Assignment 1 Code Outputs

Reproduction

1. Install the requirements

   ```
   python3 -V # Not less than 3.9.0
   python3 -m pip install -Ur requirements.txt
   ```

2. Run all the tasks

   ```
   python3 run_tasks.py
   ```

Task 1

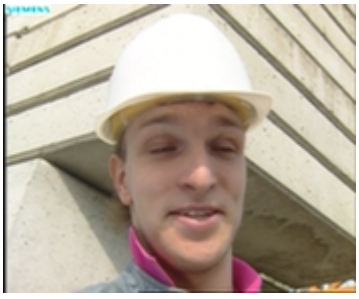
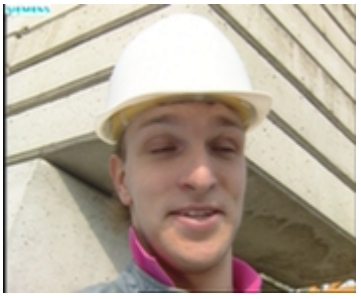
Convert an image from RGB to YCbCr `4:2:0` and recover it.

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

Visual Comparison

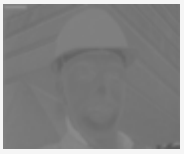
Display images.

There are the images in the RGB color space below.

Copied Image	Transformed Image
	

There are the images in the YCbCr color space re-mapped to the grayscale colorspace below.

	Before sub-sampling	After sub-sampling	After up-sampling
On Y plane			

On Cb plane			
On Cr plane			

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']]
```

Details

The process workflow is as follows.

Task 2

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

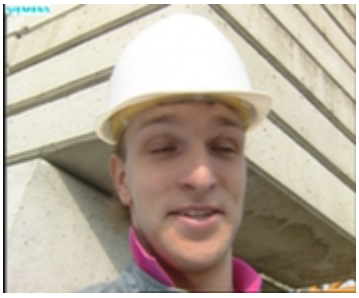
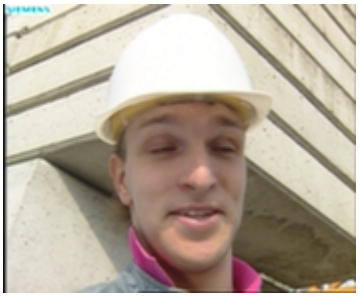
Visual Comparison

Display images.

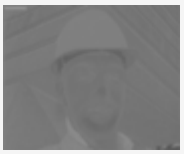
I added the up-sampled images for comparison purposes since they have the same size as the original ones.

The images with sequence number `0` are displayed below.

There are the images in the RGB color space below.

Copied Image	Transformed Image
	

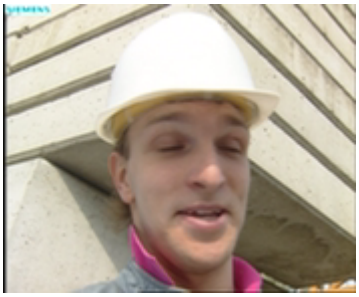
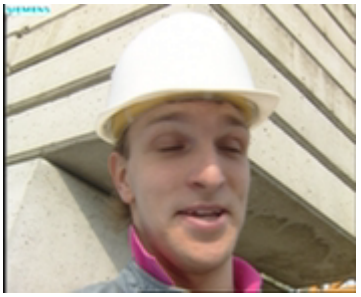
There are images in the YCbCr color space re-mapped to the grayscale color space below.

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

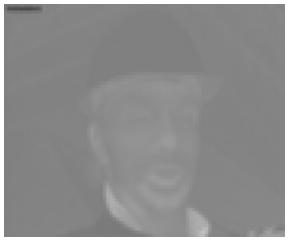
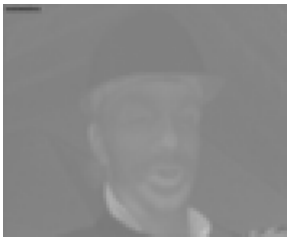
The images with sequence number `1` are displayed below.

There are the images in the RGB color space below.

Copied Image	Transformed Image

There are images in the YCbCr color space re-mapped to the grayscale color space below.

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

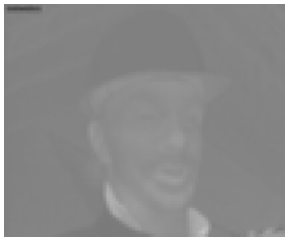
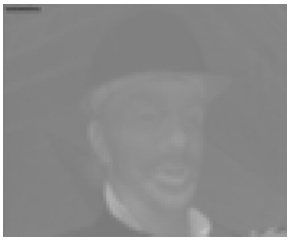
The images with sequence number `2` are displayed below.

There are the images in the RGB color space below.

Copied Image	Transformed Image

There are images in the YCbCr color space re-mapped to the grayscale color space below.

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

Statistical Comparison

Compare between the images without sub-sampling and with sub-sampling in the YCbCr color space.

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

The image pair with sequence number `0` :

On the 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']]
```

