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＊＊Abstract＊＊

・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．

・しかし，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．

・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，ICA係数のスパース性に着目してDCTとICAを併用したハイブリット型の画像符号化方式が提案されている．

・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増加することで，符号化性能が劣化する問題がある．

・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一部の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．

・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，実用的でない符号化レートでのみ向上することや，実用的な符号化レートでは大きく劣化するという問題が残されている．

・これらの課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ICA\_Blockを決定する．

・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]において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．

＊＊1. Introduction＊＊

・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．

・DCTは，DCT基底が入力画像に対して不変であり，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．

・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．

・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]．

・規則的な特徴の領域は，DCTのみを用いた画像符号化方式の方がICAを用いた方式よりも符号化性能が高く，局所的な特徴の領域では，ICAのみを用いた画像符号化方式の方がDCTを用いた方式よりも符号化性能が高い．

・汎用的なDCT基底と固有の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，入力画像の特徴の効率的な保存を目的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]．

・[3，4]は，画像を小さなブロックに分割し，すべてのブロックをDCT\_BlockとICA\_Blockという2種類のブロックに分類している．

・DCT\_blockは，DCTで符号化されたブロックを意味し，ICA\_blockは，ICAで符号化されたブロックを意味している．

・ここで，ICA基底は，入力画像に対して固有であるため，送信側と受信側で共有することが前提となる．

・高い符号化性能を得るためには，多種類のICA基底を用いることが望ましいが，ICA基底を記憶するための符号量が増加してしまうため，符号化性能の観点で望ましくない．

・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．

・[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，重要な基底を決定している．

・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である．

・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ため，各ICA基底の組み合わせを評価するための一時的なものであり，最終的なICA\_BlockはICA\_Blockの候補から決定される．

・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議論にとどまっているため，実用的な符号化レートに対して基底の符号量を考慮する手法について検討する必要がある．

・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存在している．

・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を選択することができる．

・その結果，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.の題名は考え中＊＊

＊2.1 Independent Component Analysis＊

・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．

・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，とすることができる．

・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．

・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．

・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．

・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．

・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，は単位行列である．

・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．

・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．

・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，入力画像に対して固有であることが分かる．

・入力画像“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．

・同じブロックの一部のICA基底のみを用いたものをFig.2(b)に示している．

・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]があることが分かる．

・このことから，ICA係数のスパース性に着目することで，DCT単独のものと同等の画質を保存に必要なICA基底の数は少数で済むことが見込まれる．

・すなわち，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考えられる．

(a)Reconstructed block with all of ICA coefficients

(b)Reconstructed block with same of ICA coefficients

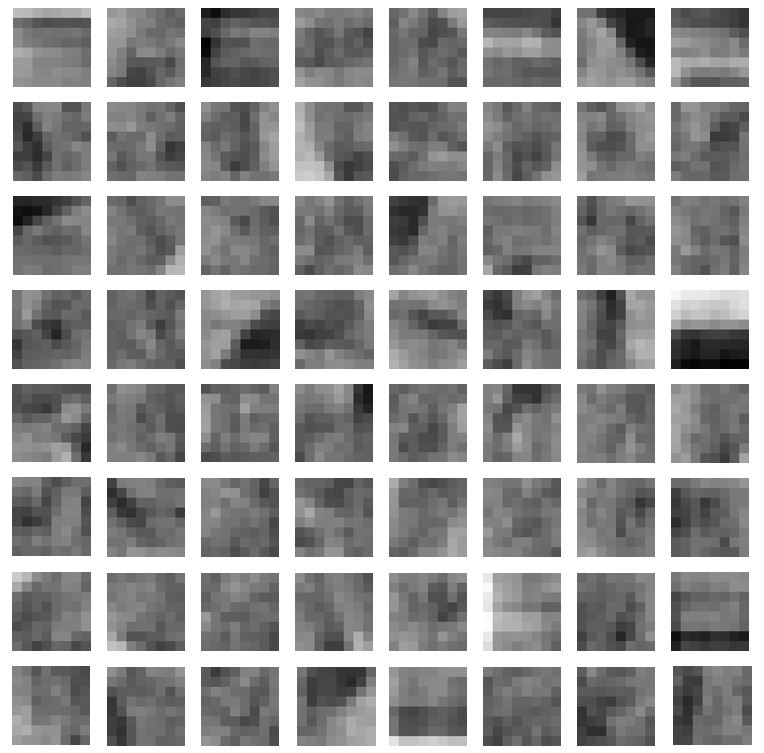
Figure2. Sparseness in the ICA coefficient



