KWANGWOON UNIVERSITY

Color Image & Intra Prediction

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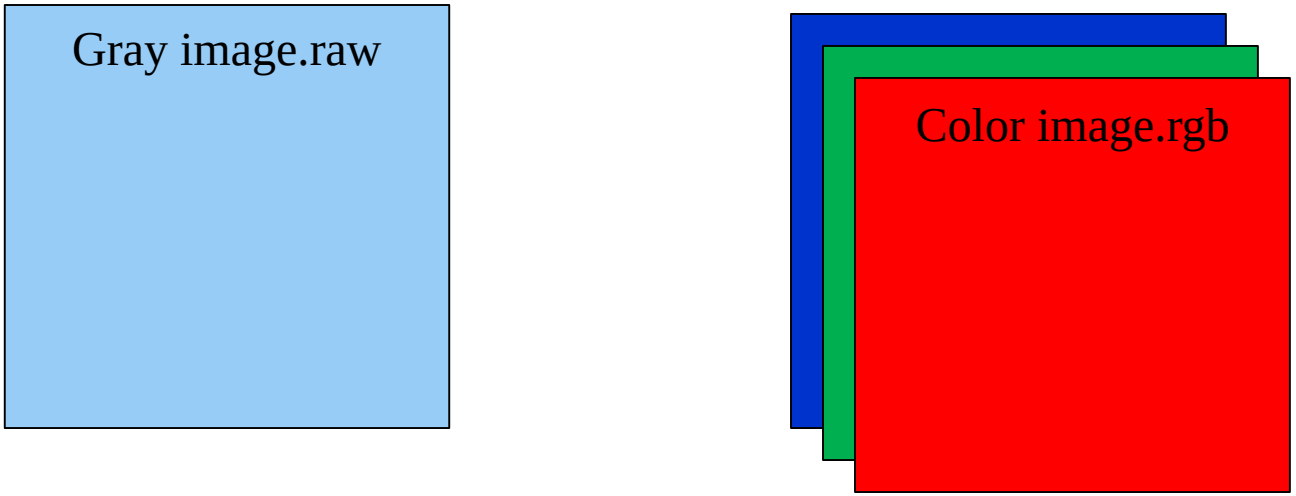
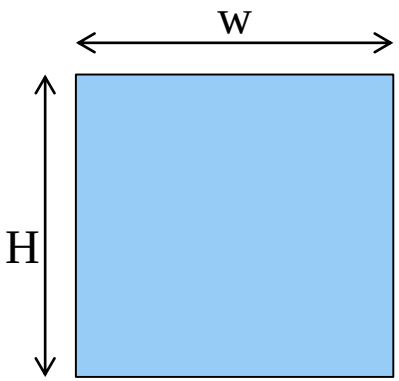
Color Image

