quantization errors in the quantized parameters of a block combine with one another in manners that are difficult to manage without multiple re-encodings and/or extremely complex quantization schemes. Avoiding block artifacts and guaranteeing maximum error control are particularly important features, especially in applications such as medical imaging or professional image/video production.

SUMMARY

In a first aspect, the present disclosure provides a method of processing a signal, the signal being an image encoded at multiple levels of quality, the method comprising: via computer processing hardware, performing image-processing operations of: receiving a first set of adjustment values, the first set of adjustment values specifying adjustments to be made to a predicted rendition of the signal at a first level of quality, the first set of adjustment values indicating how to reconstruct a rendition of the signal at the first level of quality; processing the first set of adjustment values; and deriving a second set of adjustment values based on the processed first set of adjustment values and a rendition of the signal at a second level of quality, the second level of quality lower than the first level of quality, the second set of adjustment values being at least a partial representation of the first set of adjustment values; and wherein deriving the second set of adjustment values includes: processing the first set of adjustment values to produce multiple adjustment components representative of the first set of adjustment values; and producing the second set of adjustment values based on a combination of at least one of the multiple adjustment components with at least one setting associated with the rendition of the signal at the second level of quality.

In a second aspect, the present disclosure provides a method of processing a signal, the signal being an image encoded at multiple levels of quality, the method comprising: via computer processing hardware, performing image-processing operations of: receiving setting information associated with a rendition of the signal at a first level of quality, the setting information encoded to reproduce the signal at the first level of quality; receiving a

set of adjustment values associated with the signal at the first level of quality; producing a preliminary rendition of the signal at a second level of quality based on the setting information, the second level of quality higher than the first level of quality; and producing a secondary rendition of the signal at the second level of quality based on the set of adjustment values and the preliminary rendition of the signal at the second level of quality; wherein producing the secondary rendition of the signal includes: i) modifying the set of adjustment values based at least in part on the rendition of the signal at the first level of quality, wherein modifying the set of adjustment values further includes: processing the set of adjustment values to produce multiple adjustment components representative of the set of adjustment values; and producing the modified set of adjustment values based on a combination of the multiple adjustment components with at least one setting associated with the rendition of the signal at the first level of quality; and ii) applying the modified set of adjustment values to the preliminary rendition of the signal at the second level of quality to produce a secondary rendition of the signal at the second level of quality.

In a third aspect, the present disclosure provides computer-readable storage hardware having instructions stored thereon, the instructions, when carried out by a processing device, causing the processing device to perform operations of: receiving a first set of adjustment values, the first set of adjustment values specifying adjustments to be made to a predicted rendition of a signal generated at a first level of quality to reconstruct a rendition of the signal at the first level of quality, the signal being an image encoded at multiple levels of quality; processing the first set of adjustment values; and deriving a second set of adjustment values based on the first set of adjustment values and a rendition of the signal at a second level of quality, the second level of quality lower than the first level of quality; and wherein deriving the second set of adjustment values includes: processing the first set of adjustment values to produce multiple adjustment components representative of the first set of adjustment values; and producing the second set of adjustment values based on a combination of at least one of the multiple adjustment components with at least one setting associated with the rendition of the signal at the second level of quality.

In a fourth aspect, the present disclosure provides computer-readable storage hardware having instructions stored thereon, the instructions, when carried out by a processing device, causing the processing device to perform operations of: receiving setting information associated with a rendition of a signal at a first level of quality, the signal being an image encoded at multiple levels of quality; receiving a set of adjustment values; producing a preliminary rendition of the signal at a second level of quality based on the setting information, the second level of quality higher than the first level of quality; and producing a secondary rendition of the signal at the second level of quality based on the set of adjustment values and the preliminary rendition of the signal at the second level of quality; wherein producing the secondary rendition of the signal includes: i) modifying the set of adjustment values based at least in part on the rendition of the signal at the first level of quality, wherein modifying the set of adjustment values further includes: processing the set of adjustment values to produce multiple adjustment components representative of the set of adjustment values; and producing the modified set of adjustment values based on a combination of the multiple adjustment components with at least one setting associated with the rendition of the signal at the first level of quality; and ii) applying the modified set of adjustment values to the preliminary rendition of the signal at the second level of quality to produce a secondary rendition of the signal at the second level of quality.

