the bitrate becomes lower.

・JPEGの離散コサイン変換（DCT）の基底は画像の統計的性質を考慮しているため，符号化レートが低くなると，局所的な特徴の領域で符号化画像の画質が劣化する問題がある．

・On the other hand, since the basis set of Independent Component Analysis (ICA) is corresponding to the structural features of the given input image, the hybrid image coding methods is proposed for the purpose to take advantage of each strength of DCT and ICA.

・一方，独立成分分析（ICA）は，入力画像の構造的特徴に対応する基底集合を作ることができ， DCTとICAそれぞれの長所を活かすことを目的として，ハイブリット型の画像符号化方式が提案されている．

・ Image coding using ICA has a problem that the entropy for preserving the ICA bases increases because the sender and receiver need to share the ICA bases.

・ICAを用いた符号化では，送信側と受信側でICA基底を共有することが前提となるため，基底を保存するために必要な符号量が増加する問題がある．

・To solve this problem, conventional methods use only ICA basis which contributes to the improvement of coding performance, thereby reducing the entropy to preserve the basis.

この問題を解決するために，従来手法では，符号化性能の向上に寄与するICA基底のみを使用することで，基底を保存するための符号量を削減している．

・However, the coding performance was only improved at very low bit rates compared with that of DCT when the entropy to preserve the ICA basis was considered.

・しかし，ICA基底を保存するための符号量を考慮したときの符号化性能は，DCT単独のものと比較して，実用的でない超低符号化レートでのみ改善がみられ，それ以外の符号化レートでは大きく劣化していた．

・In this paper, by selecting the combination of the proper ICA bases for improving the coding performance, improved the coding performance in the range of 30~50[dB] PSNR from DCT.

本論文では，画像中の小領域において，画質と基底を保存する符号量を含むエントロピーの改善において，符号化性能に最も寄与するICA基底の組み合わせを決定する手法を提案する．

・As the result, by determining the combination of the optimal ICA bases, our proposed method is improved to the coding performance in the range of 30~50[dB] PSNR even when the entropy of the ICA bases is added.

・その結果，ICA基底を保存するための符号量を加えた場合でも，PSNRが30~50[dB]の範囲で符号化性能が改善され，従来のハイブリット型符号化方式の課題を解決することができた．

Since the bases set of Discrete Cosine Transform (DCT) in JPEG considers the statistical characteristics of the image, that is a problem that the quality of the encoded image deteriorates in the area of local features when the bit rates become lower. On the other hand, since the basis set of Independent Component Analysis (ICA) is corresponding to the structural features of the given input image, the hybrid image coding methods is proposed for the purpose to take advantage of each strength of DCT and ICA. Image coding using ICA has a problem that the entropy for preserving the ICA bases increases because the sender and receiver need to share the ICA bases. In this paper, by selecting the combination of the proper ICA bases for improving the coding performance, improved the coding performance from DCT even when the entropy of the ICA bases is added.

＊＊1. Introduction＊＊

・Discrete Cosine Transform (DCT), which has been adopted as a standard method for image coding, is one of the effective image coding methods based on orthogonal transform with energy compression.

・画像符号化の標準方式に採用されている離散コサイン変換（DCT）は，エネルギー圧縮を伴う直交変換に基づいた有効な画像符号化手段の一つである．

・Since the same DCT basis is applied to any given input image, and the DCT coefficients are quantized based on human visual characteristics, it is effective in preserving areas which are satisfied statistical characteristics.

・DCT基底は，どの入力画像に対しても同じものが適用され，人間の視覚特性に基づいてDCT係数を量子化するため，平坦な特徴や規則的な特徴の領域の保存に有効である．

・However, it is well known that at low bit rates, there are problems of visual distortions such as mosquito noise and block noise.

・しかし，低符号化レートでは，モスキートノイズやブロックノイズなどの視覚的な歪みの問題があることがよく知られている．

・On the other hand, independent component analysis (ICA), a form of multidimensional signal analysis, can obtain a set of bases corresponding to the structural features of the given input image, and by focusing on the sparsity of the ICA coefficients, the local features of the image can be preserved with only a few bases [1, 2].

・一方，多次元信号解析の一つである独立成分分析（Independent component analysis：ICA）は，入力画像の構造的特徴に対応する基底の集合を得ることができるため，ICA係数のスパース性に着目することで，画像の局所的な特徴を少数の基底のみで保存することができる[1，2]．

・Therefore, DCT and ICA have different features to preserve image singles.

・すなわち，DCTとICAでは符号化において得意とする領域が一枚の画像中で異なっていると言える．

・A hybrid image coding method has been proposed, which uses both DCT and ICA bases to preserve of the given input image efficiently by using ICA to preserve feature that are difficult to preserve with DCT [3, 4].

・DCT基底とICA基底を併用し，DCTでは保存が困難であった特徴をICAによって保存することで，入力画像の特徴を効率的に保存することを可能とする，ハイブリット型画像符号化法が提案されている[3，4]．

・In [3, 4], the given input image is divided into small blocks and classified into two types of blocks which DCT is applied (DCT\_Block) and blocks to which ICA is applied (ICA\_Block).

・[3，4]では，入力画像を小さなブロックに分割し，DCTを適用するブロック（DCT\_Block）とICAを適用するブロック（ICA\_Block）の2種類のブロックに分類している．

・Since the obtained set of ICA basis is depends for each the given input image, it is supposed to be shared by the sender and receiver.

・ここで，ICA基底は，入力画像ごとに求められることから，送信側と受信側で共有することが前提となる．

・In order to obtain high image quality, it is desirable to use multiple types of the ICA bases, however, this is undesirable from the viewpoint of bit rates because it increases the information required to preserve the ICA bases.

・高い画質を得るためには，多種類のICA基底を用いることが望ましいが，ICA基底を保存するための情報が増加してしまうため，符号化量の観点で望ましくない．

・Therefore, [3, 4] reduce more than about 80% of the entropy to obtain the preserve equivalent image quality by selecting important the ICA basis that can improve the coding performance.