- Gray Image VS Color Image

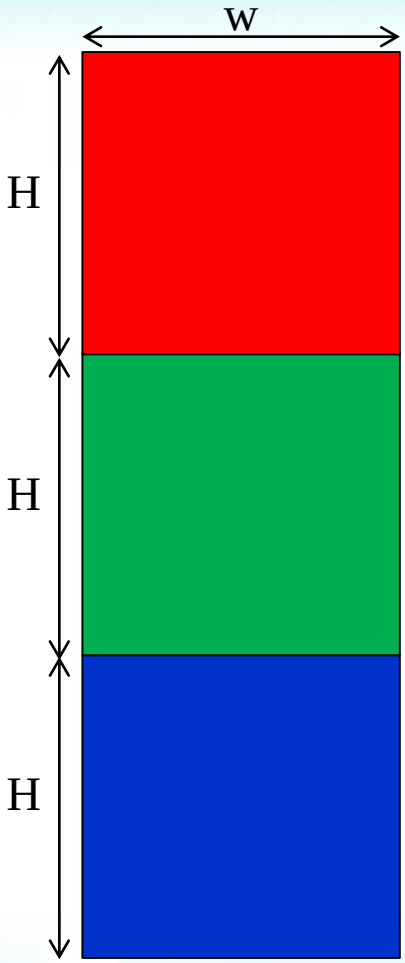


Color Image

- Gray Image VS Color Image



Gray image



Color image

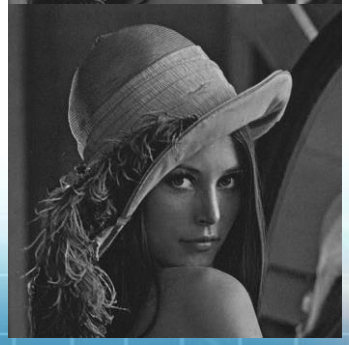
Color Image

- Gray Image VS Color Image

R

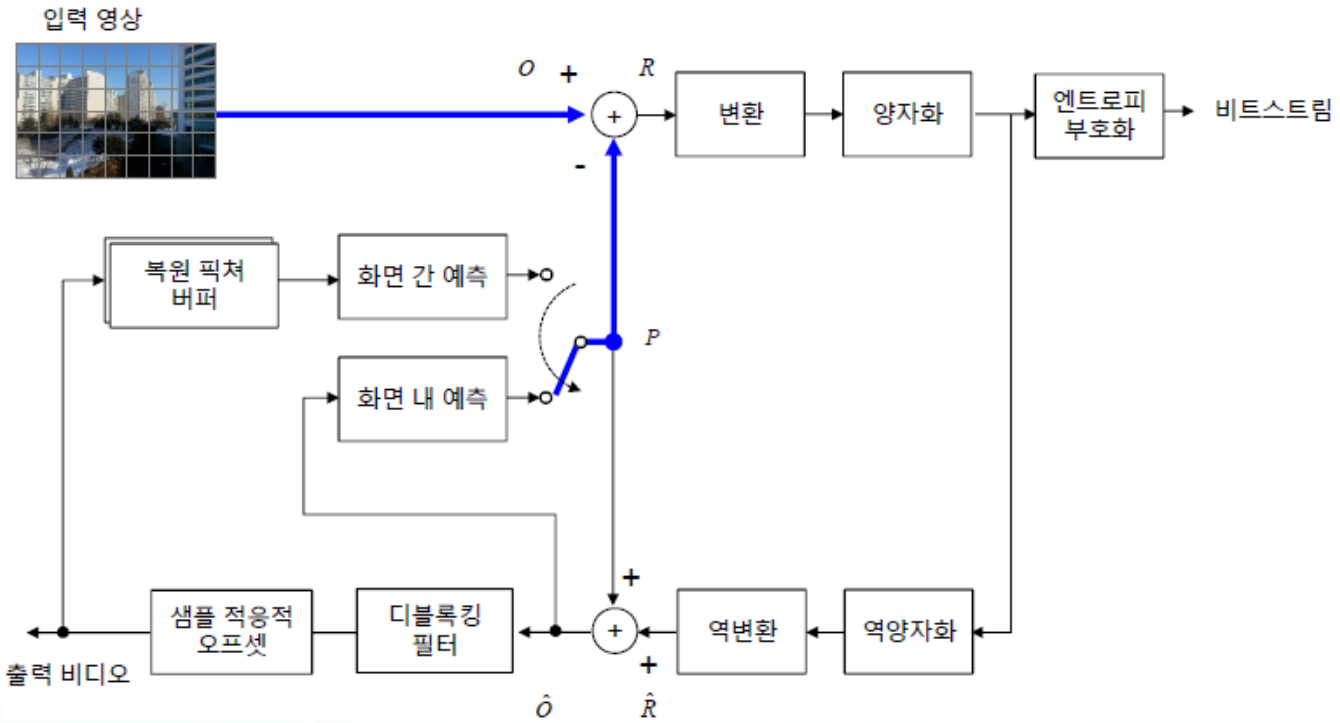
G

B



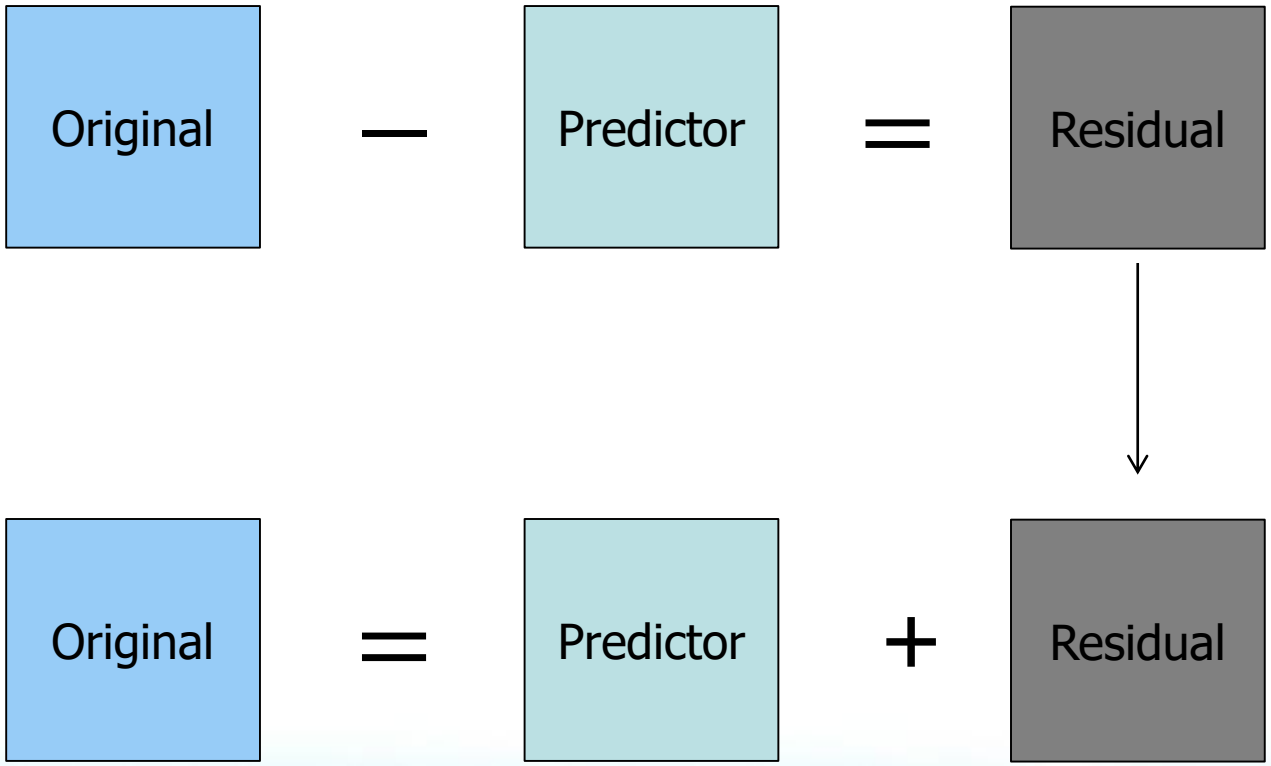
Basic Codec

❖ Structure of Encoder



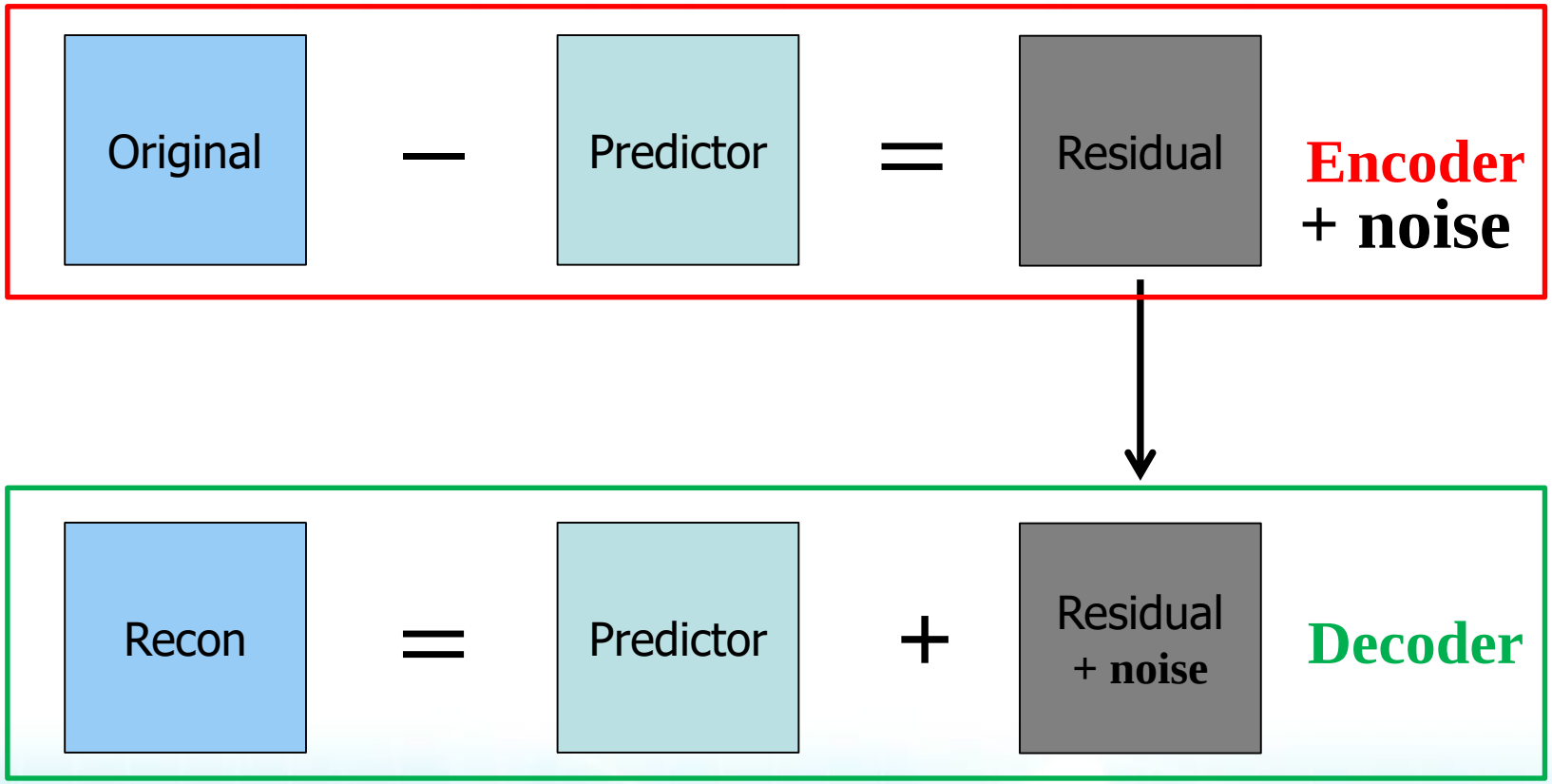
Basic Codec

- Basic Image/Video Codec



Basic Codec

- Basic Image/Video Codec



Basic Codec

❖ Structure of Encoder

118	116	114	112	113	124	140	149
111	109	109	108	109	121	138	149
