(54) Title of the Invention: Encoder, decoder and method for data

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Optional other
data

10

Image and/or video data (D1)
in first color space

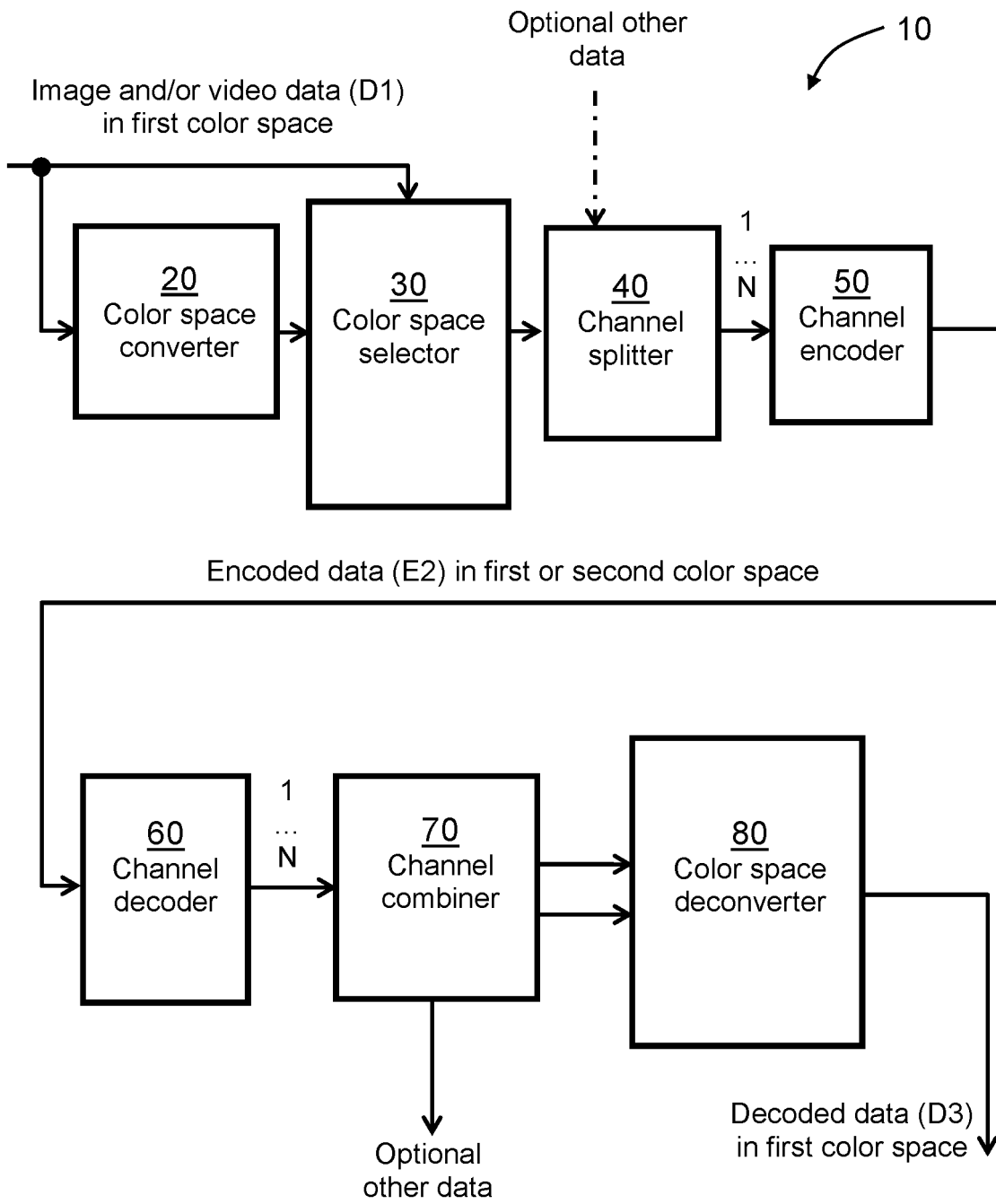Encoded data (E2) in first or second color space