 ![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)input image “Barbara” (b)ICA basis “Barbara”

(c)input image “Airplane” (d)ICA basis “Airplane”

Figure1. Input images and obtained ICA basis

＊2.2 Conventional Method＊

・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．

・一方，規則的な特徴の領域は，不規則的な形状を持つICA基底では表現しづらいため，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．

・このことから，符号量削減の観点において，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．

・また，DCTの画質は，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制御されている．

・同様に，量子化テーブルを用いてICAの結合係数を削減し，画質を制御する場合，基底の付加情報の観点で符号量が増加してしまう．

・そのため，[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，画質の制御を行っている．

・ブロックごとに原画像とのMSEが同じになるようDCTとICAを適用したときの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．

・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である．

・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ため，各ICA基底の組み合わせを評価するための一時的なものであり，最終的なICA\_BlockはICA\_Blockの候補から決定される．

・実際に使用されるICA基底が決定したときに，それらを使用するブロックがICA\_Blockとなり，それ以外のブロックがDCT\_Blockとなる．

・重要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，重要な基底を決定している．

・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ため，各ICA基底の組み合わせを評価するための一時的なものであり，最終的なICA\_BlockはICA\_Blockの候補から決定される．

・[3]では，ICA基底の符号量を加えない場合にすべての符号化レートにおいて符号化性能が改善されることや，同様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．

・また，[4]では，ICA基底の符号量を加えた場合に低符号化レートにおいて符号化性能が改善されることが明らかになっている．

・最後に，従来のハイブリット型符号化方式の課題について述べる．

・1つ目は，ICAの量子化において適切な基底がされていないことである．

・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保存するブロックが多い．

・そのため，ICAにおける画質制御のための重要度は，複数種類の基底を組み合わせることを考慮すべきだと考えられる．

・2つ目は，重要なICA基底の選出において，評価対象とする基底とブロックが不足していることである．

・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，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．

・また，ICA基底を用いなくても画質が改善されるブロックの存在が確認されている．

・そのため，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と考えられる．

・3つ目は，ICA基底の符号量を加えた場合に符号化性能を改善できる符号化レートが非実用的なことである．

・従来手法が画質評価に用いているPSNRは，30~50[dB]の符号化レートが実用的な範囲であるとされているが，従来手法では，PSNRが20[dB]前後の非実用的な符号化レートでのみ符号化性能が改善されている．

・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＊＊

・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．

・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基底などを導出する．

・提案方式の量子化では，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ブロックの保存に不要なICA基底を削減することで量子化される．

・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．

・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直流成分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．

・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，そうでない場合は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に分類する。

・DCT\_BlockはDCTを用いて符号化されたブロックであり，ICA\_BlockはICAを用いて符号化されたブロックである．

・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．

・このとき，前節で述べたように，ブロックの符号化性能を少しでも改善できる基底の組み合わせも評価の対象としている．

・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基底とし，それらが用いられているブロックと，基底を用いなくても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．

・以上の処理により，実際に使用するICA基底とICA\_Block，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．