101	101	102	102	105	117	136	149
96	97	98	100	103	115	134	149
96	97	98	100	104	115	134	150
98	98	99	101	106	117	134	152
99	99	98	101	108	118	135	152
99	98	96	100	109	119	135	152

(a) 8x8 CU 픽셀 값

128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128
128	128	128	128	128	128	128	128

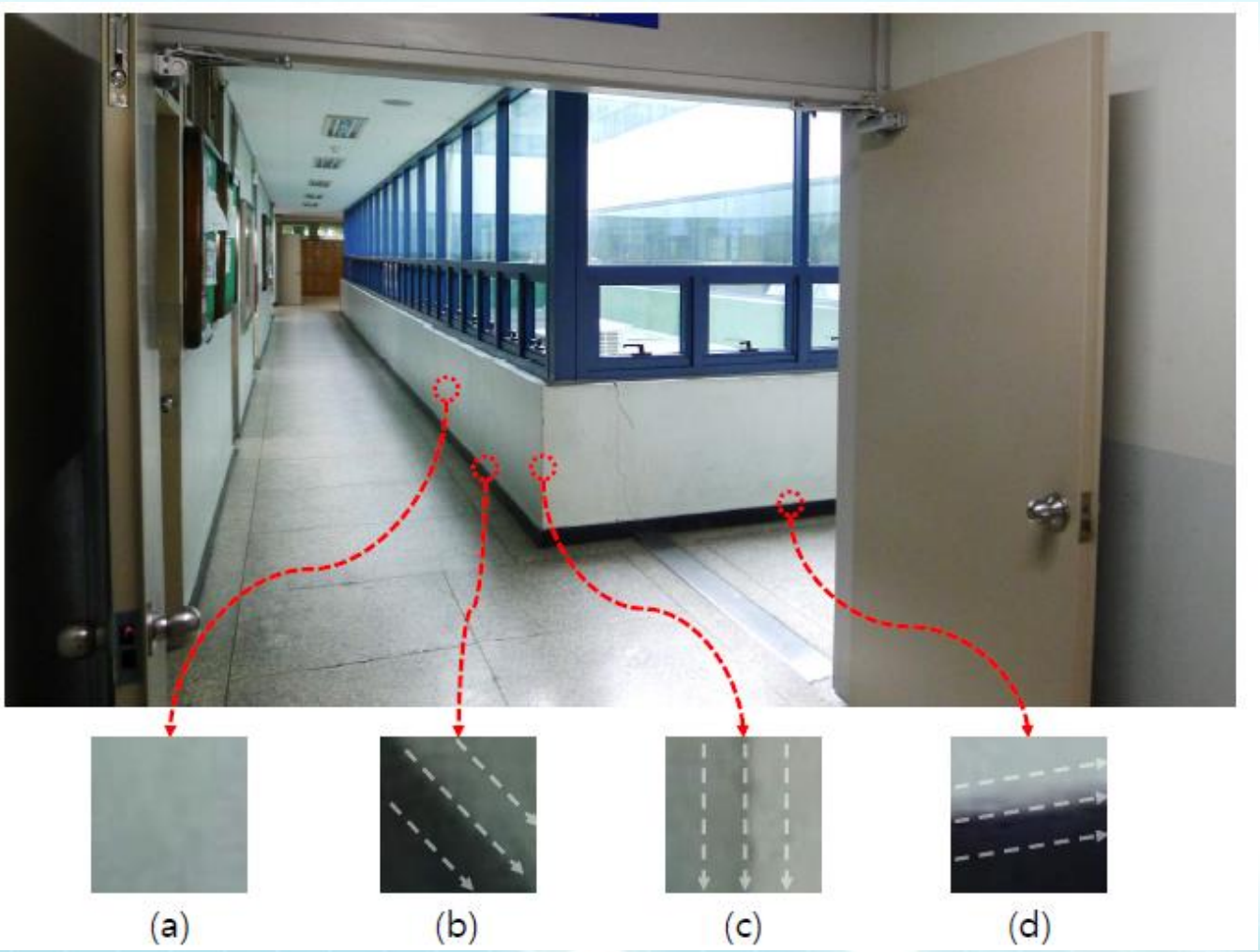
(b) 8x8 PU 예측 값 (Intra_Planar모드)

-10	-12	-14	-16	-15	-4	12	21
-17	-19	-19	-20	-19	-7	10	21
-27	-27	-26	-26	-23	-11	8	21
-32	-31	-30	-28	-25	-13	6	21
-32	-31	-30	-28	-24	-13	6	22
-30	-30	-29	-27	-22	-11	6	24
-29	-29	-30	-27	-20	-10	7	24
-29	-30	-32	-28	-19	-9	7	24