Decoded data (D3)
in first color space

Optional
other data

FIG. 1
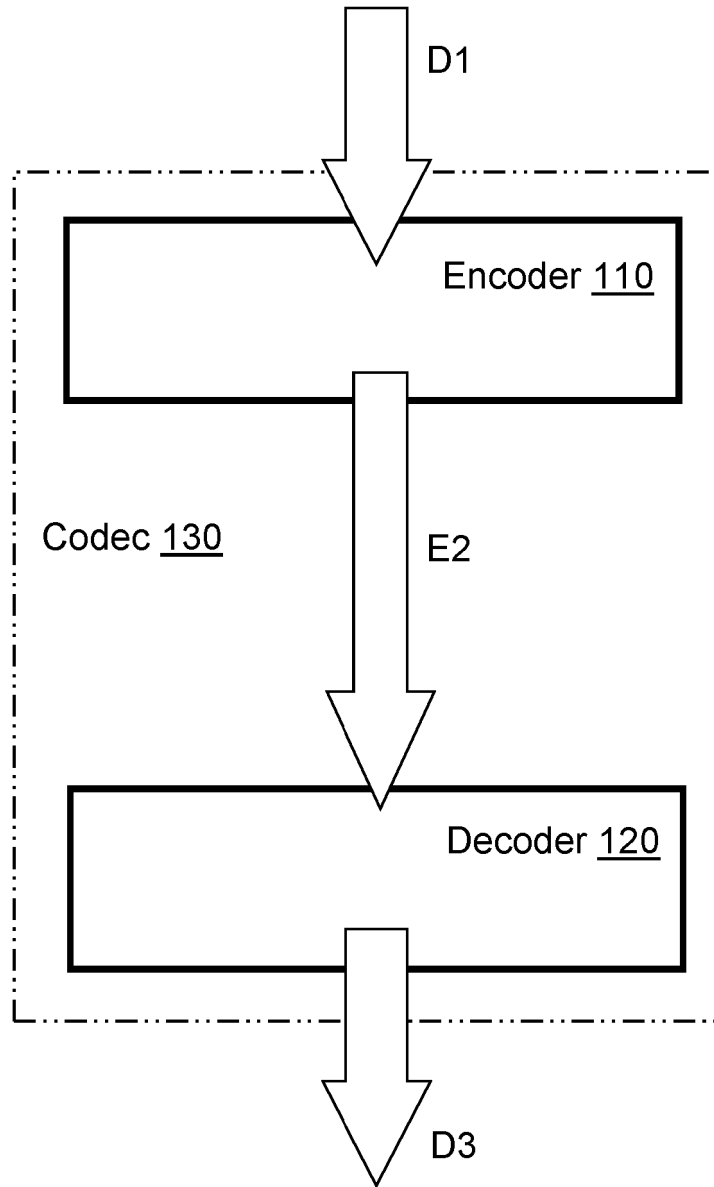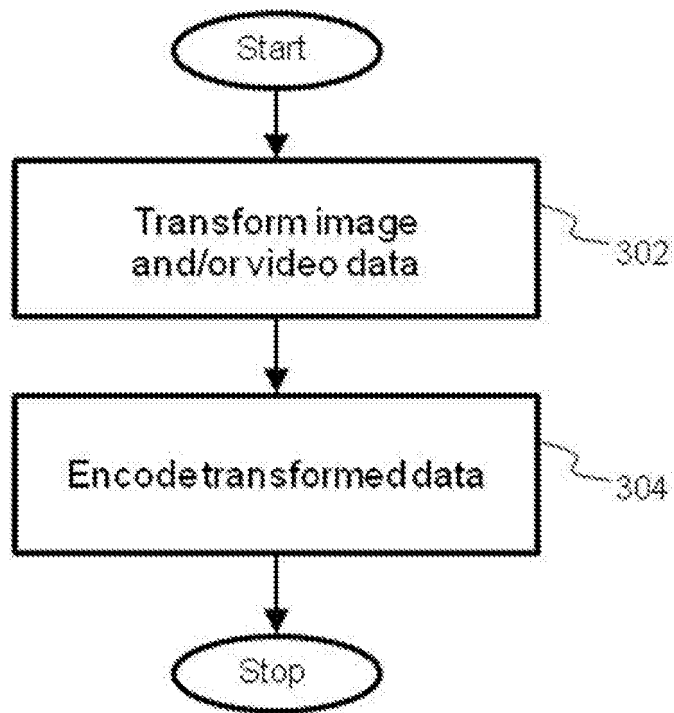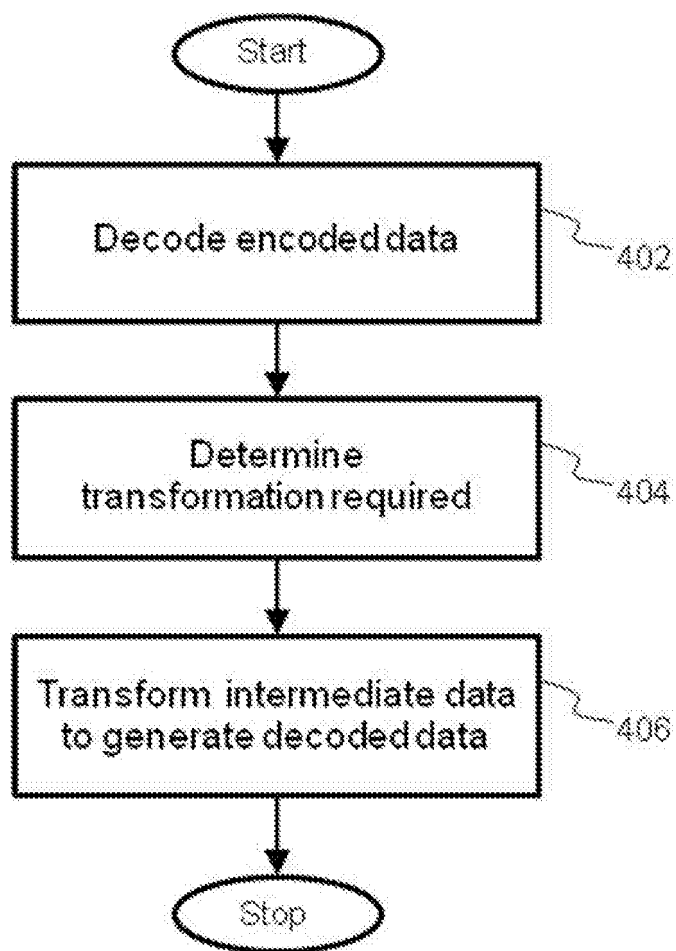
FIG. 2

