IMQA 2022 原稿 ver1.1（日本語版）

M1 中田雄大

＊＊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，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．

・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．

・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，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領域を決定する．

・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]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．

＊＊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．

・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]．

・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．

・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ため，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]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．

・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．

・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基底を保存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．

・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，それは各ICA基底の組み合わせを評価するために使用され，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．

・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．

・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．

・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. ICAを用いた画像符号化方式＊＊

＊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，と記述することができる．

・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，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，入力画像ごとに異なった基底が求められていることが分かる．

・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基底のみで再構成されたブロックを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得るために必要なICA基底の数は少数で済むことが分かる．

・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

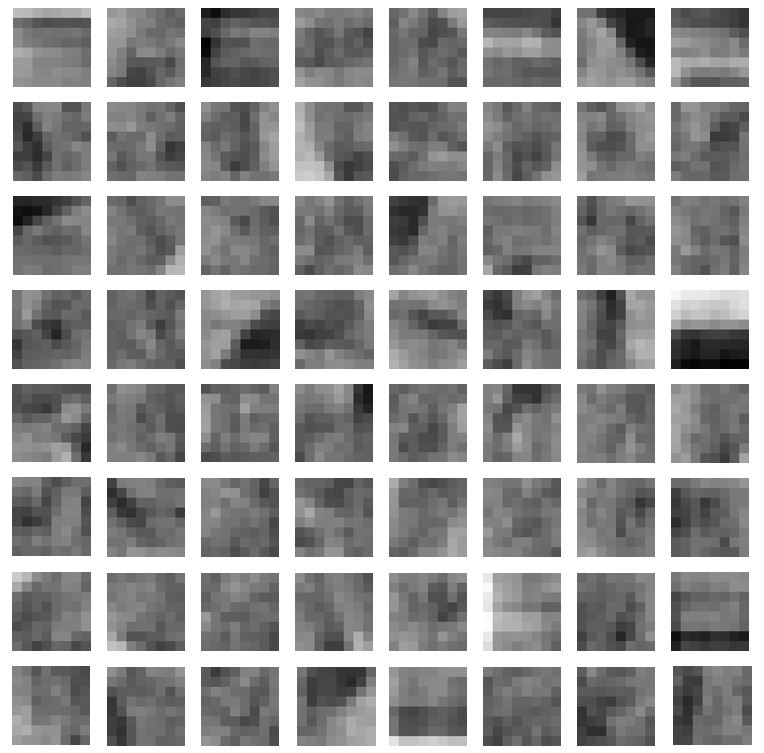
Figure2. Sparseness of the ICA coefficient



 ![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)“Barbara” (b)ICA basis of “Barbara”

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

Figure1. Images and Their 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，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．

・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．

・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．

・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．

・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．

・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に使用され，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基底の組み合わせが決定したときに，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．

・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．

・[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．

・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．

・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．

・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．

・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．

・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．

・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．

・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．

・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．

・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．

・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基底を求める．

・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MP法を適用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．

・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に分類する。

・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．

・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．

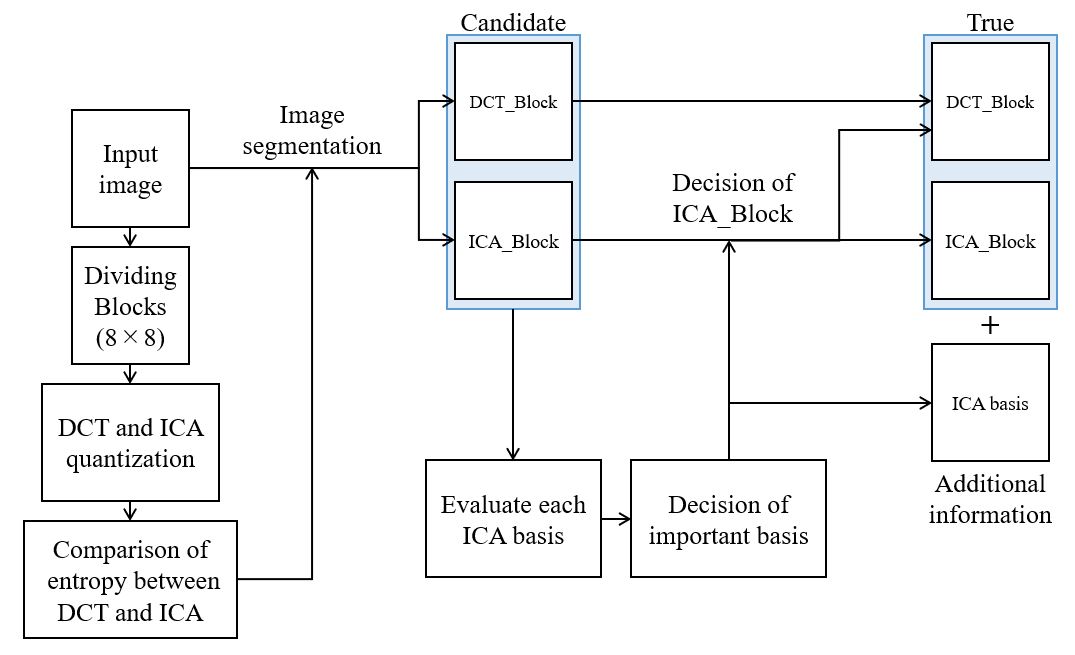


Figure3. Configuration hybrid image coding using DCT and ICA basis

＊3.1 ICA\_Blockの候補の決定 ＊

・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．

・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．

・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基底の個数とそれを必要とするブロック数をFig.4に示す．

・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．

・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．

・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．

・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．

・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．

・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 使用するICA基底の決定 ＊

・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．

・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によって異なる．

・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基底が選択されたブロックをFig.5に示す．

・Fig.5の左上にはそれぞれのICA基底を表示している．

・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．

・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，異なる基底が一つのブロックで使用されることが複数のブロックで見られた．

・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．

・なお，Table.1では，1000番目のブロックとそのブロックの保存に有効なICA基底を表示している．（図でよかったのでは？）

・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．

・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．

・そのため，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．

・そこで，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重要な基底の評価法を提案する．

・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．

・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．

・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．

・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．

・提案するICA基底の選出法を以下に示す．

・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．

・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．

・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．

・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．

・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．

・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．

・

・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．

・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. ブロックの保存に有効なICA基底の組み合わせ

|  |  |
| --- | --- |
| 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 ＊＊

・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ICA\_BlockをFig.7に示す．

・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)，(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．

・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．

・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る．

・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．

・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．

・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．

・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．

・なお，従来手法は，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，表示していない．

・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．

・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.9に示す．

・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．

・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

Figure9. Coding performance at the case of 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，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．

・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．

・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．

・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．

・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．

・そのために要する処理コストの削減が今後の課題である．

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