(c) 8x8 차분 블록 계수 값

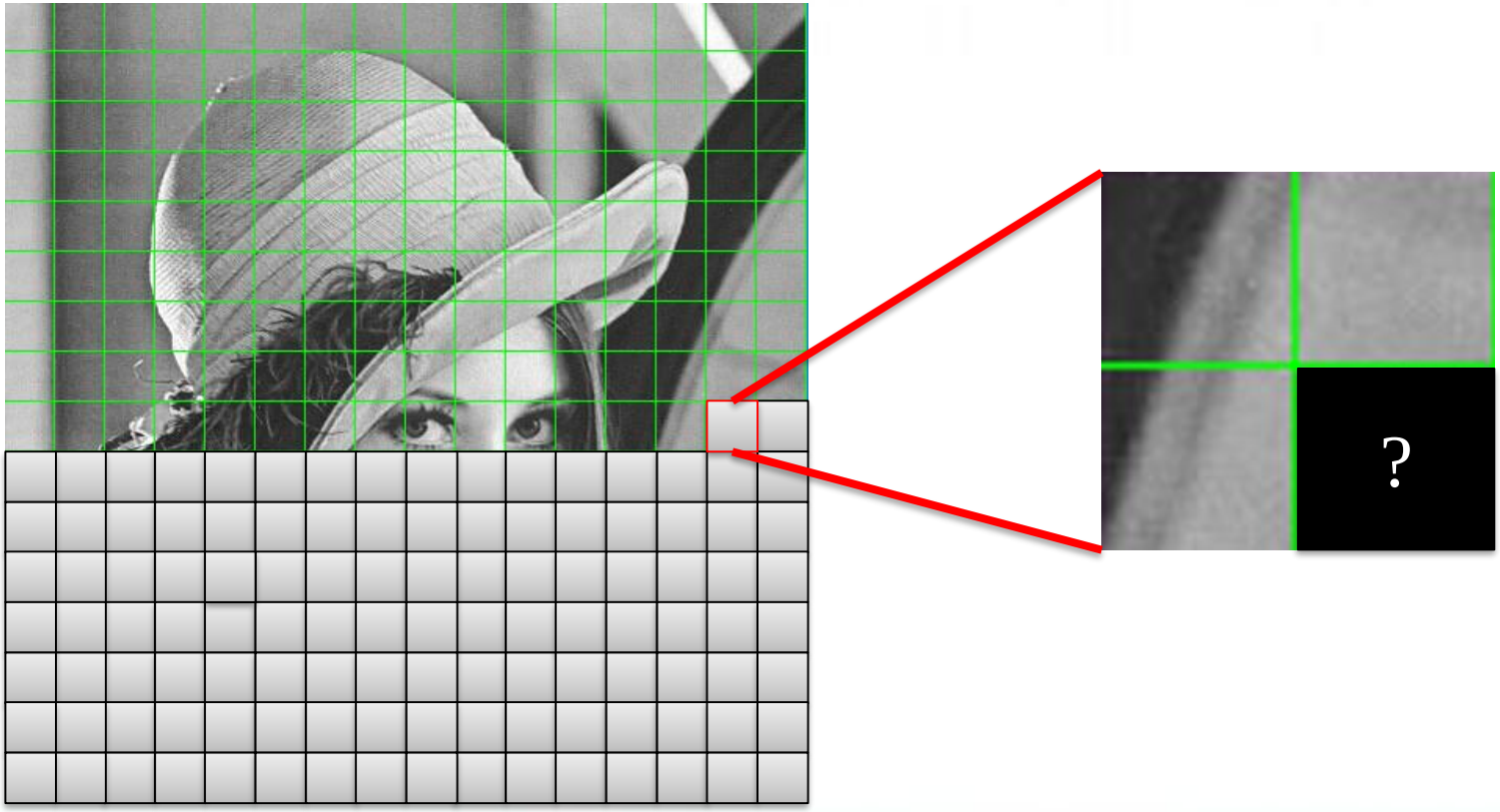
Original image — Predictor = Residual

Intra Prediction



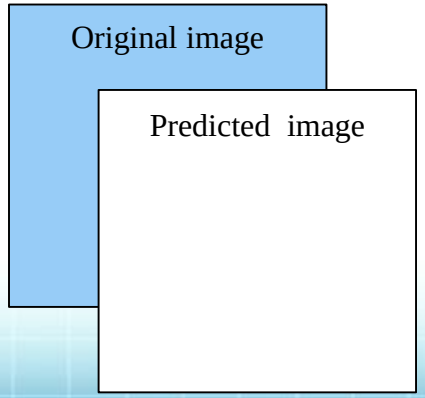
Intra Prediction

Intra Prediction



Make predictors

- Block size : 4x4
- : reference sample values at an original image
  - If reference sample is NOT available, pad a reference sample value with 128
- : predictor sample values



M	A	B	C	D	E	F	G	H
I								
J								
K								
L								

Make predictors

❖ Vertical mode

	A	B	C	D
I	A	B	C	D
J	A	B	C	D
K	A	B	C	D
L	A	B	C	D

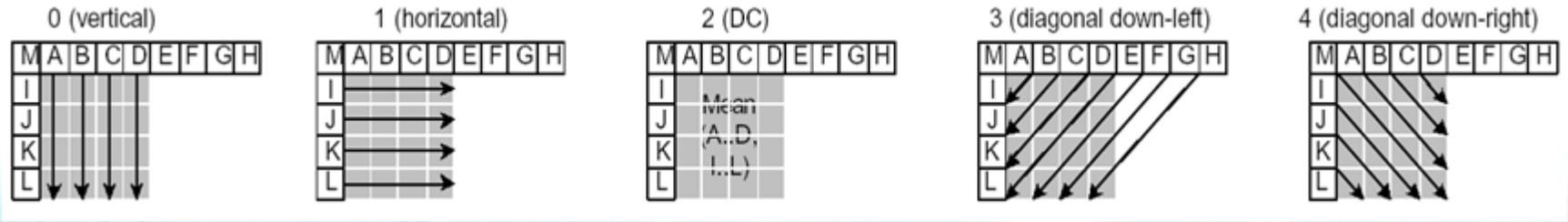
❖ Horizontal mode

	A	B	C	D
I	I	I	I	I
J	J	J	J	J
K	K	K	K	K
L	L	L	L	L

❖ DC mode

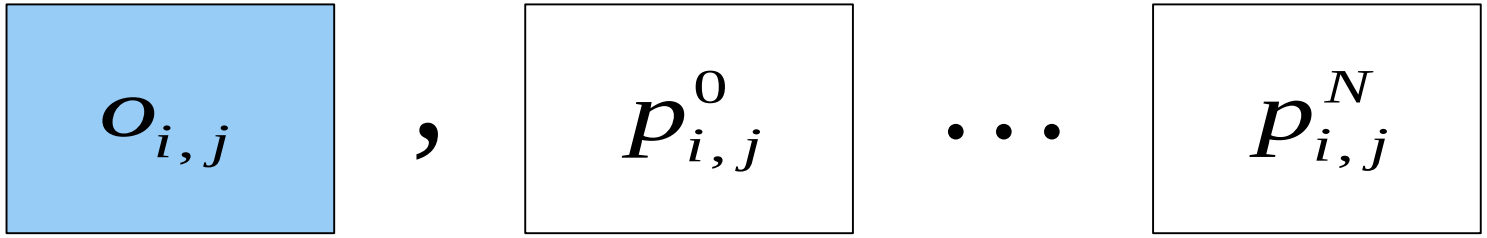
	A	B	C	D
I	μ	μ	μ	μ
J	μ	μ	μ	μ
K	μ	μ	μ	μ
L	μ	μ	μ	μ