FIG. 3

FIG. 4

The following terms are registered trade marks and should be read as such wherever they occur in this document:

Adobe
Pantone
Pkzip

ENCODER, DECODER AND METHOD FOR DATA

TECHNICAL FIELD

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The present disclosure relates to encoders for encoding data for example to encoders for encoding image and/or video data in a lossless manner using mutually different color spaces. Moreover, the present disclosure concerns methods of encoding data, for example methods of encoding image and/or

10 video data, for example in a lossless manner using mutually different color spaces. Furthermore, the present disclosure relates to decoders for decoding encoded data generated by the aforementioned encoders. Additionally, the present disclosure concerns methods of decoding encoded data, wherein the encoded data is generated by the aforementioned encoders and the

15 aforementioned methods. Yet additionally, the present disclosure is concerned with computer program products comprising a non-transitory computer-readable data storage medium having computer-readable instructions stored thereon, the computer-readable instructions being executable by a computerized device comprising processing hardware to execute the aforesaid methods. Yet

20 additionally, the present disclosure concerns codecs including at least one aforementioned encoder and at least one aforementioned decoder.

BACKGROUND

25 Conventionally, a typical video and/or image codec is operable to compress data only in one color space, or with a few pixel formats, and typically the support for different input formats for the codec is also very limited. For example, according to a contemporary JPEG/H.264/HEVC standard, associated methods compress images only in a YCbCr color space. According to a

30 contemporary PNG standard, associated methods compress images only in a sRGB color space.

PNG and JPEG support "*.bmp*" format images, but a typical JPEG implementation often is not able to provide lossless encoding of such images. A lossless JPEG implementation, as aforementioned, is able to code other sRGB images losslessly, yet yields a very poor compression ratio. However,

5 greyscale images can sometimes be coded losslessly even with a regular lossy JPEG implementation, because it is sometimes in theory possible to code the luminance channel (Y) completely losslessly with a regular lossy JPEG implementation. Moreover, a greyscale image can be generated from RGB channels into a Y channel, that then additionally has a U channel, namely blue

10 chrominance, and a V channel, namely red chrominance, which are set to a constant value. Moreover, contemporary H.264 and HEVC (see reference [1]) implementations support only "*.yuv*" format images. However, the HEVC implementation has a more recent mode of operation that enables lossless coding of YCbCr color space image, but the H.264 implementation can only

15 perform lossy encoding.

If a color conversion were executed on original information, for example by employing a conversion pair described in reference [1] below, both before compression being applied and after the compression being applied, then the

20 original information is typically not recovered losslessly. Such a loss arises from a distortion caused by the color conversion from an original color space of the original information and the color conversion back to the original color space.

Currently, only data zippers, such as contemporary *7zip®*, *rar* and *pkzip®*

25 (wherein these names include registered trademarks) and lossless JPEG, are able to encode and decode images and videos losslessly in any given color space or in any image/video format. A problem that is contemporarily encountered is that zippers do not understand data content that is required to be processed, and therefore, a compression efficiency of a zipper-based codec

30 is poor. Moreover, the content cannot be modified easily. A zipper returns the original content exactly as it was. Moreover, neither a zipper nor a lossless

JPEG implementation are able to reduce correlation between color channels as efficiently as real image and/or video codecs, during compression.

There is presently a lack of, namely one single, efficient approach to encode images and videos in a lossless manner in different color spaces. Such a lack represents a problem, which the present disclosure seeks to address.

