CLAIMS

1. A method of reconstructing a signal at successively higher levels of quality in a hierarchy, the method comprising:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation specified by the second set of decoded data; and

applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the first level of quality to reconstruct the signal at a second level of quality, the second level of quality being higher than the first level of quality.

2. The method as in claim 1 further comprising:

decoding a third set of data;

identifying an upsample operation specified by the third set of decoded data; and

applying the upsample operation identified in the third set of decoded data to the reconstructed signal at the second level of quality to reconstruct the signal at a third level of quality, the third level of quality being higher than the second level of quality in the hierarchy.

3. The method as in claim 2, wherein the upsample operation identified in the second set of decoded data is a first upsample operation; and

wherein the upsample operation identified in the third set of decoded data is a second upsample operation, the first upsample operation being different from the second upsample operation.

4. The method as in claim 1, wherein the upsample operation applied to the reconstructed signal at the first level of quality includes at least one operation selected from the group consisting of:

i) a linear filter operation, in particular a bilinear filter or a trilinear filter,

ii) a cubic filter operation, in particolar a bicubic filter or a tricubic filter,

iii) a deblending filter, and

iv) an unsharp masking filter.

5. The method as in claim 1 further comprising:

applying the upsample operation specified by the second set of decoded data to at least one reconstructed signal at least one level higher than the second level of quality until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use a different upsample operation than the upsample operation identified in the second set of decoded data.

6. The method as in claim 1 further comprising:

decoding a third set of data; and

in response to identifying that the third set of decoded data does not specify a particular upsample operation, applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the second level of quality to reconstruct the signal at a third level of quality, the third level of quality being higher than the second level of quality in the hierarchy.

7. The method as in claim 1 further comprising:

retrieving residual data from the second set of decoded data, the residual data indicating how to modify the reconstructed signal at the second level of quality subsequent to application of the upsampling operation;

modifying the reconstructed signal at the second level of quality as specified by the residual data; and

modifying, as specified by the residual data retrieved from the second set of decoded data, a reconstructed signal at a level of quality higher than the second level of quality.

8. The method as in claim 1 further comprising:

processing the second set of decoded data to identify a specific portion of the reconstructed signal at the first level of quality in which to apply the upsample operation specified by the second set of decoded data; and

wherein applying the upsample operation includes applying the upsample operation to the specific portion of the reconstructed signal at the first level of quality to reconstruct the signal at the second level of quality.

9. The method as in claim 1 further comprising:

processing the second set of decoded data to identify an attribute type of a specifically identified portion of the reconstructed signal at the first level of quality;

mapping the attribute type to a set of at least one upsample operation, the set of at least one upsample operation configured to a type of data in the signal as specified by the attribute type; and

for each portion of the signal, utilizing the set of at least one upsample operation defined by its attribute type as default upsample operations for the reconstruction of subsequent levels of quality of that portion of the signal, until a respective set of decoded data for a higher level of quality than the first level of quality specifies to use for the signal or for portions of the signal different attribute types.

10. The method as in claim 1 further comprising:

applying different upsample operations identified in the second set of decoded data to different portions of the reconstructed signal at the first level of quality to reconstruct the signal at the second level of quality; and

for each portion of the signal, utilizing the set of at least one upsample operation identified in the second set of decoded data as default upsample operations for the reconstruction of subsequent levels of quality of that portion of the signal, until a respective set of decoded data for a higher level of quality than the first level of quality specifies to use for the signal or for portions of the signal different upsample operations.

11. The method as in claim 1 further comprising:

processing the second set of decoded data to identify a scale factor value, the scale factor value indicating the resolution in which to upsample the reconstructed signal at the first level of quality into the reconstructed signal at the second level of quality; and

in accordance with the scale factor, upsampling the reconstructed signal at the first level of quality into the reconstructed signal at the second level of quality, in lieu of performing the upsampling in accordance with a default scale factor value.

12. The method as in claim 11 further comprising:

utilizing the scale factor value to upsample the reconstructed signal at the first level of quality into the reconstructed signal at the second level of quality in lieu of performing the upsampling in accordance with a default scale factor value.

