# A Lossless Image Compression Based On Hierarchical Prediction and Context Adaptive Coding

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**Abstract**: This paper introduces a new lossless compression. This is based on the hierarchical prediction and context adaptive coding. Here first we convert the RGB image into YCuCv transform. The Y component is converted by using any of the lossless gray scale image compression method. The hierarchical schema is used for the compression of the chrominance channel. Here we are using four predictors. For the prediction we are using the upper, right, left diagonal and right diagonal for the image compression. The arithmetic coding is used for the error signal calculation. This provides better compression of the images on the boundary as compared to the existing system based on the hierarchical prediction. It also reduces the bit rate when compared with other lossless compression methods.

**Keywords**: YCuCv, lossless compression, hierarchical prediction, Huffman coding, context adaptive coding, RGB, RCT,

## I INTRODUCTION

Digital images are acquiring a wide audience nowadays. Most of the cameras used today are digital cameras. The main problem comes when there is a need for transferring the image and also storing the image. The digital images are of huge size, and hence they need to be stored in a low memory, for this the only solution is to compress it. When we want to transfer an image of huge size, the only possible way is to compress it and then transfer.

Compression is mainly of two types. While compressing, if some part of the image is lost, then it is called lossy compression. But in the lossless compression the entire image is preserved even after the decompression. Due to the wide application of the image in the medical fields and other important areas, we can't afford image loss. So the lossless compression acquires wide spread acceptance. In a lossless compression technique two steps are there. The first one is that we may create a statistical model for the input data. And in the second step this model is used for the mapping of the input data. Many lossless compression techniques are there and the most commonly used ones include Lossless JPEG [1], JPEG LS [2], LOCO-1[3], CALIC [4], JPEG 2000[5], and JPEG XR [6]. Among this CALIC and JPEG are based on the JPEG standardization. CALIC provides better compression performance but more computation.

Mainly for the compression of the colour images, a colour transform is used for splitting the colour component. After that, each of the colour component is compressed independently by any of the above mentioned colour transform method. In the case of lossy image compression the RGB component is converted intoYCbCr transform [7], but in colour lossless compression, as a result of the uninvertability with integer arithmetic most of the colour transform cannot be used. So, it is better to use a reversible colour transform. Hence an RCT was defined and used in JPEG 2000[5].

In this paper, we are proposing a hierarchical prediction schema. Based on this prediction schema, the predictors are being calculated. Here four predictors are calculated and from it the most significant and apt value is chosen as the actual predictor and that particular pixel is encoded on the basis of that predictor.

A lot of existing prediction methods are there for the lossless compression. The main problem is that they all are based on the raster scan prediction method which is inefficient for some cases, mainly high frequency regions [9]. The method of hierarchical prediction was also proposed in many other papers [10], where only two predictors are used. Here in this method an edge directed predictor and context adaptive modelling is used. Here the lower rows as well as left and upper row alone are used for the prediction.

The main problem is that while predicting edge pixel, we can't accurately predict the edges. So there is a chance of improper decompression of the image.

The rest of the paper is organised as follows. The section II includes proposed method and the section III includes the conclusion and the last section covers the references.

## II PROPOSED METHOD

A. Compression of RGB to YCuCv

Normally the images are in the RGB form. The RGB colour space is widely used in computer graphics. The RGB image is converted into YCuCv form by using the RCT form mentioned in [8]. The YCuCv components are split into different components like Y, Cu and Cv.

B. Y channel encoding

The extracted Y channel needs to be encoded. That encoding is done on the basis of the gray scale image compression algorithm. The gray scale image compression is necessary due to some reasons like simplicity, that is gray scale images only contain one image plane with gray scale intensity values and data reduction.

C. Cu and Cv encoding

The Cu and Cv components are encoded on the basis of hierarchical prediction. At first the Cu and Cv are subdivided into odd $X_0{}^{(1)}$ and even $X_e{}^{(1)}$ subimages. The even subimage is used for encoding the odd subimage. The first subdivivsion is based on the rows. For more accuracy, the even row is again subdivided into odd $X_0{}^{(2)}$ and even $X_e{}^{(2)}$ on the basis of the coloumn. This result in a more specific encoding as the subdivision is more specific. Here also the even sub image is used for the encoding of the odd one.

