

2. (a) Zero-order interpolation method is a simple technique that resamples the pixel values present in an input image. A grey level intensity matrix of a 3×3 image block is shown in Figure 3. Assume a 3 to 5 zero-order interpolation is applied to the image block. Explain the Zero-order interpolation method and show the 5×5 interpolated image block.

零阶插值法是一种对输入图像中存在的像素值

进行重新采样的简单技术。

3×3 图像块的灰度强度矩阵如图3所示。

假设对图像块应用3到5个零阶插值。

解释零阶插值方法，并显示 5×5 插值图像块。

$$\begin{bmatrix} 8 & 1 & 7 \\ 1 & 1 & 1 \\ 6 & 1 & 5 \end{bmatrix}$$

Figure 3

(10 Marks)

- (b) Draw the block diagram of three-layer MPEG-2 Spatial Scalability encoding with the following functional blocks, where the input is a video and the outputs are base layer bitstream and enhancement layer bitstreams.

- Downsample by 4
- Downsample by 2
- Upsample by 2
- Base layer encoder
- Base layer decoder
- Enhancement layer 1 encoder
- Enhancement layer 1 decoder
- Enhancement layer 2 encoder

(10 Marks)

用以下功能块绘制三层MPEG-2 空间可变性编码的框图，其中输入为视频，输出为基础层比特流和增强层比特流。

下采样由4

下采样由2

上采样由2

基层编码器

基层解码器

增强层1编码器

增强层1解码器

增强层2编码器

Answer for Part (a):(a)部分的答案:

Zero-order interpolation, also known as nearest-neighbor interpolation, is a simple resampling method where each output pixel is assigned the value of the nearest pixel from the input image. This method does not compute any new pixel values but instead replicates the existing pixel values to fill the larger output image when upscaling.

零阶插值, 也称为最近邻插值, 是一种简单的重采样方法, 其中每个输出像素被分配与输入图像最近的像素的值。此方法不会计算任何新的像素值, 而是在放大时复制现有的像素值以填充更大的输出图像。

When applying a 3-to-5 zero-order interpolation to a 3×3 image block, the goal is to expand the image to a 5×5 grid by replicating the pixel values of the original image. The mapping from the input pixels to the output pixels is determined by the scaling factor, which in this case is $\frac{5}{3}$ for both dimensions.

当对 3×3 图像块应用 3 到 5 零阶插值时, 目标是通过复制原始图像的像素值将图像扩展为 5×5 网格。从输入像素到输出像素的映射由缩放因子决定, 在本例中为 $\frac{5}{3}$ 对于两个维度。

Mapping Process:映射过程:

1. Compute Scaling Factor:计算比例因子:

- Scaling factor along both axes: $S = \frac{5}{3}$. 沿两个轴的缩放因子: $S = \frac{5}{3}$ 。

2. Calculate Input Pixel Indices for Each Output Pixel:计算每个输出像素的输入像素索引:

- For each output pixel coordinate (x_{out}, y_{out}) , compute the corresponding input pixel indices (x_{in}, y_{in}) using:

对于每个输出像素坐标 (x_{out}, y_{out}) , 计算相应的输入像素索引 (x_{in}, y_{in}) 使用:

$$x_{in} = \left\lfloor \left(\frac{x_{out} - 1}{5} \times 3 \right) \right\rfloor + 1$$
$$y_{in} = \left\lfloor \left(\frac{y_{out} - 1}{5} \times 3 \right) \right\rfloor + 1$$

3. Assign Pixel Values:分配像素值:

- Set each output pixel value $O(x_{out}, y_{out})$ to the input pixel value $I(x_{in}, y_{in})$.