・そのため，[3，4]は，符号化性能を向上させることができる重要なICA基底を選択することで，同等の画質の保存に必要な基底の符号量を約80％以上削減している．

・In [4], they focus on the ICA bases that maximize the image quality in each block and determine the important bases combinations by evaluating the image quality that can be improved from DCT for each candidate for ICA\_Block.

・[4]では，それぞれのブロックの画質を最適にするICA基底の組み合わせに着目し，ICA\_Blockの候補に対して各基底の組み合わせがDCTから改善できる画質を評価することで，重要な基底の組み合わせを決定している．

・Here, the candidates for ICA\_Block are defined as a block that can improve the coding performance over DCT under the condition that all 64 ICA bases can be used.

・ここで，ICA\_Blockの候補は，64個のICA基底をすべて使える条件でDCTよりも符号化性能を向上できるブロックとして定義している．

・If all the candidates for ICA\_Block are used as ICA\_Block, the entropy to preserve the ICA bases increases significantly, so it is only used to evaluate the validity of each ICA bases combination, and the proper ICA\_Block is chosen from the candidates for ICA\_Block.

・すべてのICA\_Blockの候補をICA\_Blockとした場合，ICA基底を保存するための符号量が大幅に増加することから，それは各ICA基底の組み合わせを評価するためだけに使用され，最終的なICA\_BlockはICA\_Blockの候補から決定される．

・It has the problems in our previous method [4] that add the bit rates at which the performance can be improved for DCT method is only in the impractical region of PSNR is under of 20[dB], then we need to improve the algorithm of the hybrid-type image coding to practical bit rates.

・しかし，基底の符号量を加えた場合に符号化性能が劣化することや，性能を改善できる符号化レートはPSNRが20[dB]前後の非実用的な領域での改善にとどまっているため，実用的な符号化レートに対するハイブリット型画像符号化の適用について検討する必要がある．

・In term of improving the coding performance in each block, it is assumed that there are several effective bases other than optimize the image quality of the candidates for ICA\_Block in the conventional method.

・それぞれのブロックの符号化性能の向上という観点では，従来手法で着目されているブロックの画質を最適にする基底以外にも有効な基底が複数存在していると推測される．

・Therefore, the proposed method determines the important ICA bases and ICA\_Block that can improve the coding performance by including in the evaluation the basis that can improve the image quality even if the image quality of the block cannot be optimized in addition the block that can improve the image quality even if the basis is not used．

・そのため，提案手法では，従来手法の評価対象ではなかった，ブロックの画質を最適に出来なくとも画質を改善できる基底や，基底を用いなくても画質を改善できるブロックを評価の対象に含めることで，符号化性能を向上させることができる重要なICA基底とICA\_Blockを選択する．

・It is clarified in our proposed method that the problems of the conventional methods are solved, and the coding performance is improved over DCT at high bit rates with PSNR of 30~50[dB].

・提案手法を適用することで，従来手法の問題が解決され，PSNRが30~50[dB]の高符号化レートにおいて，DCTよりも符号化性能が向上した．

＊＊2. Image Coding Method using ICA＊＊

＊2.1 Independent Component Analysis＊

・Independent component analysis (ICA) is a method of transforming observed multi-dimensional random vectors into original signals that are as independent as statistically possible.

・独立成分分析（Independent component analysis：ICA）は，観測された多次元のランダムなベクトルを統計的に可能な限り独立した原信号に変換する手法である．

・When the input signal is represented by a linear combination of independent bases can be written as .

・入力信号が，独立な基底の線形結合により表現される場合に，と記述することができる．

・Note that is the coupling coefficient represented as an matrix, and element  represents the contribution of the independent basis to the input signal.

・なおは，行列として表される結合係数であり，その要素は，入力信号に対する独立な基底の寄与率を表している．

・Since ICA does not have the information of the bases and coefficients, it must recover the basis from the input signal only.

・ICAは，基底及び結合係数に関する知識を持たないため，入力信号のみから基底を復元しなければならない．

・By denoting the inverse of and the approximation of as and respectively, equation (1) can be transformed as .

・の逆行列およびの近似値を，それぞれおよびと表すことで，式(1)は，のように変形される．

・In ICA, the objective is to find the ICA coefficients that makes each component of the ICA bases independent.

・ICAでは，ICA基底の各成分を独立とする結合係数を求めることが目的となる．

・The Kullback-Leibler information content [5] is used as the evaluation criterion for independence, and by applying the method based on the steepest descent method [6] proposed by Bell et al, we can obtain an update rule for that minimizes the mutual information content, , where µ is the learning coefficient, I is the unit matrix, and φ is an approximation of the probability density function of . Typically, the Sigmoid function is used as .

・独立の評価基準としてはKullback-Leibler情報量[5]が使用され，Bellらによって提案された最急降下法に基づいた手法[6]を適用することで，相互情報量を最小とするとなるの更新則を得ることができる．

・ここで，は学習係数，は単位行列，はの確率密度関数を近似しているものであり，一般的にはSigmoid関数などが用いられる．

・In this paper, the number of ICA bases is determined to 64 to match the (8×8) pixel DCT bases in the proposed method.

・本論文では，提案手法の中で用いる画素のDCT基底群に合わせ，ICA基底の個数も64個に設定している．

・The ICA bases derived by applying equation (3) to the given input images "Barbara" and "Airplane" is shown in Fig. 1.

・画像“Barbara”，“Airplane”を入力画像として，式を適用することで導出されたICA基底をFig.1に示す．

・Fig.1 shows that the ICA basis corresponds to the local features of each the given input image and the shape of bases is deferent from each the given input image.

・Fig.1を見ると，ICA基底は入力画像の局所特徴に対応しており，入力画像ごとに異なった基底が求められていることが分かる．

・The ICA coefficients of an arbitrary block in the image "Barbara" are shown in Fig. 2(a).

・画像“Barbara”に含まれる任意のブロックのICA係数をFig.2(a)に示している．

・For the block in Fig. 2(a), the block reconstructed using only ICA basis with large coefficients values is shown in Fig. 2(b).