In a fifth aspect, the present disclosure provides a computer system comprising: computer processor hardware; and a hardware storage resource coupled to the computer processor hardware, the hardware storage resource storing instructions that, when executed by the computer processor hardware, causes the computer processor hardware to perform operations of: receiving a first set of adjustment values, the first set of adjustment values specifying adjustments to be made to a predicted rendition of a signal generated at a first level of quality to reconstruct a rendition of the signal at the first level of quality, the signal being an image encoded at multiple levels of quality; processing the first set of adjustment values; and deriving a second set of adjustment values based on the first set of adjustment values and a rendition of the signal at a second level of quality, the second level of quality lower than the first level of quality; and wherein deriving the second set of adjustment

values includes: processing the first set of adjustment values to produce multiple adjustment components representative of the first set of adjustment values; and producing the second set of adjustment values based on a combination of at least one of the multiple adjustment components with at least one setting associated with the rendition of the signal at the second level of quality.

In a sixth aspect, the present disclosure provides a computer system comprising: computer processor hardware; and a hardware storage resource coupled to the computer processor hardware, the hardware storage resource storing instructions that, when executed by the computer processor hardware, causes the computer processor hardware to perform operations of: receiving setting information associated with a rendition of a signal at a first level of quality, the signal being an image encoded at multiple levels of quality; receiving a set of adjustment values; producing a preliminary rendition of the signal at a second level of quality based on the setting information, the second level of quality higher than the first level of quality; and producing a secondary rendition of the signal at the second level of quality based on the set of adjustment values and the preliminary rendition of the signal at the second level of quality; wherein producing the secondary rendition of the signal includes: i) modifying the set of adjustment values based at least in part on the rendition of the signal at the first level of quality, wherein modifying the set of adjustment values further includes: processing the set of adjustment values to produce multiple adjustment components representative of the set of adjustment values; and producing the modified set of adjustment values based on a combination of the multiple adjustment components with at least one setting associated with the rendition of the signal at the first level of quality; and ii) applying the modified set of adjustment values to the preliminary rendition of the signal at the second level of quality to produce a secondary rendition of the signal at the second level of quality.

BRIEF DESCRIPTION

Embodiments herein deviate with respect to conventional systems and methods, providing novel methods to quantize and/or transform element information (such as residual data) to

reconstruct a rendition of an image, enabling encoding methods characterized by efficient entropy coding, low computational complexity, parallelism, scalability, error control, etc. Methods and embodiments herein represent an innovative approach to achieve efficient entropy coding results with low computational complexity, parallelism, scalability, and error control.

According to its broadest aspect, embodiments herein include a method for transforming sets of signal elements (i.e., suitable sequences of values) into sets of transformed signal elements, so as to efficiently entropy encode them. Embodiments illustrated herein are especially focused on the non-limiting use case wherein said signal elements correspond to residual data to be added to a predicted (i.e., preliminary) rendition of an image in order to obtain a target rendition of the same image, said predicted rendition being obtained at least in part by upsampling and/or processing a rendition of the same image at a lower level of quality (e.g., with a lower level of fidelity vs. an original signal rendition). Embodiments illustrated herein are especially focused on non-limiting cases wherein a lower level of quality is a lower resolution (i.e., a coarser sampling grid) across one or more of the dimensions of the signal, although people skilled in the art can easily adapt the same methods to cases wherein a signal at a lower level of quality is a signal with the same resolution and a lower level of detail (e.g., without limitation, a coarser quantization of element values).