In a published US patent application US 2014/355689 A1 (TOURAPIS; "*Adaptive color space transform coding*"), there is described an encoder system which includes an analyzer that analyzes a current image area in an input video to select a transform. A selectable residue transformer, controlled by the analyzer, performs the selectable transform on a residue image generated from the current image area and a predicted current image area, to generate a transformed residue image. An encoder encodes the transformed residue image to generate output data. The analyzer controls the encoder to encode information to identify the selectable transform and to indicate that the selectable transform for the current image area is different from a transform of a previous image area of the input video. A decoder system includes components appropriate for decoding the output data from the encoder system.

In a published PCT patent application WO 2004/100504 A2 (VENTANA; "*Color image compression via spectral decorrelation and elimination of spatial redundancy*"), there is described a method of compressing a colour image. The colour image comprises colour data for a plurality of pixels. The method includes a step of obtaining red, green and blue pixel values of an object of interest in the colour image. A calculation is made of the complement of the red, green and blue values of the object of interest. Transformation coefficients are calculated which transform the complements of red, green and blue values of the object of interest into representations in a transformation colour space. The transformation coefficients are applied to all the pixels in the image to obtain thereby a transformed data set representing the image having components along three mutually orthogonal axes (A, B and C herein) in a three-dimensional

transformed colour space. The transformed data set is scaled in accordance with the colour quantization used in the system; e.g., the A, B and C values are between 0 and 255 for an 8-bit quantization.

5   In a published PCT patent application WO 2013/146405 A1 (KDDI; "*Image encoding device and image decoding device*"), there is provided an image encoding device that has a high encoding efficiency, and an image decoding device. A mapping means maps pixel signals of an object to be encoded that are configured in a prescribed colour space to mapped pixel signals in which
10   redundancy between the signals is reduced by principal component analysis. The mapping coefficients are calculated from encoded pixel signals, thereby making encoding of mapping coefficients unnecessary. Furthermore, the mapping coefficients are calculated from pixel signals of an adjacent block comprising pixels similar to the pixels of the block to be encoded/decoded,
15   thereby reducing redundancy significantly. The mapping is applied to the pixel signals of the block to be encoded/decoded and to an area of pixels to be referred to by prediction information, thereby enabling prediction to be applied to the mapped pixel signals, and, after executing transformation/quantization, encoding and inverse transformation/dequantization are executed. The mapped
20   pixel signals are restored to the pixel signals by inverse mapping being applied to the mapped pixel signals by an inverse mapping means.

In a published US patent application US 6094454A (MITCHELL; "*Multi-spectral image compression and transformation*"), there is described a method for
25   compressing and decompressing multi-spectral images in two colour spaces. The system and method employ the transformation, compression and reconstruction of colour space components from which difference data between the original colour space components and the reconstructed colour space components are derived. A compressed data stream including compressed
30   colour space data and compressed difference data in another colour space is generated. The difference data is utilized to reconstruct a lossless or near lossless image of the original.

In a published US patent application US 2005/0259730 A1 (SUN; *Video coding with residual color conversion using reversible YCoCg*"), there is described a video coding algorithm which supports both lossy and lossless coding of video while maintaining high colour fidelity and coding efficiency using an in-loop, reversible colour transform. Accordingly, a method is provided to encode video data and decode the generated bitstream. The method includes generating a prediction-error signal by performing intra/inter-frame prediction on a plurality of video frames; generating a colour-transformed, prediction-error signal by performing a reversible colour-space transform on the prediction-error signal; and forming a bitstream based on the colour-transformed prediction-error signal. The method may further include generating a colour-space transformed error residual based on a bitstream; generating an error residual by performing a reversible colour-space transform on the colour-space transformed error residual; and generating a video frame based on the error residual.

SUMMARY

The present disclosure seeks to provide an encoder which is operable to compress input data in a more efficient manner, for example an encoder which is operable to compress image and/or video data in a more efficient manner.

Moreover, the present disclosure seeks to provide a method of compressing input data in a more efficient manner, for example a method of compressing image and/or video data in a more efficient manner.

Furthermore, the present disclosure seeks to provide a decoder for decoding compressed encoded data as generated by the aforementioned encoder.

Additionally, the present disclosure seeks to provide a method of decompressing compressed encoded data in a more efficient manner.

A further aim of the present disclosure is to at least partially overcome at least some of the problems of the prior art, as described above.

5   In a first aspect, there is provided an encoder including processing hardware for encoding input data (D1) to generate corresponding encoded data (E2), wherein the input data (D1) includes image and/or video data, the input data (D1) is provided in a first data format; the processing hardware of the encoder is operable to analyze the input data (D1), to select one or more

10   transformations depending upon the content of the input data (D1), to transform the input data (D1) from the first data format into at least a second data format by utilizing the selected one or more transformations, and to encode the input data in a lossless manner utilizing the at least a second data format to generate the encoded data (E2), wherein the first

15   data format includes a first colour space, and the second data format includes a second colour space, selected from a plurality of colour spaces, wherein the encoded data (E2) includes information that is indicative of the one or more transformations employed to transform the input data (D1) from the first data format into the at least a second data format, and in addition includes

20   information indicative of the second data format used in the encoding, wherein encoding of the transformed data from the at least a second data format is more efficient than encoding the input data (D1) from the first data format directly, and wherein a selection of the at least a second data format is made based on a comparison of encoding results with different formats.