・また，Fig.2(a)のブロックに対して，係数値の大きいICA基底のみで再構成されたブロックをFig.2(b)に示している．

・It is seen in Fig. 2, the ICA coefficients have sparsity [7] since only a few ICA bases can preserve the local features of the input image.

・Fig.2より，少数のICA基底のみで入力画像の局所的な特徴を保存することができることから，ICA係数にはスパース性[7]があることを確認できる．

・Therefore, it is expected that ICA basis can reduce the entropy required to preserve blocks with local features compared to the DCT.

・このことから，ICA基底を用いることで，局所的な特徴を持つブロックの保存に必要となる符号量をDCT単独のものよりも抑えることができると期待される．

(a)Reconstructed block with all ICA coefficients

(b)Reconstructed block with a part of ICA coefficients

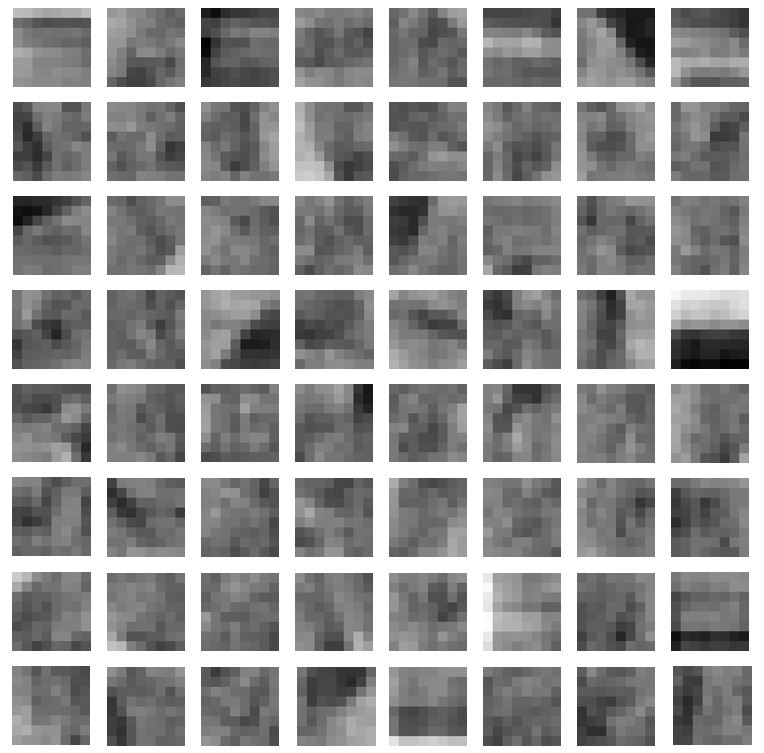
Figure2. Sparseness of the ICA coefficients



 ![屋外, 大きい, 建物, 座る が含まれている画像

自動的に生成された説明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDiRXhpZgAATU0AKgAAAAgABAE7AAIAAAANAAAISodpAAQAAAABAAAIWJydAAEAAAAKAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAOS4reeUsOmbhOWkpwAAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzg2AACSkgACAAAAAzg2AADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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(a)“Barbara” (b)ICA basis of “Barbara”

(c)“Airplane” (d)ICA basis of “Airplane”

Figure1. Images and ICA basis

＊2.2 Conventional Method＊

・As mentioned in Section 2.1, blocks with local features can be preserved with less entropy by using ICA because the ICA coefficient is sparse.

・2.1で述べたように，局所的特徴を持つブロックはICAの結合係数がスパースとなるため，ICAを用いたほうが少ない符号量で保存することができる．

・On the other hand, stochastic regions can be preserved with less entropy using DCT because the ICA coefficient are not sparse.

・一方，規則的な特徴の領域は，ICA基底の結合係数がスパースにならないため，DCTを用いたほうが少ない符号量で保存することができる．

・Therefore, from the viewpoint of the entropy reduction, we can classify the input image into blocks that are predominantly preserved by DCT basis or ICA basis and encode each block using DCT and ICA to reduce the overall entropy of the image.

・このことから，符号量削減の観点で，入力画像をDCT基底あるいはICA基底による保存が優位なブロックに分類し，それぞれのブロックをDCTおよびICAを用いて符号化することで，画像全体の符号量を少なくすることができる．

・In DCT, the entropy is controlled by using a quantization table for the DCT coefficients.

・このとき，DCTについては，DCT基底の結合係数に対して量子化テーブルを用いることで，符号量の制御を行っている．

・On the other hand, to reduce the number of ICA bases from the viewpoint of the entropy to preserve the ICA basis, in [3, 4], the importance of each ICA bases to the preservation of the block is determined by the similarity between the block and the basis based on the MP method [8], and the entropy is controlled by selecting the basis with the highest importance.

・それに対して，ICA基底を保存する符号量の観点から，使用する基底の数を少なくするため，[3，4]では，ブロックの保存に対する各ICA基底の重要度を，MP法[8]に基づくブロックと基底の類似度により決定し，重要度の高い基底から選択することで，符号量の制御を行っている．

・In each block, DCT and ICA are applied when the condition of same MSE, and the candidates for DCT\_Block and ICA\_Block are determined by comparing the entropy.

・ブロックごとに原画像とのMSEが同じになるときのDCTとICAを適用し，符号量を比較することでDCT\_BlockとICA\_Blockのそれぞれの候補が決定される．

・The candidate for ICA\_Block is defined as the blocks that requires less entropy than DCT under the condition that all of 64 ICA bases can be used.

・ICA\_Blockの候補は，64個のICA基底をすべて使える条件でDCTよりも符号量を少なくすることができるブロックとして定義される．

・If all the andidates for ICA\_Block are used as ICA\_Block, the entropy to preserve the ICA basis increase significantly, so they are only used to evaluate each ICA basis combination, and the proper ICA\_Block is determined from the candidates for ICA\_Block.