13. The method as in claim 1 further comprising:

utilizing scale factor values as specified by sets of decoded data at different levels of the hierarchy to reconstruct the signal in lieu of performing upsampling in accordance with default scale factor values for the different levels of quality in the hierarchy.

14. The method as in claim 13, wherein the scale factor values include a first scale factor value and second scale factor value, the first scale factor value specified by the first set of decoded data and the second scale factor value specified by the second set of decoded data, the first scale factor value being different than the second scale factor value, the method further comprising:

utilizing the first scale factor value to upsample and reconstruct the signal at the resolution indicated by the first scale factor and by the resolution of the first level of quality; and

utilizing the second scale factor value to reconstruct the signal at the second level of quality.

15. The method as in claim 7 further comprising:

identifying residual data as specified by second set of decoded data; and

modifying the elements of the reconstructed signal at the second level of quality in a manner as specified by the residual data; and

using the residual data as specified by the second set of decoded data also for the reconstruction of higher levels of quality than the second level of quality until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use different residual data.

16. The method as in claim 1 further comprising:

identifying residual data as specified by second set of decoded data,

utilizing a multi-scale entropy decoder to decode the residual data, the decoded residual data specifying how to modify specific elements of the reconstructed signal at the second level of quality; and

modifying the elements of the reconstructed signal at the second level of quality in a manner as specified by the decoded residual data.

17. The method as in claim 1 further comprising:

decoding the second set of data to identify characteristics of simulated residuals, the characteristics indicating to the decoder how to simulate residuals to be added to the reconstructed version of the signal, but not indicating the specific elements of the reconstructed signal that should be modified and the specific modifications to apply; and

for each signal element, using the characteristics of simulated residuals data as specified by the second set of decoded data also to characterize simulated residuals for higher levels of quality than the second level of quality of the signal elements co-located with that signal element, until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use for the signal or for portions of the signal different characteristics of simulated residuals; and

utilizing the set of characteristics to modify the elements of the reconstructed signal at the displayed level of quality in a manner as specified by the simulated residual data.

18. The method as in claim 1 further comprising:

decoding the second set of data to identify spectral characteristics associated with residuals that represent lower priority information (e.g., film grain, camera sensor noise, lower priority details of the signal, etc.), the spectral characteristics indicating to the decoder how to simulate the residuals to add to the reconstructed signal, without indicating the actual location or the specific values of the residuals; and

for each signal element, utilizing the spectral characteristics as specified by the second set of decoded data also to characterize simulated residuals for higher levels of quality than the second level of quality of the portion of the signal co-located with that signal element, until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use for the signal or for specific portions of the signal different spectral characteristics of simulated residuals; and

utilizing the set of spectral characteristics to modify the elements of the reconstructed signal at the displayed level of quality in a manner as specified by the simulated residual data.

19. The method as in claim 1, wherein the hierarchy includes an additional set of data

to reconstruct the signal according to a subsequent level of quality in the hierarchy, the subsequent level of quality being higher than the current level of quality in the hierarchy, the method further comprising:

display of image information on a display device in accordance with the reconstructed signal at the current level of quality.

20. The method as in claim 1 further comprising:

for each of multiple levels of quality above the second level of quality, repeating steps of:

decoding a next higher set of data in the hierarchy above a last processed level of quality;

identifying an upsample operation and/or scale factor specified by the next higher set of decoded data;

applying the upsample operation identified in the next higher set of decoded data to reconstruct the signal at a next higher level of quality;

identifying residual information and/or residual characteristics specified by the next higher set of decoded data; and

applying the residual information to modify the reconstructed signal at the higher level of quality.

21. The method as in claim 1 wherein:

the decoder receives separate signal hierarchies for the different color planes of the signal, the separate signal hierarchies featuring independent and potentially different scale factors, operations and highest levels of quality;

when the different reconstructed color planes feature different levels of quality, the decoder upsamples the lower-resolution color planes in order for them to match the resolution of the color plane with the highest level of quality, and subsequently joins all the reconstructed color planes into a reconstructed color signal to send to the display device.