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The present disclosure is of advantage in that the encoder is capable of compressing input data, for example image and/or video data, in a more efficient manner by transforming the input data from the first data format to the at least a second data format, from which compression is capable of being more

30   efficiently done.

Optionally, the aforementioned" data format" is regarded as a "format space".

Optionally, the first and second data formats include first and second color spaces, respectively. Optionally, the input data (D1) includes at least one of: image data, video data, audio data, seismic data, medical imaging data, but not limited thereto.

Moreover, optionally, the selection of the one or more data formats varies depending on subsampling, dynamics and so forth.

In a second aspect, there is provided a decoder including processing hardware for decoding, in a lossless manner, losslessly-encoded data (E2) to generate corresponding decoded data (D3), characterized in that the processing hardware of the decoder is operable to decode the encoded data (E2) to generate intermediate data in at least a second data format, and to determine from the encoded data (E2) one or more transformations required for transforming the intermediate data from the at least a second data format into a first data format to generate the decoded data (D3) and information indicative of the second data format used in the encoding, wherein the decoded data (D3) includes image and/or video data, the first data format includes a first colour space, and the second data format includes a second colour space selected from a plurality of colour spaces.

Optionally, the aforementioned" data format" is regarded as being a "format space".

Optionally, the first and second data formats include first and second color spaces, respectively.

In a third aspect, there is provided a codec including at least one aforementioned encoder and at least one aforementioned decoder.

In a fourth aspect, there is provided a method of encoding input data (D1) to generate corresponding encoded data (E2), via an encoder including processing hardware, wherein the input data (D1) includes image and/or video data, the input data (D1) is provided in a first data format, characterized in that

5   the method includes:

(i)   analysing the input data (D1);

(ii)   selecting one or more transformations depending upon the content of the input data (D1),

(iii)   transforming the input data (D1) from the first data format into at least a

10   second data format by utilizing the selected one or more transformations; and

(iv)   encoding the input data (D1) in a lossless manner utilizing the at least a second data format to generate the encoded data (E2),

wherein the first data format includes a first colour space, and the second data

15   format includes a second colour space selected from a plurality of colour spaces, wherein the encoded data (E2) also includes information that is indicative of the one or more transformations employed to transform the input data (D1) from the first data format into the at least a second data format, and in addition includes information indicative of the second data format used in the

20   encoding, wherein encoding of the transformed data from the at least a second data format is more efficient than encoding the input data (D1) from the first data format directly, and wherein a selection of the at least a second data format is made based on a comparison of encoding results with different formats.

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Optionally, the input data (D1) includes image and/or video data, but is not limited thereto.

Optionally, the aforementioned" data format" is regarded as being a "format

30   space".

Optionally, the first and second data formats include first and second color spaces, respectively.

5   In a fifth aspect, there is provided a computer program product comprising a non-transitory computer-readable data storage medium having computer-readable instructions stored thereon, the computer-readable instructions being executable by a computerized device comprising processing hardware to execute the aforementioned method of encoding.

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In a sixth aspect, there is provided a method of decoding in a lossless manner, losslessly encoded data (E2) to generate corresponding decoded data (D3), via a decoder including processing hardware, characterized in that the method includes:

15   (i)   decoding the encoded data (E2) in a lossless manner to generate intermediate data in at least a second data format; and

(ii)   determining from the encoded data (E2) one or more transformations required for transforming the intermediate data from the at least a second data format into a first data format to generate the decoded data (D3),
20   and information indicative of the second data format used in the encoding, wherein the decoded data (D3) includes image and/or video data, the first data format includes a first colour space, and the second data format includes a second colour space selected from a plurality of colour spaces.

25

Optionally, the aforementioned" data format" is regarded as being a "format space".

Optionally, the first and second data formats include first and second color
30   spaces, respectively.

In a seventh aspect, there is provided a computer program product comprising a non-transitory computer-readable data storage medium having computer-readable instructions stored thereon, the computer-readable instructions being executable by a computerized device comprising processing hardware to execute the aforementioned method of decoding.

Embodiments of the present disclosure are capable of providing an at least partial solution to the aforementioned problem, and are capable of executing an efficient and lossless image/video compression.

Additional aspects, advantages, features and objects of the present disclosure would be made apparent from the drawings and the detailed description of the illustrative embodiments construed in conjunction with the appended claims that follow.