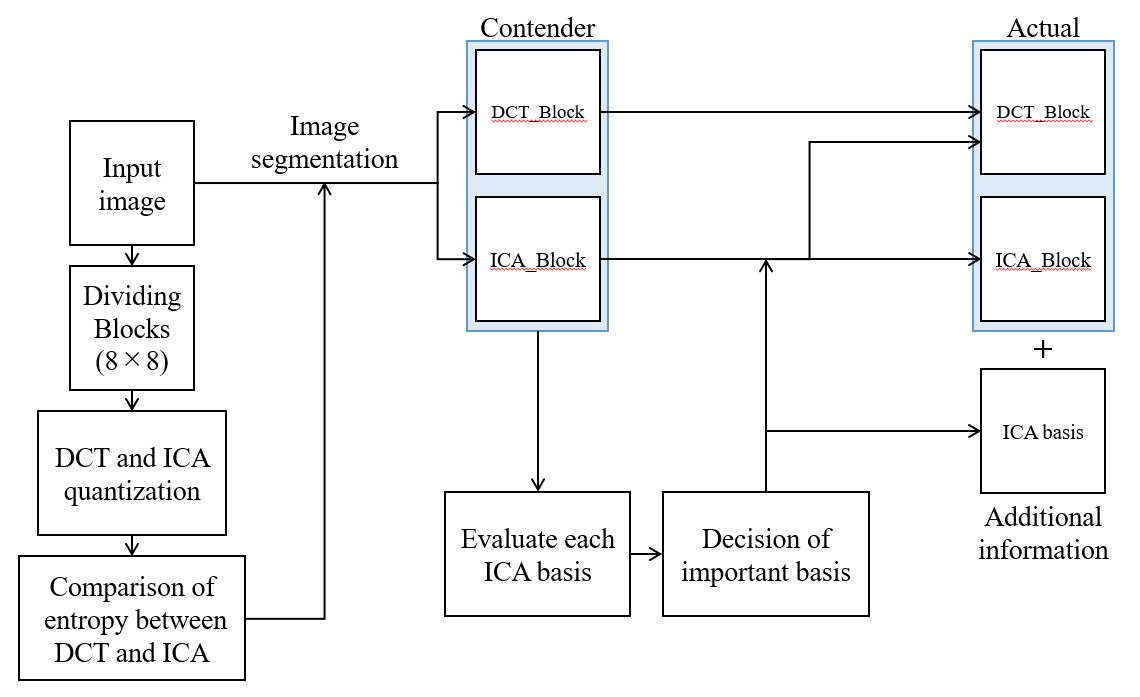


Figure3. Proposed hybrid image coding

＊3.1 Importance used for quantization＊

・提案方式の最終的な画質評価は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もMSEを評価基準とした方が自然であると考えられる．

・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場合は限られているため，複数種類の基底を組み合わせて保存する場合が多い．

・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の保存に必要なICA基底の種類をヒストグラムとした結果をFig.4に示す．

・ここで，縦軸は出現頻度であり，横軸はICA基底の種類を表している．

・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．

・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．

・その手法として，入力画像のブロックに対して，最もMSEを小さくするICA基底を求め，をそのブロックで最も重要な基底とする．

・次に，と組み合わせた場合に最もMSEを小さくする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．

・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る．

・上記の処理により，ICA基底の組み合わせが考慮されるため，従来手法の量子化における課題が解決される．

・DCT\_BlockとICA\_Blockの候補の分類では，求められた重要度を用いて，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．

・ここで，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直流成分の情報を合計したときの平均情報量を示している．

・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. Histogram of the Number of

ICA basis needed to store a block

＊3.2 Selection of the ICA basis＊

・提案方式では，入力画像ごとに64個のICA基底が導出されている．

・それらは入力画像に固有で，それぞれが局所的な特徴に対応しているため，符号化性能の改善に対して有効なブロックが異なる．

・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基底が性能改善に有効であるブロックをFig.5に示す．

・ここで，Fig.5では，それぞれのICA基底が有効なブロックを原画像で，それ以外のブロックを黒で表示している．

・Fig.5を見ると，それぞれのICA基底の有効なブロックが異なっていることが分かる．

・Fig.5では，ICA基底の有効なブロックが異なっている例を示しているが，他の基底や複数の基底を組み合わせたときの有効なブロックは同じである可能性もある．

・すなわち，一つのブロックの保存に対して，有効なICA基底の組み合わせが複数存在しているということである．

・それらのICA基底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．

・重要な基底の評価は，一つのブロックの保存に対して，有効なICA基底の組み合わせが複数存在することを考慮した手法を提案することで，従来手法の重要な基底の評価における課題を解決する．

・このとき，[3，4]からDCTと同等の画質を少数個のICA基底で保存できることや，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つまで使用するものとして検討した．

・また，従来手法のICA\_Blockでは，必ずICA基底が使用されていたが，実験により基底を使用せずにDCT単独のものよりも画質を高く保存できるブロックが確認されている．

・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．

・ここで，Fig.6では，ICA基底を使用せずにDCT単独よりも画質を高く保存できるブロックを原画像で，それ以外のブロックを黒で表示している．

・Fig.6を見るとPSNRが30[dB]の実用的な符号化レートでもそれらのブロックの存在が確認できる．

・ICAの直流成分のみでブロックを保存するとき，直流成分を保存するための符号量は必要とするが，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．

・そのため，提案手法では，ICA基底を使用せずにDCT単独よりも画質を高く保存できるブロックを用いることで，従来手法の符号化レートにおける課題を解決する．

・まず，ICA基底の組み合わせを用いてブロックを再構成する場合に，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．

・ただし，使用するブロックは，ICA基底を用いなくても画質を改善できるブロック以外のICA\_Blockの候補である．

・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．

・このとき，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ことができる．

・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，が少ない基底群を使用した場合，DCT単独のものよりも符号化性能が劣化する．

