Assignment 1 Code Outputs

Task 1

Convert an image from RGB to YCbCr `4:2:0` and recover it.

Assume that the copied image is equivalent to the original image.

Statistical Comparison

Compare between the copied and transformed images in the RGB color space.

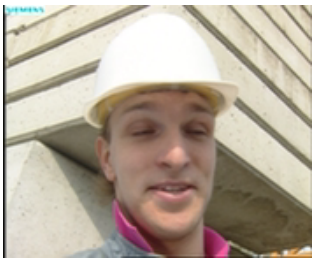
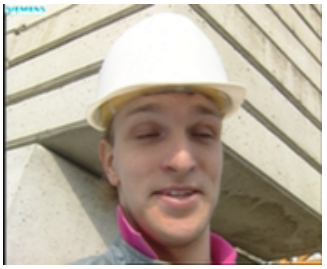
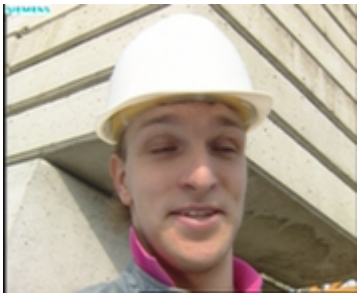
There are the metric results computed between the copied and transformed images below:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.48102', '0.00000'],
 ['MSE', '0.73883', '0.00000'],
 ['NRMSE', '0.00483', '0.00000'],
 ['PSNR', '49.44534', 'inf'],
 ['SSIM', '0.99853', '1.00000']]
```

Visual Comparison

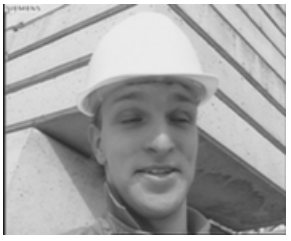
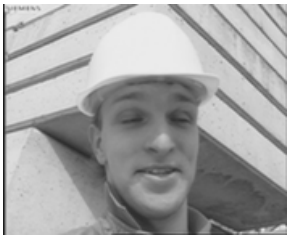
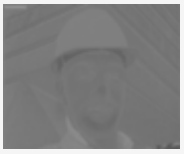
Display images.

There are the images in the RGB color space below; by the way, I add transformed images from YCbCr to RGB using `utils/YUVDisplay.exe` :

Copied Image	Transformed Image (Mine)	Transformed Image (YUVDisplay.exe)
		

There are the images in the YCbCr color space re-mapped in the grayscale colorspace:

	Before sub-sampling	After sub-sampling	After up-sampling

On Y plane			
On Cb plane			
On Cr plane			

Details

The workflow is as follows:

Task 2

Convert the multiple images from RGB to YCbCr `4:2:0` color space and pack them into a planar format.

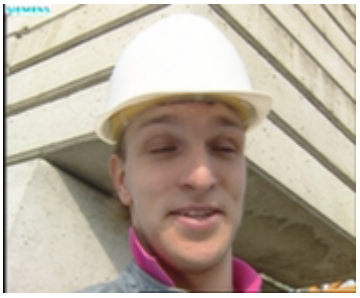
Comparison between the images with and without sub-sampling

The sub-sampled images are re-mapped from YCbCr to grayscale color space for visualization purposes.

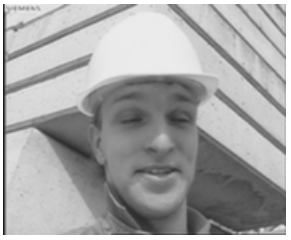
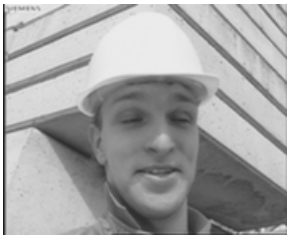
The up-sampled images are for comparison purposes.

The original image `0` in the RGB color space:

The transformed image from `0` re-exported using `utils/YUVDisplay.exe` :

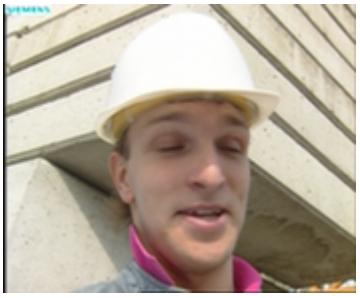


The transformed images on different Y, Cb and Cr planes from `0` in the grayscale colorspace:

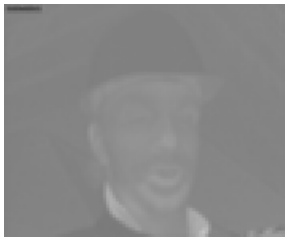
	Without sub-sampling	With sub-sampling	With up-sampling
On Y plane			
On Cb plane			
On Cr plane			

The original image `1` in the RGB color space:

The transformed image from `1` re-exported using `utils/YUVDisplay.exe` :



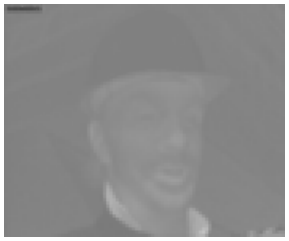
The transformed images on different Y, Cb and Cr planes from `1` in the grayscale colorspace:

	Without sub-sampling	With sub-sampling	With up-sampling
On Y plane			
On Cb plane			
On Cr plane			

The original image `2` in the RGB color space:

The transformed image from `2` re-exported using `utils/YUVDisplay.exe` :

The transformed images on different Y, Cb and Cr planes from `2` in the grayscale colorspace:

	Without sub-sampling	With sub-sampling	With up-sampling
On Y plane			
On Cb plane			
On Cr plane			

Take the images with sequence number `2` to further comparison.

Below are the comparison metrics, they are computed between the image without sub-sampling and the other one with sub-sampling and up-sampling in the YCbCr color space:

The image pair on Y plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.00000', '0.00000'],
 ['MSE', '0.00000', '0.00000'],
 ['NRMSE', '0.00000', '0.00000'],
```

```
 ['PSNR', 'inf', 'inf'],
 ['SSIM', '1.00000', '1.00000']]
```