It will be appreciated that features of the present disclosure are susceptible to being combined in various combinations without departing from the scope of the present disclosure as defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The summary above, as well as the following detailed description of illustrative embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the present disclosure, exemplary constructions of the disclosure are shown in the drawings. However, the present disclosure is not limited to specific methods and apparatus disclosed herein. Moreover, those in the art will understand that the drawings are not to scale. Wherever possible, like elements have been indicated by identical numbers.

Embodiments of the present disclosure will now be described, by way of example only, with reference to the following diagrams wherein:

FIG. 1   is a schematic illustration of a block diagram of a codec, pursuant to embodiment of the present disclosure;

FIG. 2   is a schematic illustration of an encoder for encoding image and/or video data (D1) to generate corresponding encoded data (E2) and a decoder for decoding the encoded data (E2) to generate corresponding decoded data (D3), wherein the encoder and the decoder collectively form a codec, in accordance with an embodiment of the present disclosure;

FIG. 3   is a schematic illustration of a flow chart depicting steps of a method of encoding image and/or video data (D1) to generate corresponding encoded data (E2), in accordance with an embodiment of the present disclosure; and

FIG. 4   is a schematic illustration of a flow chart depicting steps of a method of decoding encoded data (E2) to generate corresponding decoded data (D3), in accordance with an embodiment of the present disclosure.

In the accompanying diagrams, an underlined number is employed to represent an item over which the underlined number is positioned or an item to which the underlined number is adjacent. A non-underlined number relates to an item identified by a line linking the non-underlined number to the item. When a number is non-underlined and accompanied by an associated arrow, the non-underlined number is used to identify a general item at which the arrow is pointing.

DETAILED DESCRIPTION OF EMBODIMENTS

The following detailed description illustrates embodiments of the present disclosure and ways in which they can be implemented. Although some modes of carrying out the present disclosure has been disclosed, those skilled in the art would recognize that other embodiments for carrying out or practicing the present disclosure are also possible.

In a first aspect, embodiments of the present disclosure provide an encoder including processing hardware for encoding input data (D1) to generate corresponding encoded data (E2). Optionally, the processing hardware of the

5   encoder is implemented by employing at least one Reduced Instruction Set Computing (RISC) processor that is operable to execute program instructions as will be elucidated in detail below. Optionally, the input data (D1) includes at least one of: image data, video data, audio data, seismic data, medical imaging data, but not limited thereto.

10

The input data (D1), for example image and/or video data, is provided in a first data format, for example a first color space. The processing hardware of the encoder is operable to transform the input data (D1) from the first data format into at least a second data format, for example a second color space. The

15   processing hardware of the encoder is then operable to encode the transformed data from the at least a second data format to generate the encoded data (E2). The encoded data (E2) includes information that is indicative of one or more transformations employed to transform the input data (D1) from the first data format into the at least a second data format. Optionally, the aforementioned"

20   data format" is regarded as being a "format space".

According to various embodiments of the present disclosure, the aforesaid encoder is optionally used to encode images and/or videos in various different color spaces and/or different pixel formats, as a part of a single integrated

25   codec solution. Pursuant to embodiments of the present disclosure, the encoder enables efficient and lossless, or substantially lossless, image and video compression, for example, for medical or military purposes.

It is to be noted here that the aforesaid encoder is optionally implemented with

30   an electronic device or as a part of an electronic device. In an example, the electronic device is optionally an image and/or video capturing device that generates large quantities of image and/or video data, wherein lossless

compression is desired so as to preserve fine information in the image and/or video data, whilst rendering the quantities of the image and/or video data manageable for data storage and data communication purposes. Examples of such image and/or video capturing devices include, but are not limited to,

5 surveillance cameras, video recorders, X-ray devices, Magnetic Resonance Imaging (MRI) scanners, and ultrasound scanners.

In an embodiment, the processing hardware of the encoder is operable to execute a lossless image and/or video compression.

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In another embodiment, the processing hardware of the encoder is operable to execute a lossy, yet efficient, image and/or video compression. Additionally, in this regard, the processing hardware of the encoder is operable to generate residual information that is indicative of one or more errors, namely distortions,

15 arising when transforming the image and/or video data (D1) from the first data format into the at least a second data format. Optionally, the processing hardware of the encoder is operable to encode the residual information into the encoded data (E2) for enabling the encoded data (E2) to be subsequently losslessly decoded.

20

Optionally, the processing hardware of the encoder is operable to analyze the image and/or video data (D1), and to select the one or more transformation depending upon content of the image and/or video data (D1). Based on the content, it is feasible to select at least one transformation that is lossless, for

25 example by way of employing a greyscale image, or part thereof, which is susceptible to being converted between different color formats in a lossless manner. In other words, the content is also optionally information of only part of a given image and is susceptible to being converted to such a format that is possible to retain losslessly later on. In such a case, information of the part of

30 the given image beneficially does not exceed the amount of data that is possible to be described in a lossless manner with a given format, and such an issue is beneficially checked from content present in the given image and/or video data

present in the input data (D1). The selection of the one or more transformations is beneficially achieved by way of at least one of: Fourier analysis, entropy analysis, rule-based analysis or similar performed on at least a portion of the input data (D1), neural network analysis of image and/or video components.