$$\mu = (A + B + C + D + I + J + K + L + 4) >> 3$$



Best mode selection

- Find the best mode using Sum of Absolute Difference (SAD)



$$\text{bestmode} = \arg\min_k \left(\sum_{j=0}^{M} \sum_{i=0}^{M} | o(i,j) - pred_k(i,j) | \right)$$

i, j : pixel position

k : prediction mode number

$c_{i,j}$: pixel value of the current block

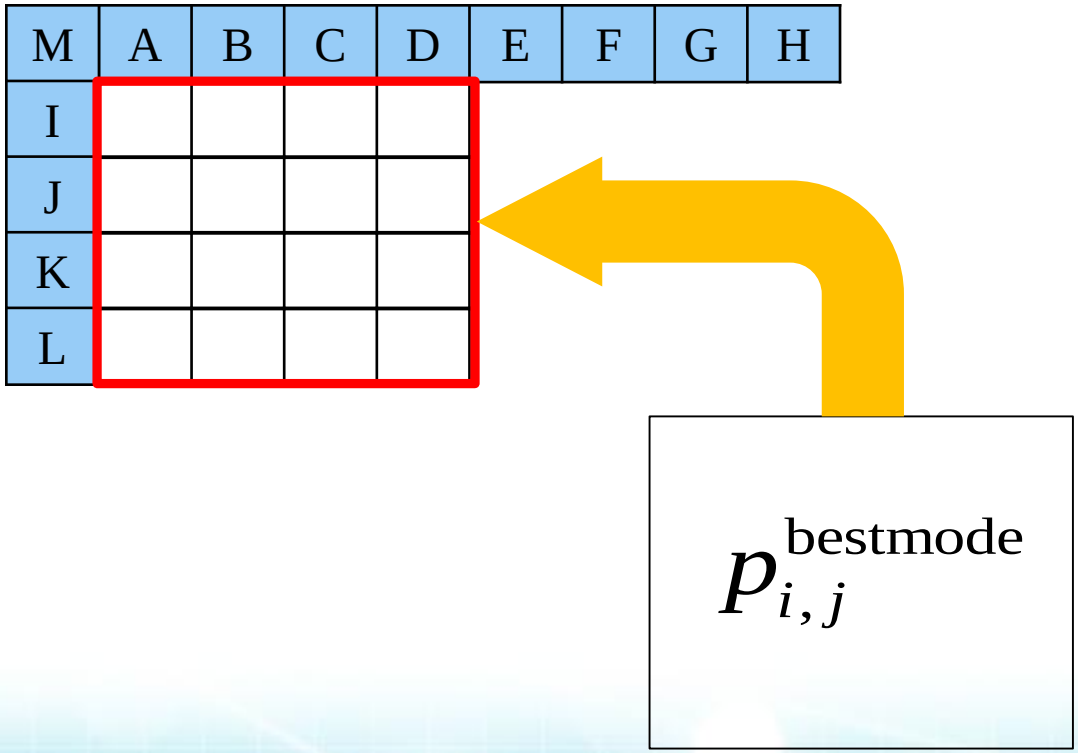
$p^k_{i,j}$: pixel value of the predictor mode k