・すべてのICA\_Blockの候補をICA\_Blockとした場合，ICA基底を保存するための符号量が大幅に増加することから，各ICA基底の組み合わせを評価するためだけに使用され，最終的なICA\_BlockはICA\_Blockの候補から決定される．

・When the proper combination of the ICA bases is determined, the blocks to which they apply are defined as the ICA\_Block, and the other blocks are the DCT\_Block.

・実際に使用されるICA基底の組み合わせが決定したときに，それらが適用されるブロックがICA\_Blockとなり，それ以外のブロックがDCT\_Blockとなる．

・In selecting the ICA bases, [3, 4] focus on the ICA bases that optimize the image quality of each block, and determine the important bases by evaluating the image quality that each basis can improve from DCT for each candidate for ICA\_Block.

・使用可能な基底の選択において，[3，4]では，それぞれのブロックの画質を最適にするICA基底に着目し，ICA\_Blockの候補に対して各基底がDCTから改善できる画質を評価することで，重要となる基底を決定している．

・In [3], it is shown that the hybrid type image coding can be reduced by more than 80% of the entropy of the ICA basis required to preserve image quality equivalent to that using DCT.

・[3]では，ハイブリット型画像符号化を適用することで，DCTを使用したものと同等の画質を保存するために必要な基底の符号量を80%以上削減できることが明らかになっている．

・Also, it has been in [4] shown that the addition of the entropy of the ICA bases can improve the coding performance over the DCT at very low bit rates.

・また，[4]では，ICA基底の符号量を加えた場合に，超低符号化レートにおいてDCT単独のものよりも符号化性能を向上できることが明らかになっている．

・The conventional hybrid-type coding methods have the following problems.

・従来のハイブリット型符号化方式の課題は次の通りである．

・The first is that the proper bases have not been chosen for the quantization of ICA.

・1つ目は，ICAの量子化において適切な基底が選択されていないことである．

・Although the ICA coefficients are sparse, there are only a limited number of blocks for which use an only base can preserve the same image quality as DCT, so multiple bases are used in combination.

・ICAの結合係数はスパース性を持っているが，1種類の基底のみでDCTと同等の画質を保存できるブロックは限られているため，複数種類の基底を組み合わせて使用される．

・Therefore, the importance of preserving the signal in the block should be considered when combining multiple types of ICA bases.

・そのため，ブロックの保存に対する重要度は，複数種類の基底を組み合わせることを考慮すべきである．

・The second is that in the selection of important ICA bases, there is other effective ICA bases besides the ones that optimize the block quality in terms of improving the coding performance.

・2つ目は，重要なICA基底の選出において，符号化性能の向上という観点では，ブロックの画質を最適にする基底以外にも有効な基底が存在していることである．

・It has also been confirmed that there are blocks that can be reconstructed using only the average of the brightness values without using the ICA bases.

・また，ICA基底を用いなくても輝度の平均値のみで再構成可能なブロックの存在が確認されている．

・Therefore, under the condition that the multiple ICA bases are used, the blocks that the candidates for ICA\_Block and the bases in the conventional methods that were evaluated are not optimal for improving the coding performance.

・そのため，複数のICA基底を使用するという条件下では，従来手法がICA\_Blockの候補としていたブロックや評価対象としていた基底では，符号化性能の改善に対して最適とは言えない．

・In addition, the range in which the conventional method can improve the coding performance is only at very low bit rates of lower than 20[dB].

・3つ目は，従来手法が符号化性能を改善できる範囲は20[dB]前後の超低符号化レートであるため，適用する範囲としては非現実的なことである．

・In sec.3, we propose a new method in ICA\_Block to solve the above problems and improve the coding performance of hybrid-type coding methods using both DCT and ICA basis.

・次章では，これらの課題を解決するためのICA\_Blockにおける新たな手法を提案することにより，DCTとICAの基底を併用したハイブリット型符号化方式の性能を改善する．

＊＊3. Proposed method＊＊

・The configuration of the proposed hybrid-type image coding method is shown in Fig. 3.

・提案するハイブリット型画像符号化方式の構成をFig.3に示す．

・In Fig. 3, we first divide the input image into uniform blocks of (8×8) pixels and then apply DCT and ICA to each block to obtain the DCT coefficients, the ICA coefficients, and the ICA basis.

・Fig3.では，まず，入力画像を一様に画素のブロックに分割し，各ブロックに対してDCTとICAを適用することで，DCT係数とICA係数，ICA基底を求める．

・In the proposed method, the DCT is quantized by a JPEG-based quantization table, and the ICA is quantized by reducing unnecessary basis to equal the quality of the DCT based on the MSE.

・提案方式では，DCTはJPEGに基づく量子化テーブルによって量子化され，ICAはMSEによる原画像との画質比較に基づいて，DCTの画質と同じになるようにMP法を適用することで量子化される．

・In the area division, first, both the entropy of DCT coefficients and ICA coefficients are calculated in each block.

・領域分割では，まず，ブロックごとにDCT係数の符号量とICA係数の符号量を求める．

・The entropy of DCT coefficients is calculated as the average information volume of the DCT coefficients, and the entropy of ICA coefficients is calculated as the average information volume of the combined ICA coefficients and the average of the blocks of the brightness values.

・ここで，DCT係数の符号量は，DCTの結合係数の平均情報量とし，ICA係数の符号量は，ICA係数の結合係数とブロックの平均値の情報を合計したときの平均情報量として算出している．

・In next, all blocks of the input image are once classified as ICA\_Block or DCT\_Block by making them of the candidate for ICA\_Block if the entropy of ICA coefficients is less than that of DCT coefficients, and making the others candidate for DCT\_Block.

・その後，ICA係数の符号量がDCT係数の符号量よりも小さい場合はICA\_Blockの候補とし，それ以外を DCT\_Blockの候補とすることで，入力画像のすべてのブロックをICA\_BlockまたはDCT\_Blockに一旦分類する。

・In the selection of the important ICA bases, we evaluate each ICA bases combination in terms of improving the coding performance for the candidates for ICA\_Block.