・基底選出は，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を提案することで，入力画像の符号化性能改善に寄与できる基底の組み合わせを汎用的に選出する．

・ICA基底を使用せずにDCT単独よりも画質を高く保存できるブロックの削減符号量をで求める．

・ここで，は，ブロックの直流成分を保存するための符号量である．

・次に，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．

・

・ここでは，使用するの基底を保存するための符号量である．

・このとき，ICA基底を使用せずにDCT単独よりも画質を高く保存できるブロックもICA\_Blockとしている．

・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基底と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)Effective blocks of ICA basis 23 (b)Effective blocks of ICA basis 40

Figure5. Effective area of ICA basis

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. Effective area of

DC component in ICA

＊＊ 4. Experimental results ＊＊

・画像“Airplane”に対しての条件で提案する重要度を適用し，ICA\_Blockの候補に分類された領域をFig.7に示す．

・ここで，ICA\_Blockの候補を原画像で，DCT\_Blockの候補を黒で表示している．

・Fig.7を見ると符号化レートによって，ICA\_Blockの候補が異なっていることが分かる．

・ICA\_Blockの候補が変わることで各ICA基底の組み合わせに対する評価も変わるため，提案手法では，符号化レートごとの処理を分けて適用させる．

・画像“Airplane”に対しての条件で提案するICA基底の重要度を適用し，ICA\_Blockの候補に分類された領域をFig.8に示す．

・ここで，Fig.8では提案手法と従来手法を比較しており，ICA\_Blockの候補を原画像で，DCT\_Blockの候補を黒で表示している．

・また，従来手法はICA基底を使用せずにDCT単独よりも画質を高く保存できるブロックを考慮していないため，それらの領域を含めない場合と含めた場合との比較を行う．

・Fig.8(b)と(c)，(d)を見ると，提案手法の方がICA\_Blockの候補を多く分類できていることが分かる．

・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る．

・そのため，提案したICA基底の重要度を用いることで，従来の重要度よりも少ない符号量で保存できると言える．

・このことから，提案したICA基底の重要度は，従来の重要度よりも適した基底を選択し，画質を制御できることが明らかになった．

・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.9に示す．

・Fig.9では，DCT単独と提案手法の結果を比較している．

・なお，提案手法は，ICA係数の符号量に対して，ICA\_Blockの直流成分を保存するための符号量とICA基底を保存するための符号量が加えられている．

・従来手法は，ICA\_Blockの直流成分を保存するための符号量が加えられていないことや，ICA基底を保存するための符号量を加えた場合にDCT単独よりも符号化性能が劣ることから，提案手法との比較を行わない．

・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．

・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．

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

・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.10に示す．

・Fig.10では，DCT単独と提案手法の結果を比較している．

・Fig.10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．

・以上のことから，提案した重要な基底の選出法は，ICA基底やICAの直流成分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符号化性能を改善できることが明らかになった．

建物, 写真, 座る, レゴ が含まれている画像

自動的に生成された説明 QR コード

自動的に生成された説明

(a)25[dB] (b)30[dB]

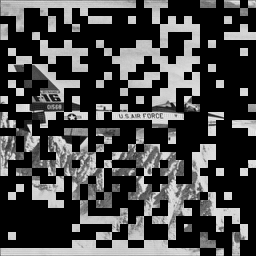
Figure7. Contender of ICA\_Block

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 QR コード

自動的に生成された説明

(a)Original (b)conventional

** **

(c) Contender of ICA\_Block (d) Contender of ICA\_Block and Blocks that do not use ICA basis

Figure8. Comparison of area classification results



(a)Airplane 　　　　　　　　　　　 (b)Barbara

(c) Cameraman　　　　　　　　　　　　　　　　 (d) Mandrill

Figure9. Comparison of area classification results

Figure10. Coding performance at low compression

＊＊ 5. Conclusion ＊＊

・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．

・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，すべてのブロックをICA\_blockとDCT\_blockの2種類に分類する．

・ICA\_blockはICAを用いて符号化されたブロックであり，DCT\_blockはDCTを用いて符号化されたブロックである．

・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増加することで，符号化性能が劣化する問題がある．

・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一部の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．

・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，実用的でない符号化レートでのみ向上することや，実用的な符号化レートでは大きく劣化するという問題が残されている．

・これらの課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ICA\_Blockを決定した．

・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．

・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．

・今後の課題として，処理コストの削減を行う予定である．

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