5

Optionally, encoding the transformed data from the at least a second data format is more efficient than encoding the image and/or video data (D1) from the first data format directly. The efficiency relates mostly to the compression ratio but in some cases it is beneficial to optimize speed of computation and

10   memory consumption of the method. Optionally, in this regard, the processing hardware of the encoder is operable to select the at least a second data format, such that the encoding of the transformed data from the at least a second data format is more efficient than the encoding the image and/or video data (D1) from the first data format directly.

15

According to an embodiment, the processing hardware of the encoder is operable to transform the image and/or video data (D1) from the first color space into a plurality of color spaces. Optionally, each color space of the plurality of color spaces is selected, such that it is more efficient to encode the

20   transformed data from that color space than to encode the image and/or video data (D1) from the first color space directly; as aforementioned, the selection of the plurality of color spaces is beneficially achieved by way of at least one of: Fourier analysis, entropy analysis, rule-based analysis or similar performed on at least a portion of the input data (D1), neural network analysis of image and/or

25   video components.

More optionally, at least one color space of the plurality of color spaces is most efficient, when compared to the first color space and/or other color spaces of the plurality of color spaces.

30

Throughout the present disclosure, the term "color space" generally refers to a specific organization of colors, which makes it possible to reproducibly

represent colors in both analogue and digital representations. A color space may either be structured mathematically, for example, such as with Adobe® RGB or sRGB, or be arbitrary with particular colors assigned to a set of physical color swatches and/or corresponding assigned names or numbers, for example, such as with the Pantone® Matching System (PMS). Examples of color spaces include, but are not limited to, RGB, sRGB, Adobe® RGB, Adobe® Wide Gamut RGB, ProPhoto RGB, scRGB, Rec. 709, Rec. 2020, CIE RGB, CIE XYZ, CIELUV, CIEUVW, CIELAB, YUV, YIQ, YDbDr, YPbPr, YCbCr, xvYCC, CMYK, HSV, HSL, Munsell® color system, Pantone® Matching System (PMS), and Natural Color System (NCS); these examples include registered trademarks. RGB and CMYK are color models that are typically used as a basis for different color spaces.

Moreover, optionally, the image and/or video data (D1) is provided in a first pixel format associated with the first color space, while the transformed data is provided in at least a second pixel format associated with the at least a second color space. Optionally, in this regard, the processing hardware of the encoder is operable to transform the image and/or video data (D1) from the first pixel format into the at least a second pixel format during the transformation. Examples of the first pixel format and/or the at least a second pixel format include, but are not limited to, RGB/BGR 8, RGB/BGR 16, RGB/BGR 24, RGB/BGR 32, RGBA32, I444, I422, I420, J422, J420, YV16, and YV12, Y8, Y8 and a palette for 24 bit RGB; these examples include registered trademarks.

Optionally, the image and/or video data (D1) is received as a stream or a file. The file is optionally provided in any suitable file format. Examples of such file formats include, but are not limited to, the Portable PixMap format (PPM), the Portable GrayMap format (PGM), the Portable BitMap format (PBM), the BitMaP file format (BMP), the YUV4MPEG2 format, the YUV format, the Portable Network Graphics format (PNG), the Joint Photographic Experts Group format (JPEG), and the Graphics Interchange Format (GIF). Examples of corresponding filename extensions include, but are not limited to, "*.ppm*",

".pgm", ".pbm", ".bmp", ".y4m", ".yuv", ".png", ".jpeg", and ".gif". These filename extensions refer to qualifying endings of data files as recorded in a contemporary file directory.

5   Moreover, optionally, the processing hardware of the encoder is operable to remove unnecessary information, for example redundant information, from a given header of the image and/or video data (D1).

Additionally or alternatively, optionally, the processing hardware of the encoder

10   is operable to remove unnecessary information from one or more channels of the image and/or video data (D1) that are less relevant (hereinafter referred to as "less-relevant channels"). Such removal of unnecessary information is optionally performed without degrading or distorting original image and/or video information in one or more other channels of the image and/or video data (D1)

15   that are more relevant (hereinafter referred to as "more-relevant channels"). This potentially enables an efficient channel correlation between the first color space and the at least a second color space. This also enables flexibility in respect of pixel formats that can be employed.

20   In this regard, optionally, the processing hardware of the encoder is operable to encode the more-relevant channels first, and then to encode the less-relevant channels. This potentially enables a more efficient channel correlation reduction.