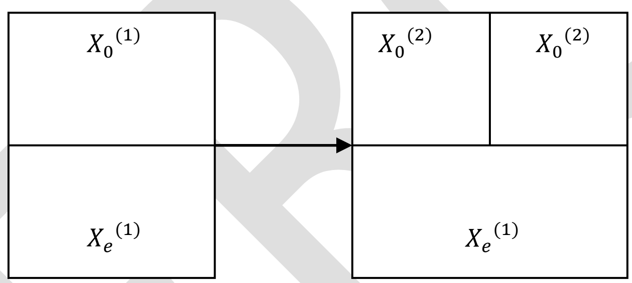


Fig 1 Images Subdivision

D. Predictors

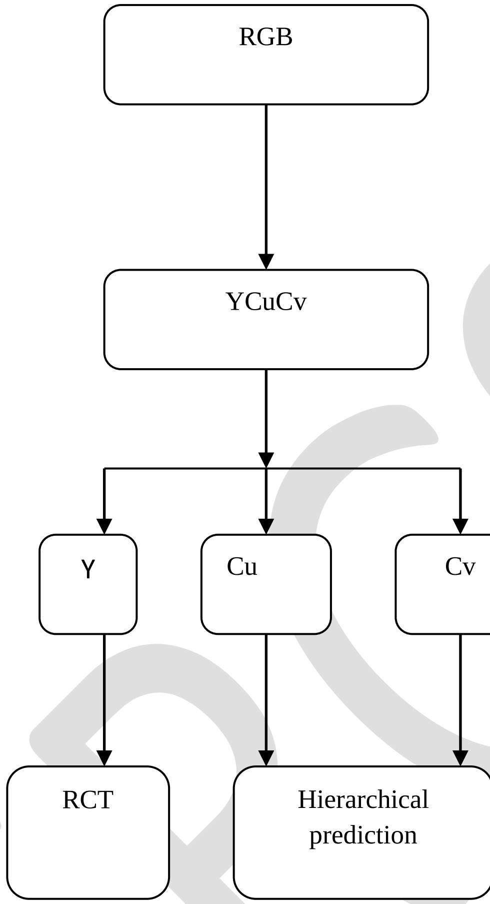


Fig 2 System Architecture of the Proposed System

For encoding the pixel in the image, we are using four predictors. The four predictors are calculated based on the following equation.

$$Xp_0(i,j) = X_0{}^{(2)}(i,j) \tag{1}$$

$$Xp_1(i,j) = round\,((X_0{}^{(2)}(i+1,j-1) + X_0{}^{(2)}(i-1,j+1))/2) \tag{2}$$

$$Xp_2(i,j) = X_0{}^{(2)}(i-1,j) \tag{3}$$

$$Xp_3(i,j) = round((X_0{}^{(2)}(i-1,j-1) + X_0{}^{(2)}(i+1,j+1))/2) \tag{4}$$

After calculating the predictors, the next step is to find the predictor with the maximum value. This can be obtained by comparing the four values. After obtaining the actual predictor, we have to compare this with a particular threshold value. This value is chosen based on the object. Based on the threshold value the value of the predicted value change. Then only the exact prediction process will happen. This can be calculated based on the following algorithms.

**Algorithm 1**

Calculate the prediction vector

Prediction vector = $(Xp_0, Xp_1, Xp_2, Xp_3)$

**Algorithm II**

Prediction algorithm

if (prediction vector < threshold)

$$\text{prediction}(i,j) = \Big( \big( X_0{}^{(2)}(i,j+1) + X_0{}^{(2)}(i-1,j+1) + X_0{}^{(2)}(i-1,j) + X_0{}^{(2)}(i-1,j-1) + X_0{}^{(2)}(i,j-1) + X_0{}^{(2)}(i+1,j-1) + X_0{}^{(2)}(i+1,j) + X_0{}^{(2)}(i+1,j+1) \big)/8 \Big)$$

else

$$\text{prediction}(i,j) = 0.85 \Big( \big( X_0{}^{(2)}(i-1,j+1) + X_0{}^{(2)}(i+1,j-1) \big)/2 \Big) + 0.15 \Big( \big( X_0{}^{(2)}(i,j+1) + X_0{}^{(2)}(i-1,j) + X_0{}^{(2)}(i-1,j-1) + X_0{}^{(2)}(i,j-1) + (i+1,j) + X_0{}^{(2)}(i+1,j+1) \big)/6 \Big)$$

The above algorithm calculates the exact prediction of each pixel is calculated. Based on this prediction the entire image is being encoded. For the proper working of the algorithm the threshold value need to be perfectly chosen based on the property of the images.

E. Error Calculation

After the prediction process, the error of each sub image is calculated; we need to calculate the error value. The context adaptive coding can be used for the actual modelling of the image. For the purpose of context adaptive coding, the error value which is found by using the equation given below is fed into any of the variable length coding.

Error = original image –predicted image

$$\text{ie, error}(i,j) = X(i,j) - \text{prediction}(i,j) \quad (5)$$

The error of each sub image is calculated by subtracting the prediction image from the actual image. Either Huffman or arithmetic coding can be used for the context adaptive coding. The best one is the Huffman coding .The obtained error image is fed on to the Huffman coding for the purpose of context adaptive coding[11]. Many coding techniques are there [12]. The Huffman coding is an algorithm which is used mainly for the lossless compression. The reason for which the Huffman coding is used is that the output of the algorithm can be viewed as variable length code. The Huffman code is mainly used for creating the prefix codes. The output obtained by using the Huffman coding is much more accurate.

## III CONCLUSION

Here we have proposed a method for lossless compression based on the hierarchical prediction schema and context adaptive coding is used for the error calculation. At first the RGB is converted into YCuCv colour space using any reversible colour transform. Then Y channel is encode by using any of the gray scale conversion. The chrominance channel is encoded by using hierarchical prediction. Four predictors are being calculated and one among them (here it is minimum valued predictor) is chosen as the prediction vector. And based on this prediction of individual pixels are done. Finally the arithmetic or Huffman coding is used for the error calculation and thereby for the context adaptive coding.

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