设置每个输出像素值 $O(x_{out}, y_{out})$ 到输入像素值 $I(x_{in}, y_{in})$ 。

Interpolated 5×5 Image Block:插值 5×5 图像块:

$$\begin{bmatrix} 8 & 8 & 1 & 1 & 6 \\ 8 & 8 & 1 & 1 & 6 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 7 & 7 & 1 & 1 & 5 \end{bmatrix}$$

Explanation of the Interpolated Values:插值的解释:

- **First Two Rows:前两行:**

- The values 8 and 1 from the first row of the original image are replicated to fill the expanded rows.价值观 8 和 1 从原始图像的第一行开始复制以填充扩展的行。

- **Middle Rows:中间行:**

- The value 1 from the second row of the original image fills the middle rows.价值 1 从原始图像的第二行开始填充中间行。

- **Last Row:最后一行:**

- The values 7 and 5 from the third row of the original image are replicated accordingly.价值观 7 和 5 从原始图像的第三行开始相应地复制。

Answer for Part (b):(b) 部分的答案:

Below is the block diagram of a three-layer MPEG-2 Spatial Scalability encoder:

下面是三层 MPEG-2 空间可扩展性编码器的框图:

1. Input Video:输入视频:

- The original high-resolution video input.原始高分辨率视频输入。

2. Base Layer Processing:基础层处理:

• Downsample by 4:下采样 4:

- Reduces the input video resolution by a factor of 4.将输入视频分辨率降低 4 倍。

• Base Layer Encoder:基础层编码器:

- Encodes the downsampled video to generate the base layer bitstream.

对下采样视频进行编码以生成基础层比特流。

• Base Layer Bitstream Output:基础层比特流输出:

- The compressed base layer data.压缩的基础层数据。

• Base Layer Decoder:基础层解码器:

- Decodes the base layer bitstream for prediction in enhancement layers.

解码基础层比特流以在增强层中进行预测。

• Upsample by 2:上采样 2:

- Increases the resolution of the decoded base layer video by a factor of 2 to match the next layer's resolution.

将解码的基础层视频的分辨率提高 2 倍以匹配下一层的分辨率。

3. Enhancement Layer 1 Processing:增强层 1 处理:

- **Downsample by 2:下采样 2:**

- The original input video is downsampled by a factor of 2.

原始输入视频被下采样 2 倍。

- **Difference Calculation:差异计算:**

- Compute the residual by subtracting the upsampled base layer video from the downsampled input video.

通过从下采样的输入视频中减去上采样的基础层视频来计算残差。

- **Enhancement Layer 1 Encoder:增强层 1 编码器:**

- Encodes the residual to generate the first enhancement layer bitstream.

对残差进行编码以生成第一增强层比特流。

- **Enhancement Layer 1 Bitstream Output:增强层 1 比特流输出:**

- The compressed data for the first enhancement layer.第一增强层的压缩数据。

- **Enhancement Layer 1 Decoder:增强层 1 解码器:**

- Decodes the first enhancement layer bitstream for use in the next layer.