・重要なICA基底の選出では，ICA\_Blockの候補に対する符号化性能の改善という観点で各ICA基底の組み合わせの評価を行う．

・As mentioned in the previous section, all the ICA basis combinations that can improve the block coding performance are included in the evaluation.

・このとき，前節で述べたように，ブロックの符号化性能を改善できるすべてのICA基底の組み合わせを評価の対象としている．

・Then, among the combinations of ICA bases that can be reduced to less than the entropy of DCT even when the entropy of preserving the ICA bases is added, that can maximize the image quality of the entire image is determined to be the important ICA bases, and the blocks in which these bases are used and the blocks whose image quality can be improved by only the average of the brightness values are determined to be the proper ICA\_ Block.

・その後，基底を保存するための符号量を加えた場合でもDCT単独の符号量よりも改善する基底の組み合わせにおいて，画像全体の画質を最大とするものを重要なICA基底であると決定し，それらが用いられているブロックに加え，ブロックの平均値のみで画質を改善できるブロックを最終的なICA\_Blockとして決定する．

・The above process determines the ICA basis and ICA\_Block, and the DCT\_Block excludes all the areas in the image to them, and then DCT and ICA are applied to each block for image coding.

・以上の処理により，実際に使用するICA基底とICA\_Block，それらを除いたものとしてDCT\_Blockが決定され，それぞれのブロックにDCT及びICAを適用することで符号化が行われる．

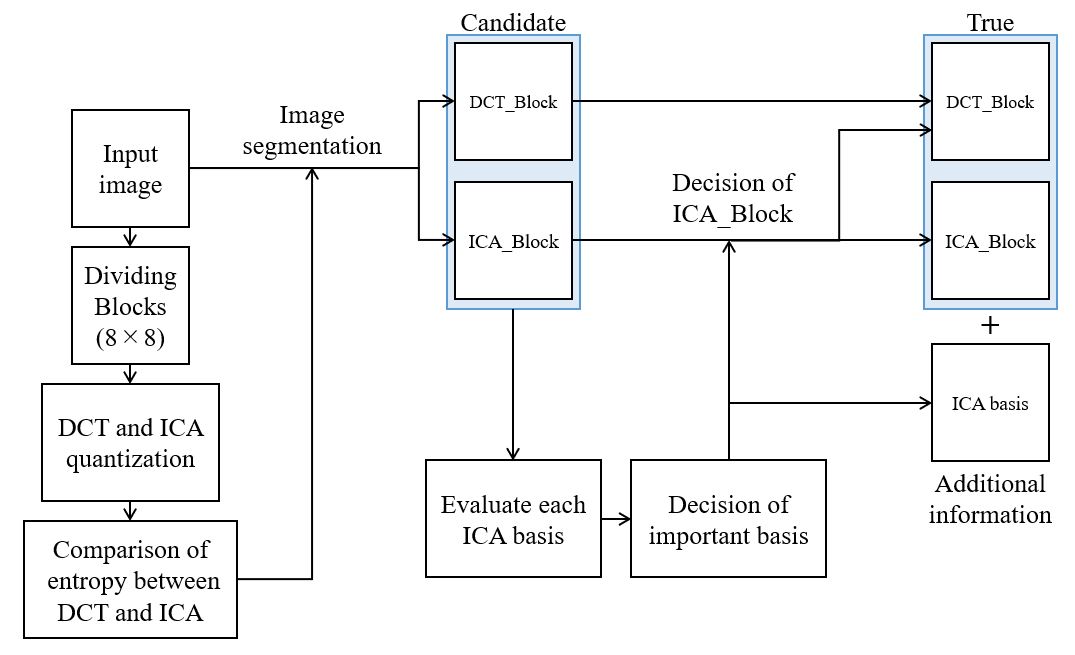


Figure3. Configuration of hybrid image coding using DCT and ICA basis

＊3.1 Determination of ICA\_Block candidates ＊

・Since the image quality evaluation is based on PSNR, the importance used in quantization is also based on MSE in the proposed method.

・提案方式の画質評価はPSNRであり，選出する基底の評価もMSEによって行われるため，量子化で用いられる重要度にもMSEを使用する．

・Although the ICA coefficients are sparse, only few blocks can preserve image quality equivalent to DCT with only one ICA basis, and often multiple types of the ICA bases are combined to preserve the image quality.

・また，ICAの結合係数はスパース性を持っているが，1種類の基底のみでDCTと同等の画質を保存できるブロックは少数であり，複数種類の基底を組み合わせて保存する場合が多い．

・When the conventional method is applied to the image "Airplane" with PSNR=31[dB], the number of ICA bases that are required to preserve for the candidate for ICA\_Block and the number of blocks that required them is shown in Fig.4.

・画像“Airplane”に対して，の条件で従来手法の量子化を適用し，ICA\_Blockの候補に分類された各ブロックにおいて，保存に必要なICA基底の個数とそれを必要とするブロック数をFig.4に示す．

・Fig.4 shows that although there are many blocks that can preserve image quality equivalent to DCT using only one ICA basis, there are more blocks that can preserve by combining multiple types of bases.

・Fig.4を見ると，1種類のICA基底のみでDCTと同等の画質を保存できるブロックは多く存在しているが，それ以上に，複数種類の基底を組み合わせて保存するブロックが存在していることがわかる．

・Therefore, we solve the problem in the quantization of ICA of the conventional method by proposing the importance of the bases that preserve the blocks based on the MSE when the combination of ICA bases is considered.

・そのため，ICAの量子化において，基底の組み合わせを考慮したときの原画像とのMSEに基づいてブロックの保存に対する重要度を提案することで，従来手法の量子化における課題を解決する．

・For each block of the given input image, we find the ICA basis that minimizes the MSE and make the most important basis for that block.

・その手法として，入力画像の各ブロックに対して，MSEを最小にするICA基底を求め，をそのブロックで最も重要な基底とする．

・Then, the other ICA basis ( where ) that can minimize the MSE when combined with is the second most important basis in that block.