The image pair on Cb plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.01417', '0.00000'],
 ['MSE', '0.04257', '0.00000'],
 ['NRMSE', '0.00173', '0.00000'],
 ['PSNR', '61.83934', 'inf'],
 ['SSIM', '0.99984', '1.00000']]
```

The image pair on Cr plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.02095', '0.00000'],
 ['MSE', '0.21784', '0.00000'],
 ['NRMSE', '0.00346', '0.00000'],
 ['PSNR', '54.74938', 'inf'],
 ['SSIM', '0.99982', '1.00000']]
```

Details

The workflow is as follows:

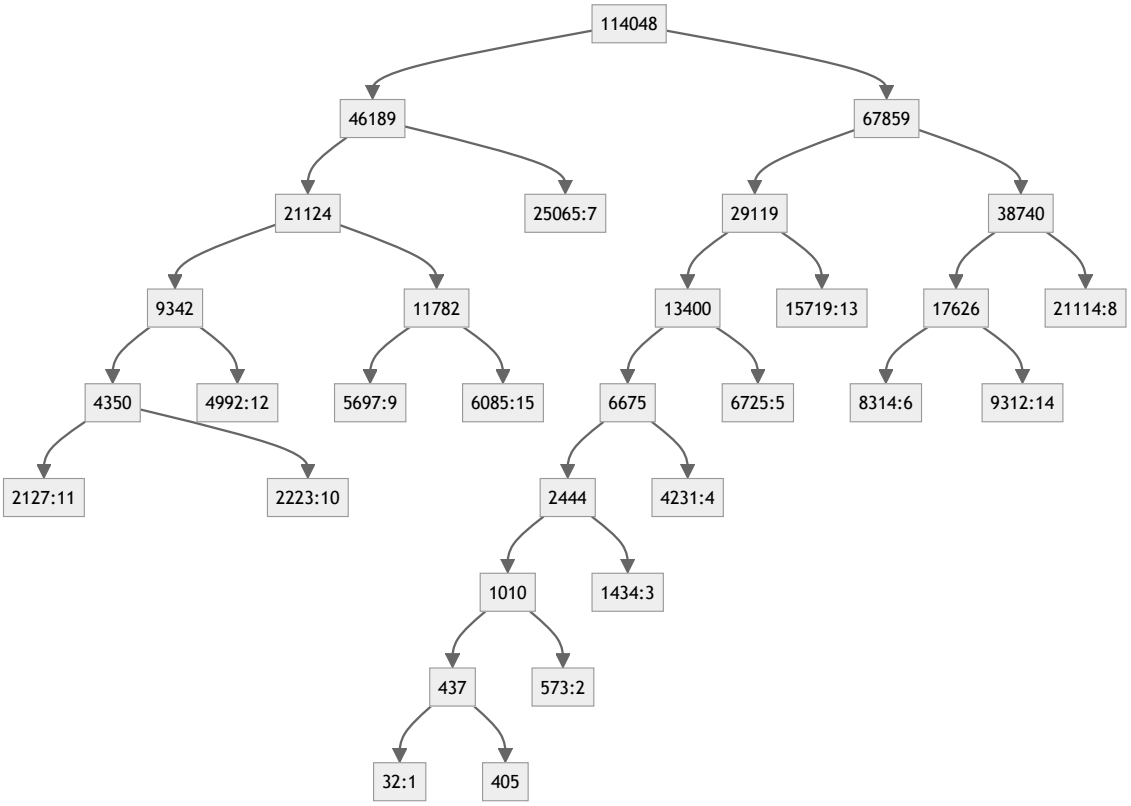
Task 3

Quantize and encode YCbCr `4:2:0` images and recover them.

Taking quantization levels as symbols, here are the Huffman tree and code table used:

```
{0: '10000001',
 1: '10000000',
 2: '1000001',
 3: '100001',
 4: '10001',
 5: '1001',
 6: '1100',
 7: '01',
 8: '111',
 9: '0010',
 10: '00001',
 11: '00000',
 12: '0001',
 13: '101',
```

```
14: '1101',
15: '0011'}
```



Comparison between the images without and with quantization

The quantized versions are visually different from the original RGB images.

The transformed image `0` on different Y, Cb and Cr planes in the grayscale colorspace:

	Before quantization	After quantization & de-quantization
On Y plane		

On Cb plane		
On Cr plane