解码第一个增强层比特流以供下一层使用。

- **Upsample by 2:上采样 2:**

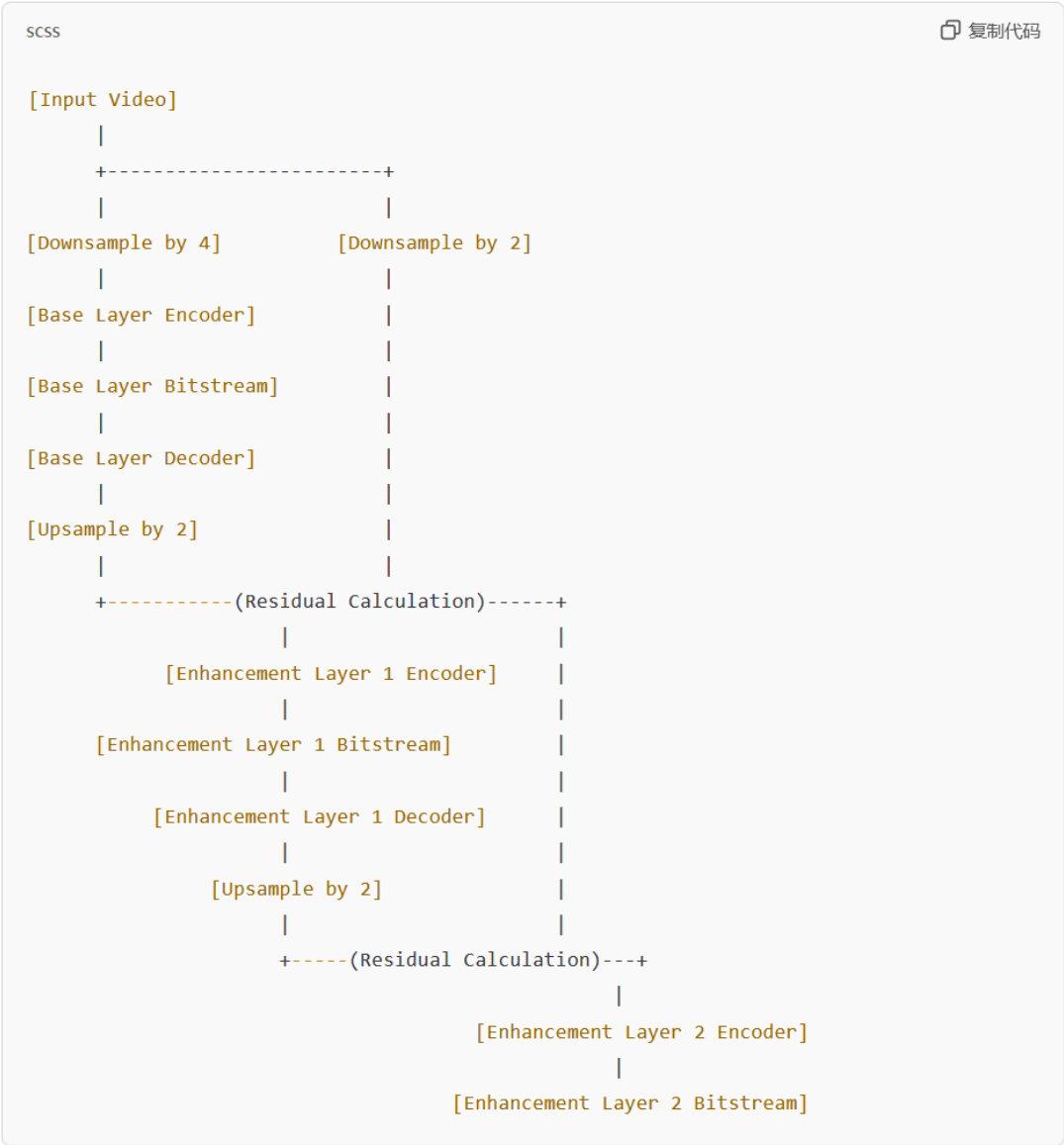
- Upsamples the decoded residual to match the original input video resolution.

对解码残差进行上采样以匹配原始输入视频分辨率。

4. Enhancement Layer 2 Processing:增强第2层处理:

- **Difference Calculation:差异计算:**
 - Compute the residual by subtracting the upsampled enhancement layer 1 video from the original input video.
通过从原始输入视频中减去上采样的增强层 1 视频来计算残差。
- **Enhancement Layer 2 Encoder:增强第 2 层编码器:**
 - Encodes the residual to generate the second enhancement layer bitstream.
对残差进行编码以生成第二增强层比特流。
- **Enhancement Layer 2 Bitstream Output:增强第 2 层比特流输出:**
 - The compressed data for the second enhancement layer.第二增强层的压缩数据。

Block Diagram Representation:框图表示:



Explanation:解释:

- The **Base Layer** provides the basic video quality by encoding the heavily downsampled video.**基础层**通过对大量下采样的视频进行编码来提供基本的视频质量。
- The **First Enhancement Layer** improves video quality by encoding the residual between the upsampled base layer and the less downsampled input.
第一增强层通过对上采样基础层和较少下采样输入之间的残差进行编码来提高视频质量。
- The **Second Enhancement Layer** further enhances quality by encoding the residual between the upsampled first enhancement layer and the original input video.
第二增强层通过对上采样的第一增强层和原始输入视频之间的残差进行编码来进一步增强质量。
- **Downsampling** reduces the video resolution to lower layers.
下采样将视频分辨率降低到较低层。
- **Upsampling** increases the resolution of decoded layers for comparison and residual calculation.**上采样**提高了解码层的分辨率，以进行比较和残差计算。
- **Encoders** compress the data at each layer, and **Decoders** reconstruct it for the next enhancement layer.**编码器**在每一层压缩数据，**解码器**为下一个增强层重建数据。

This layered approach allows for scalable video coding, where the base layer ensures basic playback, and enhancement layers improve quality when bandwidth allows.

这种分层方法允许可扩展的视频编码，其中基础层确保基本播放，增强层在带宽允许的情况下提高质量。