・次に，と組み合わせた場合に最もMSEを小さくできるICA基底(，ただし)をそのブロックで2番目に重要な基底とする．

・This process is continued until the importance is determined for 64 ICA bases, and the importance order of the basis is calculated for all of the blocks.

・64個のICA基底において重要度が決定されるまでこの処理を続け，全てのブロックにおいて基底の重要度を求めておく．

・When the image quality is controlled to be higher than that of DCT according to the importance order obtained in the candidates for DCT\_Block and ICA\_Block classified, the improvement in the image quality and the entropy from DCT is obtained by and , respectively.

・DCT\_BlockとICA\_Blockの候補の分類において求められた重要度に従って，DCT単独の画質を上回るよう画質を制御したとき， によりDCT単独のものからの画質と符号量の改善値を求める．

・Where is the DCT and is the mean square error (MSE) with the original image when the small area is reconstructed using ICA bases of according to importance order, in addition denotes DCT and denotes the entropy by summing the information of the coefficients and the information of the average of the brightness values in the blocks when the small area is reconstructed using ICA bases of .

・ここで，はDCT単独で，はICA基底を重要基底の順に個使用して小領域を再構成したときの原画像との平均二乗誤差(MSE)であり，はDCT単独で，はICA基底を個使用して小領域を再構成したときの結合係数とブロックの平均値の情報を合計したときの平均情報量を示している

・The blocks for which equations (4) and (5) are positive, i.e., the blocks with higher image quality and less the entropy than DCT, are candidates for ICA\_Block, and the other blocks are candidates for DCT\_Block.

・式(4)と式(5)が正となる，すなわち，DCT単独よりも画質を高くかつ，符号量を削減できるブロックをICA\_Blockの候補とする．

また，それ以外のブロックをDCT\_Blockの候補とする．

Figure4. Number of ICA basis for reconstruction in each block

＊3.2 Determination of Important ICA basis ＊

・In the proposed method, 64 ICA bases are determined for a given image.

・提案方式では，画像が入力されると64個のICA基底が導出される．

・Since they are specific to the given image and each represents the local features, the type of the ICA bases that is effective in improving the coding performance are different from each block.

・それらは入力画像に固有で，それぞれが局所的な特徴を表しているため，符号化性能の改善に対して有効なICA基底の種類はブロックごとに異なる．

・We applied the quantization of the proposed method to the image "Barbara" with PSNR=30[dB], and among classified to the candidates for ICA\_Block, the blocks optimizing by the 23rd and 40th ICA basis are shown in Fig. 5.

・画像“Barbara”に対しての条件で提案手法の量子化を適用し，分類されたICA\_Blockの候補のうち，23番目及び40番目のICA基底が選択されたブロックをFig.5に示す．

・The shape of the ICA basis is shown in the upper left corner of Fig. 5.

・Fig.5の左上にはそれぞれのICA基底を表示している．

・In Fig. 5, we can see that each ICA basis is used in the different block.

・Fig.5を見ると，ICA基底によって，それが使用されるブロックは異なることが分かる．

・However, if we consider the preservation of the signal of a block by the combination of multiple ICA bases, there are multiple combinations of bases that can improve the coding performance.

・しかしながら，単独ではなく複数の基底の組み合わせによる表現を考えた場合，一つのブロックにおいて，符号化性能を改善できる基底の組み合わせは複数存在する．

・Table.1 shows combinations of the ICA bases that can improve the coding performance over DCT when preserving the signals of the 1000th block for the image "Airplane" with PSNR=25[dB].

・画像“Airplane”に対しての条件で1000番目のブロックを保存するとき，DCT単独のものよりも符号化性能を向上できるICA基底の組み合わせをTable.1に示す．

・Table.1 shows that there are multiple combinations of the ICA bases that are effective in preserving the signal of the block.

・Table.1を見ると，一つのブロックの保存に有効なICA基底の組み合わせは複数存在していることが分かる．

・In the conventional method, since only the ICA basis that can maximize the image quality of the block is evaluated that it, Table.1(a) is evaluated as the basis that can improve the coding performance of this block, while the bases of Table.1(b) and (c) are excluded.

・ブロックの画質を最大にできるICA基底のみを評価している従来手法では，Table.1(a)がそのブロックの符号化性能を改善できる基底として評価され，Table.1(b)，(c)は評価されていない．

・In the proposed method, by including all of combinations of the ICA basis in the evaluation, we can properly evaluate the importance of each combination of the ICA basis for the preservation of the candidates for ICA\_Block.

・そのため，すべての組み合わせを評価の対象に加えることで，ICA\_Blockの候補の保存に対する各ICA基底の組み合わせの重要度を正しく評価することができる．

・Since it has been already shown from [3, 4] that the coding performance can be improved even when the entropy of about two ICA bases is added at low bit rates, we decided to use up to three bases in the proposed method.

・このとき，[3，4]から低符号化レートにおいて2つ程度の基底の符号量を考慮しても符号化性能が改善されることが明らかとなっているため，提案手法では，基底を3つまで使用できるものとした．

・In addition, although the ICA\_Block of the conventional method always requires the use of the ICA basis, it is confirmed that some the blocks can preserve higher image quality than DCT by simply using the average of the brightness value without using the ICA bases.

・加えて，従来手法のICA\_Blockでは，必ずICA基底を使用する条件であったが，実験により基底を使用せずに平均値を用いるだけでDCT単独のものよりも画質を高く保存できるブロックの存在が確認されている．

・Fig. 6 shows the blocks that preserves higher image quality than DCT without using ICA basis when ICA is applied to the image "Barbara" under the condition of PSNR=30[dB].

・画像“Barbara”に対しての条件でICAを適用したとき，ICA基底を使用せずにDCT単独のものよりも画質を高く保存できるブロックをFig.6に示す．

・Fig. 6 shows that some blocks can be reconstructed using only the average of the brightness values even at the practical bit rates of PSNR=30[dB].