Embodiments herein are useful in conjunction with traditional encoding methods, and are useful in conjunction with tier-based encoding methods, a set of other novel methods that

CLAIMS

1. A method of processing a signal, the signal being an image encoded at multiple levels of quality, the method comprising:

via computer processing hardware, performing image-processing operations of:

receiving a first set of adjustment values, the first set of adjustment values specifying adjustments to be made to a predicted rendition of the signal at a first level of quality, the first set of adjustment values indicating how to reconstruct a rendition of the signal at the first level of quality;

processing the first set of adjustment values; and

deriving a second set of adjustment values based on the processed first set of adjustment values and a rendition of the signal at a second level of quality, the second level of quality lower than the first level of quality, the second set of adjustment values being at least a partial representation of the first set of adjustment values; and

wherein deriving the second set of adjustment values includes: processing the first set of adjustment values to produce multiple adjustment components representative of the first set of adjustment values; and

producing the second set of adjustment values based on a combination of at least one of the multiple adjustment components with at least one setting associated with the rendition of the signal at the second level of quality.

2. The method as in claim 1 further comprising:

calculating at least one of the adjustment values in the second set based on a linear combination of the first set of adjustment values with the rendition of the signal at the second level of quality.

3. The method as in claim 1 further comprising:

receiving the rendition of the signal at the first level of quality;

producing the rendition of the signal at the second level of quality based on the rendition of the signal at the first level of quality;

producing the predicted rendition of the signal at the first level of quality based at least in part on the rendition of the signal at the second level of quality;

producing the first set of adjustment values as a difference between the rendition of the

signal at the first level of quality and the predicted rendition of the signal at the first level of quality;

encoding the second set of adjustment values and the rendition of the signal at the second level of quality into corresponding encoded information; and

transmitting the corresponding encoded information to decoder processing hardware;

further comprising:

at the decoder processing hardware:

receiving the encoded information;

from the encoded information, obtaining reconstruction data specifying how to reconstruct the rendition of the signal at the second level of quality;

from the encoded information, obtaining the second set of adjustment values;

reproducing the predicted rendition of the signal at the first level of quality based on the obtained reconstruction data.

4. The method as in claim 1 further comprising:

producing multiple sets of reconstruction data, each set of reconstruction data including settings for multiple components, each of the sets of multiple components including a first component value and a second component value, the first component value in each of the sets corresponding to a first attribute class, the second component value in each of the sets corresponding to a second attribute class;

creating a first grouping to include a first component value from each of multiple sets of

reconstruction data;

creating a second grouping to include a second component value from each of multiple sets of reconstruction data; and

encoding the first grouping independently of encoding the second grouping.

5. The method as in claim 1, wherein the second set of adjustment values is one of multiple sets of reconstruction data used to reconstruct a plane of elements in the signal, the method further comprising:

encoding each of at least two of the multiple sets of reconstruction data using a common symbol.

6. The method as in claim 1, wherein deriving the second set of adjustment values further includes:

i) producing a formatted set of adjustment values from the first set of adjustment values;

ii) transforming the formatted set of adjustment values into the second set of adjustment values, the method further comprising:

applying a quantization algorithm to the second set of adjustment values to produce a set of quantized adjustment values.

7. The method as in claim 1 further comprising:

quantizing the adjustment components to produce a quantized set of adjustment values.

8. The method as in claim 1, wherein the first level of quality is a first image resolution; and

wherein the second level of quality is a second image resolution, the second image resolution lower than the first image resolution.

9. A method of processing a signal, the signal being an image encoded at multiple levels of quality, the method comprising:

via computer processing hardware, performing image-processing operations of:

receiving setting information associated with a rendition of the signal at a first level of quality, the setting information encoded to reproduce the signal at the first level of quality;

receiving a set of adjustment values associated with the signal at the first level of quality;

producing a preliminary rendition of the signal at a second level of quality based on the setting information, the second level of quality higher than the first level of quality; and

producing a secondary rendition of the signal at the second level of quality based on the set of adjustment values and the preliminary rendition of the signal at the second level of quality;

wherein producing the secondary rendition of the signal includes: i) modifying the set of adjustment values based at least in part on the rendition of the signal at the first level of quality, wherein modifying the set of adjustment values further includes: processing the set of adjustment values to produce multiple adjustment components representative of the set of adjustment values; and producing the modified set of adjustment values based on a combination of the multiple adjustment components with at least one setting associated with the rendition of the signal at the first level of quality; and ii) applying the modified set of adjustment values to the preliminary rendition of the signal at the second level of quality to produce a secondary rendition of the signal at the second level of quality.