22. The method as in claim 1 wherein:

decoding separate received signal hierarchies for different color planes associated with the signal, the separate received signal hierarchies featuring independent and potentially different scale factors, operations and highest levels of quality; and

when different reconstructed color planes feature different levels of quality, upsampling

the lower-resolution color planes to match the resolution of the color plane with the highest level of quality, and subsequently joining the reconstructed color planes into a reconstructed color signal to send to a display device.

23. The method as in claim 1 further comprising:

retrieving auxiliary information, in particular information on motion, warp information and so on, from the second set of decoded data, the auxiliary information indicating parameters influencing the application of the upsampling operation(s) to the signal at the first level of quality and influencing the modification of the reconstructed signal at the second level of quality as specified by the residual data.

24. A computer system comprising:

a processor;

a memory unit that stores instructions associated with an application executed by the processor; and

an interconnect coupling the processor and the memory unit, enabling the computer system to execute the application and perform operations of:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation specified by the second set of decoded data; and

applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the first level of quality to reconstruct the signal at a second level of quality, the second level of quality being higher than the first level of quality.

25. A computer-readable hardware storage hardware having instructions stored thereon, the instructions, when carried out by a processing device, causes the processing device to perform operations of:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation specified by the second set of decoded data; and

applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the first level of quality to reconstruct the signal at a second level of quality, the second level of quality being higher than the first level of quality.

CLAIMS

1. A method of reconstructing a signal at successively higher levels of quality in a hierarchy, the method comprising:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation specified by the second set of decoded data; and

applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the first level of quality to reconstruct a preliminary rendition of the signal at a second level of quality, the second level of quality being higher than the first level of quality.

2. The method as in claim 1 further comprising:

adjusting the preliminary rendition of the signal at the second level of quality to reconstruct a rendition of the signal at the second level of quality;

decoding a third set of data;

identifying an upsample operation specified by the third set of decoded data; and

applying the upsample operation identified in the third set of decoded data to the reconstructed signal at the second level of quality to reconstruct the signal at a third level of quality, the third level of quality being higher than the second level of quality in the hierarchy and the upsample operation specified by the third set of data including a set of upsample kernel coefficients and/or an image processing operation that is substantially specific to the signal at a third level of quality and different from each of the sets of upsample kernel coefficients and image processing operations used by the upsample operation specified by the second set of decoded data.

3. The method as in claim 1, wherein the encoded upsample operation data is decoded by means of a tier based decoding method, the method comprising:

decoding upsample operation data at a first (lower) level of quality;

based on the decoded upsample operation data at the first level of quality, producing a preliminary rendition of upsample operation data at a second (higher) level of quality;

decoding a set of upsample operation adjustments;

combining upsample operation adjustments with the preliminary rendition of upsample operation data at the second level of quality, producing upsample operation data at the second level of quality.

4. The method as in claim 1, wherein the upsample operation applied to the reconstructed signal at the first level of quality includes at least one operation selected from the group consisting of:

i) an upsample operation with cubic kernel parameters, in particular a bicubic filter,

ii) an edge reconstruction upsample filter, in particular a deblending filter, and

iii) an unsharp masking operation.

5. The method as in claim 3 further comprising:

from the second set of data, decoding an inheritance symbol corresponding to a given portion of the signal;

applying the upsample operation identified for the given portion of the signal in the second set of decoded data to the reconstructed signal at the second level of quality to reconstruct a preliminary rendition of a corresponding portion of the signal at a third level of quality, the third level of quality being higher than the second level of quality in the hierarchy.

6. The method as in claim 1, wherein the upsample operation includes upsampling the signal along more than two dimensions (such as a volumetric upsampling operation or a space-temporal upsampling operation).

7. The method as in claim 1 further comprising:

decoding a third set of data; and

in response to identifying that the third set of decoded data does not specify a particular upsample operation, applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the second level of quality to reconstruct the signal at a third level of quality, the third level of quality being higher than the second level of quality in the hierarchy.