・Fig.6を見るとPSNRが30[dB]の実用的な符号化レートでもいくつかのブロックは平均値のみで再構成できることが分かる．

・When preserving blocks with only the average of the brightness values, since it need not the entropy to preserve the ICA coefficients and the ICA basis, it is very effective in terms of performance improvement.

・ICAの平均値のみでブロックを保存するとき，平均値を保存するための符号量を必要とするが，ICA係数やICA基底を保存するための符号量は必要ないため，性能改善の観点で非常に有効である．

・Selecting method of the optimal ICA basis is described as follows.

・提案する最適なICA基底の選出法を以下に示す．

・First, the image quality improvement and the reduction bit rates for each , which is the sum of the improvement values calculated from equations (4) and (5), are obtained using and .

・まず，式(4)と式(5)から求められる改善量の合計である，各の画質改善量と削減符号量を，で求める．

・The ICA\_Block in equations (6) and (7) corresponds to the candidate for the ICA\_Block computed earlier, excluding the blocks that do not need the basis in Figure 6.

・ここで，式(6)，(7)におけるICA\_Blockは，先に求められたICA\_Blockの候補から図6に示す基底を必要としないブロックを除いたものである．

・The above process determines both the entropy that can be reduced and the image quality that can be improved from DCT for all the combinations of the ICA bases.

・上記の処理により，各基底の組み合わせを用いたときに，DCT単独から削減できる符号量や改善できる画質が求められる．

・As a result, since it can evaluate the improvement in coding performance in consideration of the entropy for the ICA basis added, we can compare the entropy required to preserve the basis and the entropy that can be reduced from DCT for each combination of the ICA basis.

・この結果，ICA基底の組み合わせごとに基底の保存に必要な符号量とDCT単独から削減できる符号量を比較することができるため，基底の符号量を考慮した上で符号化性能の改善を評価することができる．

・Since the entropy of the image coding using ICA is calculated by adding the entropy of the ICA basis to the ICA coefficients and the average of the brightness values of each block, the coding performance may deteriorate than that of DCT that does not need the entropy of the basis.

・ICA基底を用いる符号化においては，ICA\_Blockの結合係数から求められる符号量の他に，使用する基底を表すための符号量とブロックの直流成分を表すための符号量が加わるため，が少ない基底の組み合わせを使用した場合に，付加情報を考慮しないDCT単独のものよりも符号化性能が劣化する可能性がある．

・Therefore, the basis selection method must be evaluated that the coding performance improve considering the entropy of the ICA basis.

・そこで，基底の選出は，ICA基底の付加情報を考慮した上で符号化性能を改善できることを評価する手法でなければならない．

・When the entropy to preserve the block shown in Figure 6 is , , which satisfies equation (8) and maximizes , is selected as the ICA basis important for preserving the given image, and the ICA\_Block using is determined as the proper ICA\_Block of the given image.

・図6に示したブロックにおいて，ブロックの平均値を保存するための符号量をとするとき，式(8)を満たし，が最大となるを入力画像の保存に重要な基底として選出し，が使用されるICA\_Blockを入力画像に対するICA\_Blockとして決定する．

・

・ is the entropy to preserve the basis of , and equation (8) implies that even with the addition of the entropy to preserve the ICA basis, the overall entropy will be less than DCT.

・ここでは，使用するの基底を保存するための符号量であり，式(8)はICA基底を保存するための符号量を加えても，DCT単独よりも全体の符号量が少なくなることを意味している．

・The above process can be applied to determine the combination of the ICA bases that can optimize the overall image quality and the ICA\_Block, considering the entropy of the ICA basis.

・上記の処理により，ICA基底を表す符号量を考慮した上で，画像全体の画質を最大にできる最適な基底の組み合わせとそれが適用されるICA\_Blockを求めることができる．

![グラフィカル ユーザー インターフェイス, アプリケーション

自動的に生成された説明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDiRXhpZgAATU0AKgAAAAgABAE7AAIAAAANAAAISodpAAQAAAABAAAIWJydAAEAAAAKAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAOS4reeUsOmbhOWkpwAAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzA3AACSkgACAAAAAzA3AADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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ユーザー インターフェイス, アプリケーション

自動的に生成された説明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDiRXhpZgAATU0AKgAAAAgABAE7AAIAAAANAAAISodpAAQAAAABAAAIWJydAAEAAAAKAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAOS4reeUsOmbhOWkpwAAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzY3AACSkgACAAAAAzY3AADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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(a)ICA base of No.23 (b)ICA base of No.40

Figure5. A set of blocks is applied to each ICA base

グラフィカル ユーザー インターフェイス が含まれている画像

自動的に生成された説明

Figure6. A set of blocks is reconstructed by only DC component in ICA

Table1. ICA basis combinations effective for block preservation

|  |  |
| --- | --- |
| Block of No.1000 | Effective ICA basis for block of No.1000 |
| (a)  座る, 小さい, タイル張り, 流し が含まれている画像  自動的に生成された説明　 　 　ツリーマップ図 が含まれている画像  自動的に生成された説明  ICA base of No.39 ICA base of No.59 |
| (b)  座る, 小さい, タイル張り, 流し が含まれている画像  自動的に生成された説明  ICA base of No.39 |
| (c)  ツリーマップ図 が含まれている画像  自動的に生成された説明  ICA base of No.59 |

＊＊ 4. Experimental results ＊＊

・The optimal ICA\_Block for the conditions of PSNR=30[dB] and 25[dB], obtained by applying the proposed method to the image "Airplane", are shown in Fig. 7.

・画像“Airplane”に対しての条件で提案手法の式(8)を適用することで求められた最適なICA\_BlockをFig.7に示す．

・Fig. 7 compares the ICA\_Block of the proposed method and the conventional method, where the ICA\_Block is shown in the original image and the DCT\_Block is shown in black.

・Fig.7は，提案手法と従来手法のICA\_Blockを比較しており，ICA\_Blockを原画像で，DCT\_Blockを黒で表示している．

・Fig.7(b) and (c) show that the ICA\_Block differs depending on the bit rates.