10. The method as in claim 9, wherein the setting information is first setting information; and

wherein modifying the set of adjustment values includes:

receiving the first setting information, the first setting information associated with the rendition of the signal at the first level of quality;

receiving second setting information, the second setting information associated with the preliminary rendition of the signal at the second level of quality, the preliminary rendition of the signal at the second level of quality derived from the first setting information;

applying a mathematical algorithm to a combination of the first setting information and the second setting information to produce a modification value; and

applying the modification value to the set of adjustment values to produce the modified set of adjustment values.

11. The method as in claim 10, wherein applying the modification value to the set of adjustment values to produce the modified set of adjustment values includes:

retrieving a data component from the set of adjustment values; and

summing the modification value and the retrieved component to modify the component.

12. The method as in claim 11, wherein the preliminary rendition of the signal at the second level of quality is a predicted rendition of the signal at the second level of quality; and

wherein the secondary rendition of the signal at the second level of quality is used as a basis to produce a preliminary rendition of the signal at a third level of quality, the third level of quality higher than the second level of quality.

13. The method as in claim 9, wherein at least one of multiple components in the set of adjustment values includes directional tilt information capturing settings associated with multiple elements in the rendition of the signal at the second level of quality.

14. The method as in claim 9 further comprising:

receiving metadata associated with the set of adjustment values;

identifying an operation as specified by the metadata; and

applying the operation to the set of adjustment values to derive the secondary rendition of the signal from the preliminary rendition of the signal.

15. The method as in claim 9 further comprising:

applying a linear combination function to the modified set of adjustment values to generate a set of modifier values; and

applying the modifier values to the preliminary rendition of the signal to produce the secondary rendition of the signal at the second level of quality, wherein the linear combination function includes addition functions and subtraction functions to generate the set of modifier values, wherein addition functions and subtraction functions

correspond to coefficients of a matrix selected from a group comprising:

$$\underline{\underline{M}} = \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}; \begin{pmatrix} 1 & 2 & 1 \\ 1 & -1 & 1 \\ 1 & -1 & -2 \end{pmatrix}; \begin{pmatrix} 1 & 1 & 1 & 1 \\ -1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{pmatrix}; \begin{pmatrix} 1 & 3 & 2 & 1 \\ 1 & -1 & 2 & 1 \\ 1 & -1 & -2 & 1 \\ 1 & -1 & -2 & -3 \end{pmatrix}; \begin{pmatrix} 1 & 4 & 3 & 2 & 1 \\ 1 & -1 & 3 & 2 & 1 \\ 1 & -1 & -2 & 2 & 1 \\ 1 & -1 & -2 & -3 & 1 \\ 1 & -1 & -2 & -3 & -4 \end{pmatrix}$$

$$; \begin{pmatrix} 1 & 5 & 4 & 3 & 2 & 1 \\ 1 & -1 & 4 & 3 & 2 & 1 \\ 1 & -1 & -2 & 3 & 2 & 1 \\ 1 & -1 & -2 & -3 & 2 & 1 \\ 1 & -1 & -2 & -3 & -4 & 1 \\ 1 & -1 & -2 & -3 & -4 & -5 \end{pmatrix}.$$

16. The method as in claim 9 further comprising:

applying a first dequantization operation to reproduce a first adjustment value in the set; and

applying a second dequantization operation to reproduce a second adjustment value, the first dequantization operation different than the second dequantization operation.