8. A method of reconstructing a signal at successively higher levels of quality in a hierarchy, the method comprising:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation; and

applying the identified upsample operation to the reconstructed signal at the first level of quality to reconstruct a preliminary rendition of the signal at a second level of quality, the second level of quality being higher than the first level of quality;

simultaneously processing subsets of the second set of data in parallel to retrieve residual data, the residual data indicating how to modify the preliminary rendition of the signal at the second level of quality reconstructed subsequent to application of the upsampling operation;

modifying the preliminary rendition of the signal at the second level of quality as specified by the residual data.

9. The method as in claim 1 further comprising:

simultaneously processing subsets of the second set of data in parallel and for each of said subsets decoding the upsample operation to apply to a specific portion of the reconstructed signal at the first level of quality; and

wherein applying the upsample operation includes applying the upsample operation to the specific portion of the reconstructed signal at the first level of quality to reconstruct the signal at the second level of quality.

10. The method as in claim 1 further comprising:

processing the second set of decoded data to identify an attribute type of a specifically identified portion of the reconstructed signal at the first level of quality;

mapping the attribute type to a set of at least one upsample operation, the set of at least one upsample operation configured to a type of data in the signal as specified by the attribute type; and

for each portion of the signal, utilizing the set of at least one upsample operation defined by its attribute type as default upsample operations for the reconstruction of subsequent levels of quality of that portion of the signal, until a respective set of decoded data for a higher level of quality than the first level of quality specifies to use for the signal or for portions of the signal different attribute types.

11. The method as in claim 1 further comprising:

applying different upsample operations identified in the second set of decoded data to different portions of the reconstructed signal at the first level of quality to reconstruct the signal at the second level of quality; and

for each portion of the signal, utilizing the set of at least one upsample operation identified in the second set of decoded data as default upsample operations for the reconstruction of subsequent levels of quality of that portion of

the signal, until a respective set of decoded data for a higher level of quality than the first level of quality specifies to use for the signal or for portions of the signal different upsample operations.

12. The method as in claim 1 further comprising:

processing the second set of decoded data to identify a scale factor value, the scale factor value indicating the resolution, such as spatial and/or temporal resolution, in which to upsample the reconstructed signal at the first level of quality into the reconstructed signal at the second level of quality; and

in accordance with the scale factor, upsampling the reconstructed signal at the first level of quality into the reconstructed signal at the second level of quality.

13. The method as in claim 1 further comprising:

utilizing scale factor values as specified by sets of decoded data at different levels of the hierarchy to reconstruct the signal in lieu of performing upsampling in accordance with default scale factor values for the different levels of quality in the hierarchy.

14. The method as in claim 13, wherein the scale factor values include a first scale factor value and second scale factor value, the first scale factor value specified by the first set of decoded data and the second scale factor value specified by the second set of decoded data, the first scale factor value being different than the second scale factor value, the method further comprising:

utilizing the first scale factor value to upsample and reconstruct the signal at the resolution indicated by the first scale factor and by the resolution of the first level of quality; and

utilizing the second scale factor value to reconstruct the signal at the second level of quality.

15. The method as in claim 8 further comprising:

identifying residual data as specified by the second set of decoded data; and

modifying the elements of the reconstructed signal at the second level of quality in a manner as specified by the residual data; and

using residual data as specified by the second set of decoded data also for the reconstruction of higher levels of quality than the second level of quality until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use different residual data.

16. The method as in claim 1 further comprising:

identifying residual data as specified by second set of decoded data,

utilizing a set of parallel entropy decoders to decode the residual data, the decoded residual data specifying how to modify specific elements of the reconstructed signal at the second level of quality; and

modifying the elements of the reconstructed signal at the second level of quality in a manner as specified by the decoded residual data.