N : the number of mode

M : block size

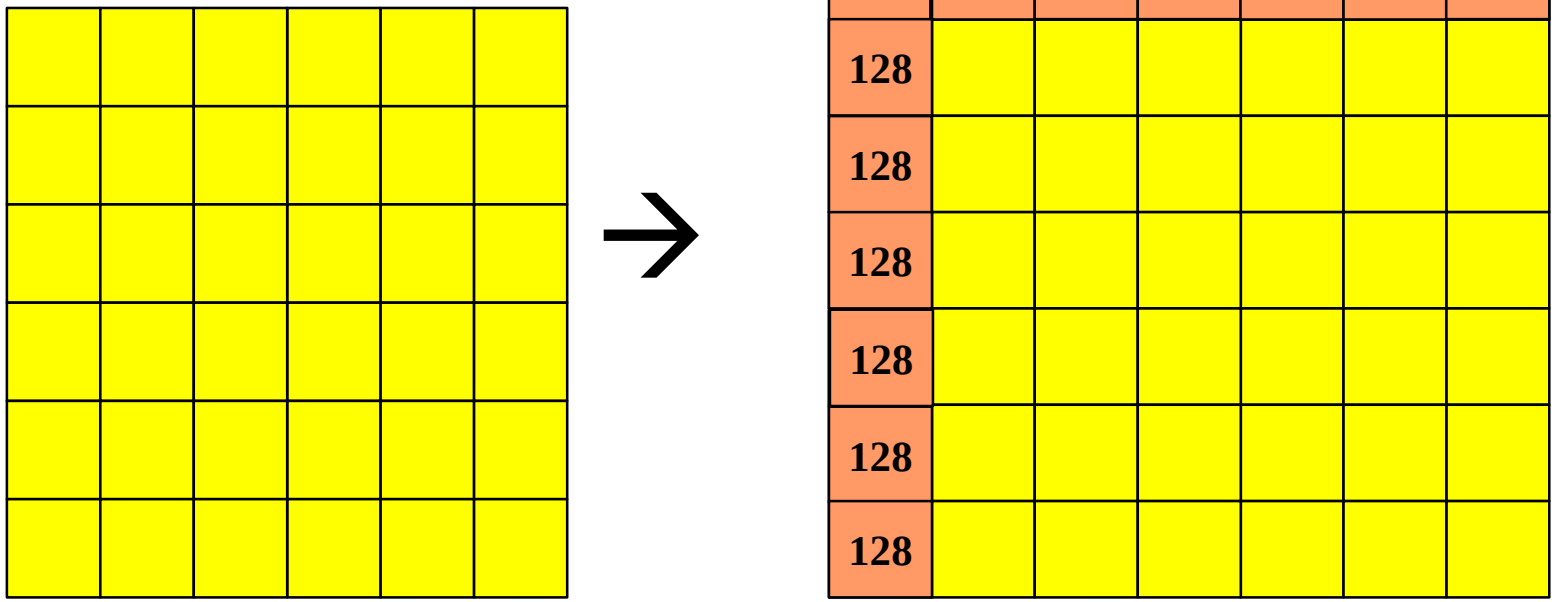
Reconstruction

- Make the new image using the predictor which is best mode



Guideline

- Padding the image
  - 8bit → 128



Programming Guide

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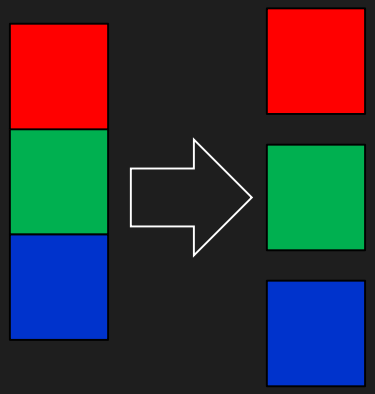
```c
#include <stdio.h>
#include <math.h>
#include <stdlib.h>
#include <string.h>

#define WIDTH       512 //  image size
#define HEIGHT      512
#define BLOCK_SIZE  4   // block size
#define NMODE       3

typedef unsigned char BYTE;

void  MemFree_2D        (BYTE** arr, int height);                    // 2D memory free
void  MemFree_2D_int    (int** arr, int height);                     // 2D memory free
void  FileRead          (char* filename, BYTE** img_in, int width, int height); //  read data from a file
void  FileWrite         (char* filename, BYTE** img_out, int width, int height);    //  write data to a file
void  Encode            (BYTE** img_ori, BYTE** img_pred,int** img_resi, BYTE** img_recon );

BYTE** MemAlloc_2D      (int width, int height);                     // 2D memory allocation
int**  MemAlloc_2D_int  (int width, int height);                     // 2D memory allocation

int   intra_prediction (BYTE* ori, BYTE* ref, BYTE (pred)[3][16], int (resi)[3][16], BYTE (recon)[3][16]);
int   intra_dc         (BYTE* ori, BYTE* ref, BYTE* pred, int* resi);
int   intra_hor        (BYTE* ori, BYTE* ref, BYTE* pred, int* resi);
int   intra_ver        (BYTE* ori, BYTE* ref, BYTE* pred, int* resi);

float GetPSNR           (BYTE** img_ori, BYTE** img_dist, int width, int height);       //  PSNR calculation
```

VIAME

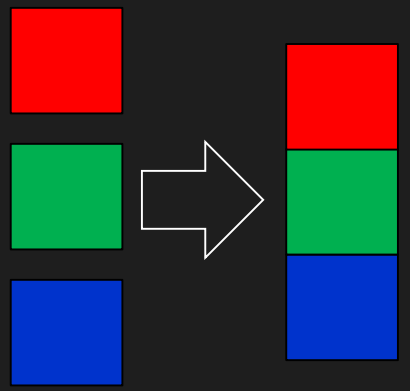
Programming Guide

```
int main()
{
    BYTE **img_ori, **img_pred, **img_recon, **img_in_R, **img_in_G, **img_in_B, **img_pred_R, **img_pred_G, **img_pred_B;
    int  **img_resi_R,**img_resi_G, **img_resi_B;

    int i,j;

    img_ori    = MemAlloc_2D(WIDTH, HEIGHT*3);
    img_pred   = MemAlloc_2D(WIDTH, HEIGHT*3);
    img_recon  = MemAlloc_2D(WIDTH, HEIGHT*3);

    img_in_R   = MemAlloc_2D(WIDTH, HEIGHT);
    img_in_B   = MemAlloc_2D(WIDTH, HEIGHT);
    img_in_G   = MemAlloc_2D(WIDTH, HEIGHT);

    img_pred_R = MemAlloc_2D(WIDTH, HEIGHT);
    img_pred_G = MemAlloc_2D(WIDTH, HEIGHT);
    img_pred_B = MemAlloc_2D(WIDTH, HEIGHT);

    img_resi_R = MemAlloc_2D_int(WIDTH, HEIGHT);
    img_resi_G = MemAlloc_2D_int(WIDTH, HEIGHT);
    img_resi_B = MemAlloc_2D_int(WIDTH, HEIGHT);

    FileRead("Lena(512x512).RGB",img_ori,WIDTH,HEIGHT*3);

    for(i = 0 ; i < HEIGHT ; i++)
    {
        memcpy(img_in_R[i],img_ori[i],sizeof(BYTE) * WIDTH);
    }
    for(i = 0 ; i < HEIGHT ; i++)
    {
        memcpy(img_in_G[i],img_ori[i + HEIGHT],sizeof(BYTE) * WIDTH);
    }
    for(i = 0 ; i < HEIGHT ; i++)
    {
        memcpy(img_in_B[i],img_ori[i + (HEIGHT<<1) ],sizeof(BYTE) * WIDTH);
    }
```



Programming Guide

```
////////////////////////////////////////////////////
/*          Intra Prediction Processing           */
////////////////////////////////////////////////////

Encode(img_in_R, img_pred_R, img_resi_R, &img_recon[0]);

Encode(img_in_G, img_pred_G, img_resi_G ,&img_recon[HEIGHT]);

Encode(img_in_B, img_pred_B, img_resi_B, &img_recon[HEIGHT*2]);

////////////////////////////////////////////////////

// merging result image
for(i=0;i<HEIGHT;i++)
{
    memcpy(img_pred[i],img_pred_R[i],sizeof(BYTE) * WIDTH);
}
for(i=0;i<HEIGHT;i++)
{
    memcpy(img_pred[i+HEIGHT],img_pred_G[i],sizeof(BYTE) * WIDTH);
}
for(i=0;i<HEIGHT;i++)
{
    memcpy(img_pred[i+HEIGHT*2],img_pred_B[i],sizeof(BYTE) * WIDTH);
}

// get psnr

printf("PREDICTION VS ORIGINAL PSNR : %.2f\n", GetPSNR(img_ori,img_pred,WIDTH,HEIGHT*3));

printf("RECON VS ORIGINAL PSNR : %.2f\n", GetPSNR(img_ori,img_recon,WIDTH,HEIGHT*3));

// get result

FileWrite("[Intra]Lena(512x512).RGB",img_pred,WIDTH,HEIGHT*3);

FileWrite("[Recon]Lena(512x512).RGB",img_recon,WIDTH,HEIGHT*3);
```



Programming Guide

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```
    // memory free
    MemFree_2D(img_in_R,HEIGHT);
    MemFree_2D(img_in_G,HEIGHT);
    MemFree_2D(img_in_B,HEIGHT);
    MemFree_2D(img_pred_R,HEIGHT);
    MemFree_2D(img_pred_G,HEIGHT);
    MemFree_2D(img_pred_B,HEIGHT);
    MemFree_2D(img_ori , HEIGHT*3);
    MemFree_2D(img_pred, HEIGHT*3);
    MemFree_2D_int(img_resi_R,HEIGHT);
    MemFree_2D_int(img_resi_G,HEIGHT);
    MemFree_2D_int(img_resi_B,HEIGHT);

    return 0;
}
BYTE** MemAlloc_2D(int width, int height)
{
    BYTE** arr;
    int i;

    arr = (BYTE**)malloc(sizeof(BYTE*) * height);
    for(i=0; i<height; i++)
        arr[i] = (BYTE*)malloc(sizeof(BYTE) * width);

    return arr;
}
int** MemAlloc_2D_int(int width, int height)
{
    int** arr;
    int i;

    arr = (int**)malloc(sizeof(int*) * height);
    for(i=0; i<height; i++)
        arr[i] = (int*)malloc(sizeof(int) * width);

    return arr;
}
```

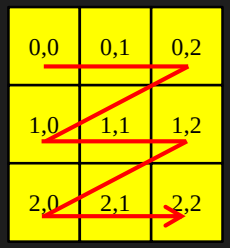
VIAME

Programming Guide