On the Cb plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.01610', '0.00000'],
 ['MSE', '0.04553', '0.00000'],
 ['NRMSE', '0.00179', '0.00000'],
 ['PSNR', '61.54750', 'inf'],
 ['SSIM', '0.99981', '1.00000']]
```

On the Cr plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.02233', '0.00000'],
 ['MSE', '0.22230', '0.00000'],
 ['NRMSE', '0.00350', '0.00000'],
 ['PSNR', '54.66139', 'inf'],
 ['SSIM', '0.99976', '1.00000']]
```

The image pair with sequence number `1` :

On the 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']]
```

On the Cb plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.01172', '0.00000'],
 ['MSE', '0.04076', '0.00000'],
 ['NRMSE', '0.00169', '0.00000'],
 ['PSNR', '62.02855', 'inf'],
 ['SSIM', '0.99988', '1.00000']]
```

On the Cr plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '0.02225', '0.00000'],
```

```
 ['MSE', '0.21607', '0.00000'],
 ['NRMSE', '0.00345', '0.00000'],
 ['PSNR', '54.78492', 'inf'],
 ['SSIM', '0.99980', '1.00000']]
```

The image pair with sequence number `2` :

On the 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']]
```

On the 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']]
```

On the 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 process workflow is as follows.

Task 3

Quantize in 16 levels and encode YCbCr `4:2:0` images and recover them.

Uses Huffman coding scheme.

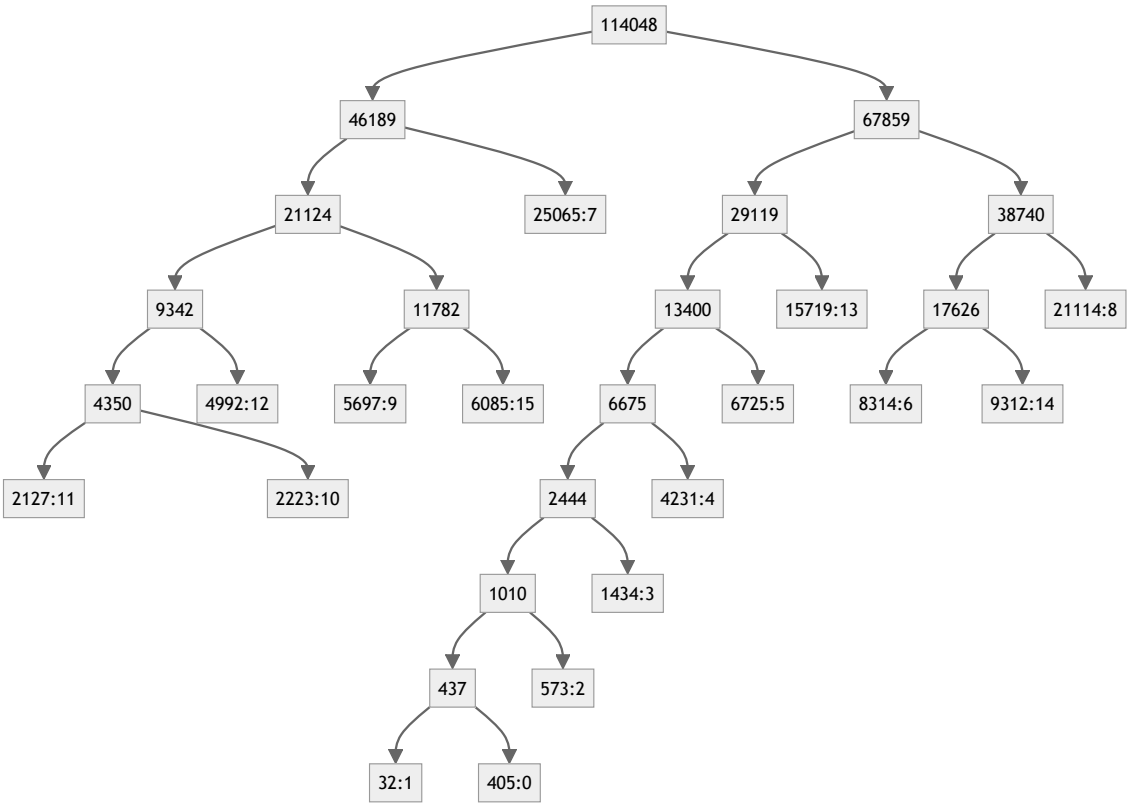
Visual Comparison

Display structures and images.

There are 16 symbols in Huffman code table as the number of quantization levels.

There are the code table and tree diagram of the Huffman tree used below.