17. The method as in claim 1 further comprising:

decoding the second set of data to identify characteristics of simulated residuals, the characteristics indicating to the decoder how to simulate residuals to be added to the reconstructed version of the signal, but not indicating the specific elements of the reconstructed signal that should be modified and the specific modifications to apply; and

for each signal element, using the characteristics of simulated residuals data as specified by the second set of decoded data also to characterize simulated residuals for higher levels of quality than the second level of quality of the signal elements co-located with that signal element, until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use

for the signal or for portions of the signal different characteristics of simulated residuals; and

utilizing the set of characteristics to modify the elements of the reconstructed signal at the displayed level of quality in a manner as specified by the simulated residual data.

18. The method as in claim 1 further comprising:

decoding the second set of data to identify spectral characteristics associated with residuals that represent lower priority information (e.g., film grain, camera sensor noise, lower priority details of the signal, etc.), the spectral characteristics indicating to the decoder how to simulate the residuals to add to the reconstructed signal, without indicating the actual location or the specific values of the residuals; and

for each signal element, utilizing the spectral characteristics as specified by the second set of decoded data also to characterize simulated residuals for higher levels of quality than the second level of quality of the portion of the signal co-located with that signal element, until a respective set of decoded data for a higher level of quality than the second level of quality specifies to use for the signal or for specific portions of the signal different spectral characteristics of simulated residuals; and

utilizing the set of spectral characteristics to modify the elements of the reconstructed signal at the displayed level of quality in a manner as specified by the simulated residual data.

19. The method as in claim 1, wherein the hierarchy includes an additional set of data to reconstruct the signal according to a subsequent level of quality in the hierarchy, the subsequent level of quality being higher than the current level of quality in the hierarchy, the method further comprising:

display of image information on a display device in accordance with the reconstructed signal at the current level of quality.

20. The method as in claim 1 further comprising:

for each of multiple levels of quality above the first level of quality, repeating steps of:

decoding a next higher set of data in the hierarchy above a last processed level of quality;

identifying an upsample operation and/or scale factor specified by the next higher set of decoded data;

applying the upsample operation identified in the next higher set of decoded data to reconstruct the signal at a next higher level of quality;

identifying residual information and/or residual characteristics specified by the next higher set of decoded data; and

applying the residual information and/or the residual characteristics to modify the reconstructed signal at the higher level of quality.

21. The method as in claim 1 wherein:

the decoder receives separate signal hierarchies for the different color planes of the signal, such as chrominance planes in a YUV image or spectral bands in a multispectral image, the separate signal hierarchies featuring independent scale factors, operations and highest levels of quality;

the upsample operation applied to a given color hierarchy to produce a rendition of the given color plane at a next higher level of quality is based at least in part on the element values of a different color plane hierarchy of the same signal.

22. A computer system comprising:

a processor;

a memory unit that stores instructions associated with an application executed by the processor; and

an interconnect coupling the processor and the memory unit, enabling the computer system to execute the application and perform operations of:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation specified by the second set of decoded data; and

applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the first level of quality to reconstruct the signal at a second level of quality, the second level of quality being higher than the first level of quality.

23. A computer-readable hardware storage hardware having instructions stored thereon, the instructions, when carried out by a processing device, causes the processing device to perform operations of:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation specified by the second set of decoded data; and

applying the upsample operation identified in the second set of decoded data to the reconstructed signal at the first level of quality to reconstruct the signal

at a second level of quality, the second level of quality being higher than the first level of quality.

24. A computer system comprising:

a processor;

a memory unit that stores instructions associated with an application executed by the processor; and

an interconnect coupling the processor and the memory unit, enabling the computer system to execute the application and perform operations of:

decoding a first set of data;

utilizing the first set of decoded data to reconstruct the signal according to a first level of quality;

decoding a second set of data;

identifying an upsample operation; and

applying the identified upsample operation to the reconstructed signal at the first level of quality to reconstruct a preliminary rendition of the signal at a second level of quality, the second level of quality being higher than the first level of quality;

simultaneously processing subsets of the second set of data in parallel to retrieve residual data from the second set of decoded data, the residual data indicating how to modify the preliminary rendition of the signal at the second level of quality reconstructed signal at the second level of quality subsequent to application of the upsampling operation;

modifying the reconstructed preliminary rendition of the signal at the second level of quality as specified by the residual data.