```
void MemFree_2D(BYTE** arr, int height)                    //  2D memory free
{
    int i;
    for(i=0; i<height; i++){
        free(arr[i]);
    }
    free(arr);
}

void MemFree_2D_int(int** arr, int height)                    //  2D memory free
{
    int i;
    for(i=0; i<height; i++){
        free(arr[i]);
    }
    free(arr);
}
void FileRead(char* filename, BYTE** img_in, int width, int height) // read data from a file
{
    FILE* fp_in;
    int i;
    fp_in = fopen(filename, "rb");
    for(i = 0 ; i < height ; i++)
        fread(img_in[i], sizeof(BYTE), width, fp_in);
    fclose(fp_in);
}
void FileWrite(char* filename, BYTE** img_out, int width, int height)   //  write data to a file
{
    FILE* fp_out;
    int i;

    fp_out = fopen(filename, "wb");
    for(i = 0 ; i < height ; i++)
        fwrite(img_out[i], sizeof(BYTE), width, fp_out);
    fclose(fp_out);
}
```

Programming Guide

```
float GetPSNR(BYTE** img_ori, BYTE** img_dist, int width, int height)       //  PSNR calculation
{
    float mse= 0;
    int i,j;

    for(i = 0 ; i < height ; i++){                    // MSE calculation
        for(j = 0 ; j < width ; j++){
            mse += ((img_ori[i][j] - img_dist[i][j]) * (img_ori[i][j] - img_dist[i][j])) / (float)(width*height);
        }
    }
    return 10*(float)log10((255*255)/mse);      // PSNR
}


void Encode(BYTE** img_ori, BYTE** img_pred, int** img_resi, BYTE** img_recon )
{
    int i,j,m,n;
    int best_mode;
    int min_SAD,temp_SAD;

    static BYTE ori  [BLOCK_SIZE*BLOCK_SIZE];
    static BYTE ref  [BLOCK_SIZE*2+1];
    static BYTE pred [3][BLOCK_SIZE*BLOCK_SIZE];
    static BYTE recon[3][BLOCK_SIZE*BLOCK_SIZE];
    static int  resi [3][BLOCK_SIZE*BLOCK_SIZE];


    BYTE** img_padding = MemAlloc_2D(WIDTH + 1, HEIGHT + 1);

    for(i=0; i< HEIGHT; i++)
        for(j=0;j<WIDTH;j++)
            img_padding[i+1][j+1] = img_ori[i][j];

    for(i=0; i<HEIGHT; i++)
        img_padding[i+1][0] = 128;

    for(i=0; i<WIDTH + 1; i++)
        img_padding[0][i] = 128;
```



Programming Guide

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```
    //intra prediction loop
    for(i = 0 ; i < HEIGHT; i += BLOCK_SIZE)
    {
        for(j = 0; j < WIDTH ; j += BLOCK_SIZE)
        {

            // get original block
            for(m=0;m<BLOCK_SIZE;m++)
                for(n=0;n<BLOCK_SIZE;n++)
                {
                    ori[m * BLOCK_SIZE + n ] = img_ori[i + m][j + n];
                }

            // get reference samples
            for(m=0;m<BLOCK_SIZE+1;m++)
                ref[m]   = img_padding[i][j+m];

            for(m=0;m<BLOCK_SIZE;m++)
                ref[5+m] = img_padding[(i+1)+m][j];

            // serch for best mode
            best_mode = intra_prediction(ori, ref,          // input
                                         pred,resi,recon);  // output

            // generate reconstructed image
            for(m=0;m<BLOCK_SIZE;m++)
                for(n=0;n<BLOCK_SIZE;n++)
                {
                    img_pred [i + m][j + n] = pred [best_mode][m * BLOCK_SIZE + n];
                    img_resi [i + m][j + n] = resi [best_mode][m * BLOCK_SIZE + n];
                    img_recon[i + m][j + n] = recon[best_mode][m * BLOCK_SIZE + n];
                }

        }
    }
    MemFree_2D(img_padding,HEIGHT + 1);
}
```