・Fig.7(b)，(c)を見ると符号化レートによって，ICA\_Blockの領域が異なっていることが分かる．

・Fig.7(b), (c), (d), and (e) show that the ICA\_Block of the proposed method is more than the conventional method, which is since the proposed method considers the combinations of ICA bases.

・Fig.7(b)と(c)，(d)，(e)を見ると，提案手法のICA\_Blockは従来手法よりも多くなっていることが分かり，これは，提案手法が基底の組み合わせを考慮したためである．

・Since the combination of each ICA basis changes according to the candidates for ICA\_Block, the ICA basis selected for each bit rate will also be different in the proposed method.

・また，ICA\_Blockの候補が変わることで各ICA基底の組み合わせも変わるため，提案手法では，符号化レートごとに選択されるICA基底も異なるものになる．

・Next, we apply the proposed method to the pixel images "Airplane", "Barbara", "Cameraman", and "Mandrill" as the given input images, and the PSNR vs. entropy results of the proposed method are shown in Fig. 8.

・次に，画素の画像“Airplane”，“Barbara”，“Cameraman”と“Mandrill”を入力画像として，提案手法を適用したときのPSNR対エントロピー特性を求めた結果をFig.8に示す．

・In Fig. 8, the results of DCT and the proposed method are compared.

・Fig.8では，DCT単独と提案手法の結果を比較している．

・An increase in ICA\_Block means that more blocks can be preserved with less entropy than DCT at the same PSNR, which is expected to improve coding performance.

・ICA\_Blockが増えることは，同じPSNRで保存するときにDCT単独よりも符号量を少なく保存できるブロックが増えるということであり，符号化性能の改善が期待できる．

・Fig.8 shows that the coding performance of the proposed method is better than that of DCT.

・Fig.8を見ると，提案手法の符号化性能がDCT単独よりも優れていることが分かる．

・In PSNR=30[dB], which is a practical bit rate, the proposed method can save on average 0.0025[bit/pel] less than the entropy of DCT.

・実用的な符号化レートとされるにおいて，提案手法を用いることで，DCT単独よりも平均で0.0025[bit/pel]少なく保存できることが分かった．

・Note that the entropy of the proposed method is the sum of the entropy for the ICA coefficients, the entropy for preserving the average of the brightness values of the ICA\_Block, and the entropy for preserving the ICA bases.

・なお，提案手法は，ICA係数の符号量とICA\_Blockの平均値を保存するための符号量，ICA基底を保存するための符号量を合計したものになっている．

・We also found that at lower bit rates, around PSNR=25[dB], we can save up to 0.03[bit/pel] of the entropy.

・また，低符号化レートである前後において，符号量を最大で0.03[bit/pel]小さく保存できることも分かった．

・The result of applying the proposed method to the image "Airplane" under the conditions of PSNR=50[dB] is shown in Fig. 9.

・さらに，画像“Airplane”に対しての条件で提案手法を適用したときのPSNR対エントロピー特性を求めた結果をFig.9に示す．

・Fig.9 shows that the coding performance of the proposed method is better than that of DCT.

・Fig.9を見ると，提案手法の符号化性能がDCT単独よりもわずかに優れていることが分かる．

・From the above, it has come the proposed method can improve the coding performance from that of DCT in practical bit rates.

・以上のことから，提案した重要な基底の選出法は，実用的な符号化レートにおいてDCT単独のものから符号化性能を改善できることが明らかになった．

雪の上を飛ぶ飛行機の白黒写真

中程度の精度で自動的に生成された説明  

(a) Original (b) 25[dB] ICA\_Block (c) 30[dB] ICA\_Block

** **

(d) 25[dB] Conventional (e) 30[dB] Conventional

Figure7. ICA\_Block compared with conventional method



(a)Airplane 　　　　　　　　　　　 (b)Barbara

(c) Cameraman　　　　　　　　　　　　　　　　 (d) Mandrill

Figure8. Coding performance of proposed method compared with DCT

＊＊ 5. Conclusion ＊＊

・In this paper, we proposed the ICA bases selection method to improve the performance of the hybrid image coding method using ICA and DCT.

・本論文では，ICAとDCTを用いたハイブリッド型画像符号化方式における性能改善のための基底選出法を提案した．

・The proposed method divedes the given image into 8×8 blocks and classifies them into two types: blocks to which DCT is applied (DCT\_Block) and blocks to which ICA is applied (ICA\_Block).

・提案手法では，画像を一様に8×8の矩形ブロックに分割し，DCTを適用するブロック（DCT\_Block）とICAを適用するブロック（ICA\_Block）の2種類のブロックに分類している．

・ Image coding using ICA has a problem that the entropy for preserving the ICA bases increases because the sender and receiver need to share the ICA bases.

・ICAを用いた符号化では，送信側と受信側でICA基底を共有することが前提となるため，基底を保存するための符号量が必要である．

・To solve these problems, each combination of the ICA bases was evaluated in terms of image quality, and the entropy that each combination of the ICA bases can reduce and the entropy need to preserve the ICA bases were compared to determine the combination of the optimal ICA bases and the proper ICA\_Block.

・この問題を解決するために，改善できる画質の観点から各ICA基底の組み合わせを評価し，削減できる符号量と基底を保存するための符号量を比較することで，符号化性能の改善に最も寄与する基底の組み合わせとそれを適用するICA\_Blockを決定した．

・ As the result, the proposed method is improved to the coding performance in the range of 30~50[dB] PSNR even when the entropy to preserve the ICA bases is added.

・その結果，ICA基底を保存するための符号量を加えた場合でも，実用的な符号化レートにおいてDCT単独のものから符号化性能が改善され，従来のハイブリット型符号化方式の課題を解決することができた．

・In the proposed method, the combination of the ICA basis and ICA\_Block used in the ICA\_Block differs depending on the bit rates, so the processing for each bit rates is necessary, and the reduction of the processing cost of the proposed method is left by the future problem.

・提案手法では，符号化レートによってICA\_Blockとそこで使用されるICA基底の組み合わせが異なるため，符号化レートごとの処理が必要である．

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