```
{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'}
```

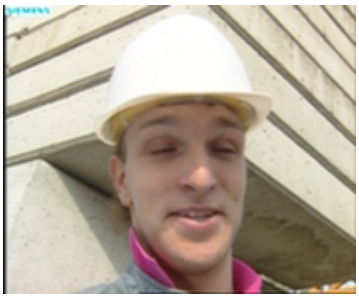


I added assertion checks to ensure that the decoded images are equal to the quantized images. (See the module `src.tasks.quantize_and_encode_multi_frame_in_ycbcr420_and_back`)

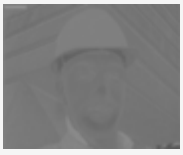
I added the up-sampled images for comparison purposes since they have the same size as the original ones.

The images with sequence number `0` are displayed below.

There are the images in the RGB color space below.

Original Image	Transformed Image
	

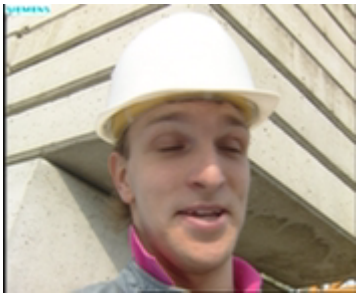
There are images in the YCbCr color space re-mapped to the grayscale color space below.

	Before quantized	After de-quantized
On Y plane		
On Cb plane		
On Cr plane		

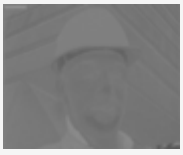
The images with sequence number `1` are displayed below.

There are the images in the RGB color space below.

Original Image	Transformed Image

There are images in the YCbCr color space re-mapped to the grayscale color space below.

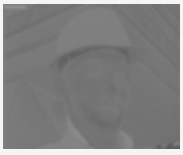
	Before quantized	After de-quantized
On Y plane		
On Cb plane		
On Cr plane		

The images with sequence number `2` are displayed below.

There are the images in the RGB color space below.

Original Image	Transformed Image


There are images in the YCbCr color space re-mapped to the grayscale color space below.

	Before quantized	After de-quantized
On Y plane		
On Cb plane		
On Cr plane		

Statistical Comparison

The image pair with sequence number `0` :

On the Y plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '7.39583', '0.00000'],
 ['MSE', '68.90554', '0.00000'],
 ['NRMSE', '0.04882', '0.00000'],
 ['PSNR', '29.74826', 'inf'],
 ['SSIM', '0.93219', '1.00000']]
```

On the Cb plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '6.20739', '0.00000'],
 ['MSE', '54.14331', '0.00000'],
 ['NRMSE', '0.06166', '0.00000'],
 ['PSNR', '30.79536', 'inf'],
 ['SSIM', '0.91321', '1.00000']]
```

On the Cr plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '5.69776', '0.00000'],
 ['MSE', '48.57812', '0.00000'],
 ['NRMSE', '0.05172', '0.00000'],
 ['PSNR', '31.26640', 'inf'],
 ['SSIM', '0.92156', '1.00000']]
```

The image pair with sequence number `1`:

On the Y plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '7.42551', '0.00000'],
 ['MSE', '69.23674', '0.00000'],
 ['NRMSE', '0.04901', '0.00000'],
 ['PSNR', '29.72744', 'inf'],
 ['SSIM', '0.93298', '1.00000']]
```

On the Cb plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '6.22617', '0.00000'],
 ['MSE', '54.61695', '0.00000'],
 ['NRMSE', '0.06194', '0.00000'],
 ['PSNR', '30.75753', 'inf'],
 ['SSIM', '0.91339', '1.00000']]
```

On the Cr plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '5.70849', '0.00000'],
 ['MSE', '48.54467', '0.00000'],
 ['NRMSE', '0.05167', '0.00000'],
 ['PSNR', '31.26939', 'inf'],
 ['SSIM', '0.92171', '1.00000']]
```

The image pair with sequence number `2`:

On the Y plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '7.41020', '0.00000'],
 ['MSE', '69.00994', '0.00000'],
 ['NRMSE', '0.04898', '0.00000'],
 ['PSNR', '29.74169', 'inf'],
 ['SSIM', '0.93281', '1.00000']]
```

On the Cb plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '6.23658', '0.00000'],
 ['MSE', '55.15199', '0.00000'],
 ['NRMSE', '0.06224', '0.00000'],
 ['PSNR', '30.71519', 'inf'],
 ['SSIM', '0.90988', '1.00000']]
```

On the Cr plane:

```
[['<Metrics>', '<Score>', '<Goal>'],
 ['MAE', '5.77383', '0.00000'],
 ['MSE', '49.73122', '0.00000'],
 ['NRMSE', '0.05226', '0.00000'],
 ['PSNR', '31.16451', 'inf'],
 ['SSIM', '0.92437', '1.00000']]
```

Details

The process workflow is as follows.