Programming Guide

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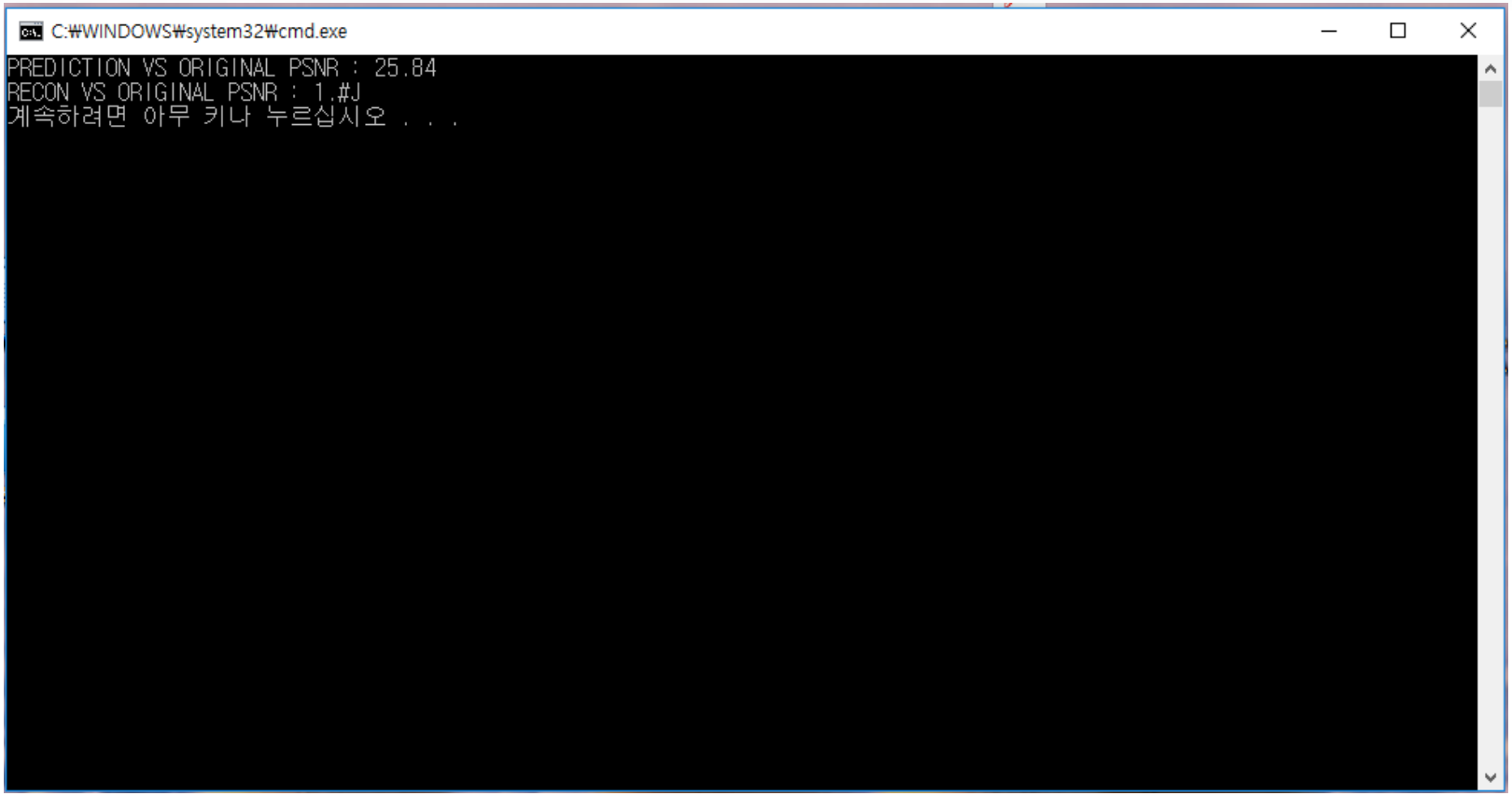
```
int intra_prediction(BYTE* ori, BYTE* ref,                                    //intput
                     BYTE (pred)[3][16], int (resi)[3][16], BYTE (recon)[3][16]) // output
{

    static int SAD[3];
    int min_SAD,best_mode,i,j,n,m;

    SAD[0] = intra_ver(ori, ref, pred[0], resi[0], recon[0]);

    SAD[1] = intra_hor(ori, ref, pred[1], resi[1], recon[1]);

    SAD[2] = intra_dc (ori, ref, pred[2], resi[2], recon[2]);

    best_mode = 0;
    min_SAD = SAD[0];

    for( n =1 ; n < NMODE; n++)
    {
        if(min_SAD > SAD[n])
        {
            min_SAD = SAD[n];
            best_mode = n;
        }
    }

    return best_mode;
}
```

VIAME

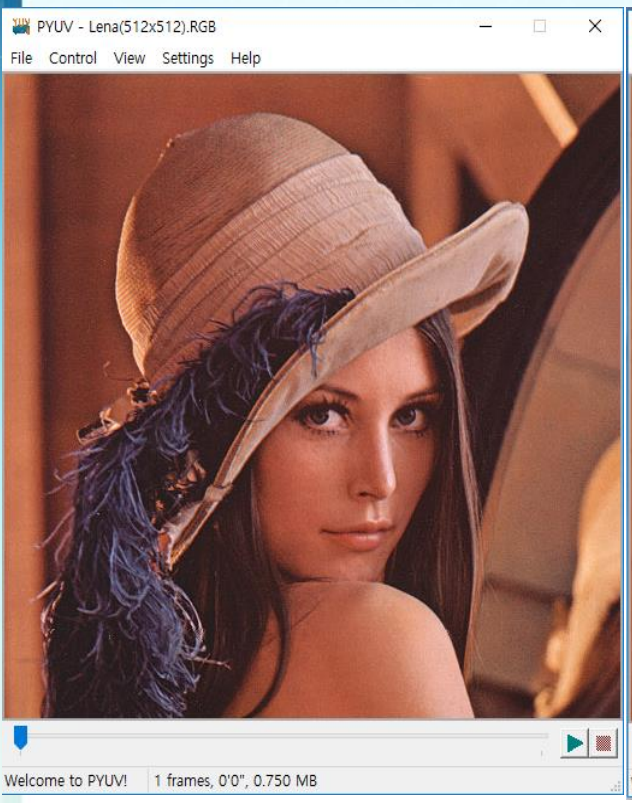
Programming Guide

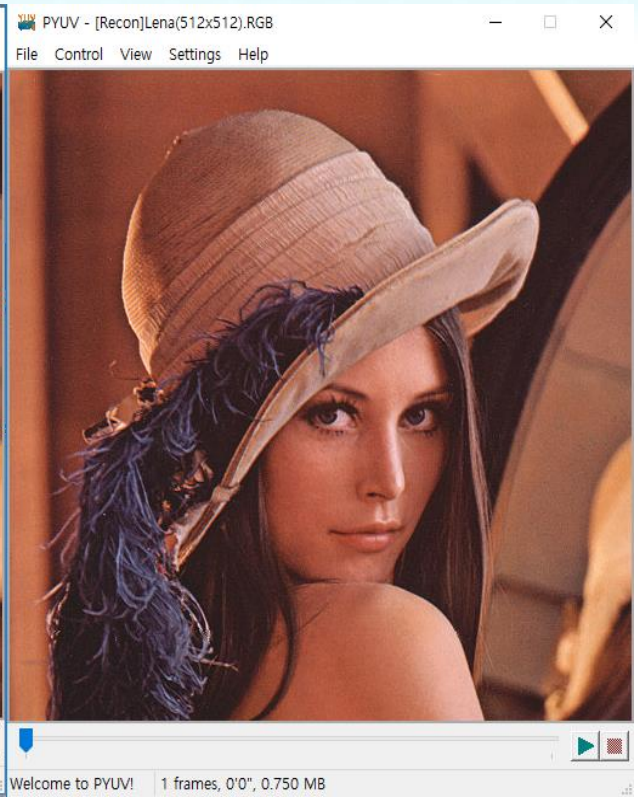
```
int intra_dc(BYTE* ori, BYTE* ref,                          // input
             BYTE* pred, int* resi, BYTE* recon)            // output
{




}

int intra_hor(BYTE* ori, BYTE* ref,                         // input
              BYTE* pred, int* resi, BYTE* recon)           // output
{




}

int intra_ver(BYTE* ori, BYTE* ref,                        // input
              BYTE* pred, int* resi, BYTE* recon)          // output
{




}
```

Result


C:₩WINDOWS₩system32₩cmd.exe
PREDICTION VS ORIGINAL PSNR : 25.84
RECON VS ORIGINAL PSNR : 1.#J
계속하려면 아무 키나 누르십시오 . . .

Result





Original Predicted Image Reconstructed Image

pYUV.exe

- RAW file player
  - Freeware for a researcher