17. Computer-readable storage hardware having instructions stored thereon, the instructions, when carried out by a processing device, causing the processing device to perform operations of:

receiving a first set of adjustment values, the first set of adjustment values specifying adjustments to be made to a predicted rendition of a signal generated at a first level of quality to reconstruct a rendition of the signal at the first level of quality, the signal being an image encoded at multiple levels of quality;

processing the first set of adjustment values; and

deriving a second set of adjustment values based on the first set of adjustment values and a rendition of the signal at a second level of quality, the second level of quality lower than the first level of quality; and

wherein deriving the second set of adjustment values includes: processing the first set of adjustment values to produce multiple adjustment components representative of the first set of adjustment values; and producing the second set of adjustment values based on a combination of at least one of the multiple adjustment components with at least one setting associated with the rendition of the signal at the second level of quality.

18. Computer-readable storage hardware having instructions stored thereon, the instructions, when carried out by a processing device, causing the processing device to perform operations of:

receiving setting information associated with a rendition of a signal at a first level of quality, the signal being an image encoded at multiple levels of quality;

receiving a set of adjustment values;

producing a preliminary rendition of the signal at a second level of quality based on the setting information, the second level of quality higher than the first level of quality; and

producing a secondary rendition of the signal at the second level of quality based on the set of adjustment values and the preliminary rendition of the signal at the second level of quality;

wherein producing the secondary rendition of the signal includes: i) modifying the set of adjustment values based at least in part on the rendition of the signal at the first level of

quality, wherein modifying the set of adjustment values further includes: processing the set of adjustment values to produce multiple adjustment components representative of the set of adjustment values; and producing the modified set of adjustment values based on a combination of the multiple adjustment components with at least one setting associated with the rendition of the signal at the first level of quality; and ii) applying the modified set of adjustment values to the preliminary rendition of the signal at the second level of quality to produce a secondary rendition of the signal at the second level of quality.

19. A computer system comprising:

computer processor hardware; and

a hardware storage resource coupled to the computer processor hardware, the hardware storage resource storing instructions that, when executed by the computer processor hardware, causes the computer processor hardware to perform operations of:

receiving a first set of adjustment values, the first set of adjustment values specifying adjustments to be made to a predicted rendition of a signal generated at a first level of

quality to reconstruct a rendition of the signal at the first level of quality, the signal being an image encoded at multiple levels of quality;

processing the first set of adjustment values; and

deriving a second set of adjustment values based on the first set of adjustment values and a rendition of the signal at a second level of quality, the second level of quality lower than the first level of quality; and

wherein deriving the second set of adjustment values includes: processing the first set of adjustment values to produce multiple adjustment components representative of the first set of adjustment values; and producing the second set of adjustment values based on a combination of at least one of the multiple adjustment components with at least one setting associated with the rendition of the signal at the second level of quality.

20. A computer system comprising:

computer processor hardware; and

a hardware storage resource coupled to the computer processor hardware, the hardware storage resource storing instructions that, when executed by the computer processor hardware, causes the computer processor hardware to perform operations of:

receiving setting information associated with a rendition of a signal at a first level of quality, the signal being an image encoded at multiple levels of quality;

receiving a set of adjustment values;

producing a preliminary rendition of the signal at a second level of quality based on the setting information, the second level of quality higher than the first level of quality; and

producing a secondary rendition of the signal at the second level of quality based on the set of adjustment values and the preliminary rendition of the signal at the second level of quality;

wherein producing the secondary rendition of the signal includes: i) modifying the set of adjustment values based at least in part on the rendition of the signal at the first level of quality, wherein modifying the set of adjustment values further includes: processing the set of adjustment values to produce multiple adjustment components representative of the set of adjustment values; and producing the modified set of adjustment values based on a

combination of the multiple adjustment components with at least one setting associated with the rendition of the signal at the first level of quality; and ii) applying the modified set of adjustment values to the preliminary rendition of the signal at the second level of quality to produce a secondary rendition of the signal at the second level of quality.