25   Throughout the present disclosure, the term "channel" generally refers to a certain component of an image. In some examples, the term "channel" refers to a color channel that corresponds to a range of wavelengths. As an example, in the RGB and CMYK color models, a color channel typically includes spectroscopic information that is indicative of radiation intensity corresponding

30   to a given primary color, namely red, green or blue in the RGB color model, or cyan, magenta, yellow and black in the CMYK color model. In the YUV color space, a Y channel corresponds to luminance, while U and V channels

correspond to chrominance. In the HSV color space, one channel corresponds to brightness, while other two channels correspond to colour information.

In other examples, the term "channel" refers to other channels, for example, such as metadata, text, binary data, audio channels, preview image channels, transparent image channels, an alpha channel, and channels of other views of a three-dimensional image, but are not limited thereto.

It is to be noted here that a given color space has a plurality of channels, wherein often at least one channel of the plurality of channels is more relevant than one or more other channels of the plurality of channels. As an example, in the YUV or YCbCr color spaces, the Y channel includes most information, and therefore, is more relevant than other channels. Thus, it is advantageous to encode the Y channel first, so as to enable the more efficient channel correlation reduction. Similarly, in the sRGB color space, a G channel includes most information, and therefore, is more relevant than R and B channels.

Optionally, the channels are encoded and subsequently decoded separately. Optionally, the channels utilize information from each other. This potentially enables flexibility in respect of usage.

Moreover, optionally, the processing hardware of the encoder is operable to add information into a new header and/or one or more new channels of the transformed data. Such addition of information is optionally performed without degrading or distorting the original image and/or video information in the relevant channels. It is to be noted here that such new headers and/or new channels are typically formed as a result of the transformation.

Pursuant to embodiments of the present disclosure, original image and/or video header is typically not delivered in any format from the encoder to a corresponding decoder, if there is no request to return an output file that is exactly similar to an original file. Typically, image and/or video content of the

image and/or video data (D1) is preserved losslessly, and then a new header that is similar to the original image and/or video header as employed in the original file is generated in the decoder.

5   If the original image and/or video header includes metadata or other critical data, it is delivered as its own channel or as header information in a new pixel format, depending on the image and/or video content and an amount of the image and/or video data (D1). A given media player associated with the decoder is then able to select how to use or show information available in such

10   channels or headers to a user. In an example, additional text or graphics is separately shown on top of the image and/or video. In another example, the additional text or graphics is overlaid to the image and/or video with or without transparency. In yet another example, only a preview image is decoded and then shown. In still another example, only metadata is shown.

15

Furthermore, optionally, the encoder is operable to communicate the encoded data (E2) to a data server and/or data storage for storing in a database. The data server and/or data storage is arranged to be accessible to a decoder, which is beneficially compatible with the encoder, for subsequently decoding the

20   encoded data (E2).

In some examples, the decoder is optionally operable to access the encoded data (E2) from the data server and/or data storage.

25   In alternative examples, the encoder is optionally operable to stream the encoded data (E2) to the decoder, either via a communication network or via a direct connection. Moreover, it is to be noted that a device equipped with a hardware-based or software-based encoder optionally also communicates directly with another device equipped with a hardware-based or software-based

30   decoder.

In yet other alternative examples, the decoder is optionally implemented so as to retrieve the encoded data (E2) from a non-transitory (namely non-transient) computer-readable storage medium, such as a hard drive and a Solid-State Drive (SSD).

In a second aspect, embodiments of the present disclosure provide a decoder including processing hardware for decoding encoded data (E2) to generate corresponding decoded data (D3). Optionally, the processing hardware of the decoder is implemented by employing at least one RISC processor that is operable to execute program instructions as will be elucidated in detail below.

The processing hardware of the decoder is operable to decode the encoded data (E2) to generate intermediate data in at least a second data format. The processing hardware of the decoder is operable to determine from the encoded data (E2) one or more transformations required for transforming the intermediate data from the at least a second data format into a first data format to generate the decoded data (D3). Optionally, the aforementioned" data format" is regarded as being a "format space".

Optionally, the processing hardware of the decoder is operable to transform the intermediate data from the at least a second data format, for example a color space, into a plurality of data formats, for example color spaces.

In an embodiment of the present disclosure, the processing hardware of the decoder is operable to extract, from the encoded data (E2), residual information that is indicative of one or more errors, namely distortions, arising when transforming image and/or video data (D1) from the first data format into the at least a second data format. In this embodiment, the processing hardware of the decoder is operable to apply a correction for the one or more errors, namely distortions, for enabling the encoded data (E2) to be subsequently losslessly decoded to provide the decoded data (D3).

In a third aspect, embodiments of the present disclosure provide a codec including at least one encoder and at least one decoder. The at least one encoder and the at least one decoder can be implemented as the aforementioned encoder and the aforementioned decoder, respectively.

In a fourth aspect, embodiments of the present disclosure provide a method of encoding image and/or video data (D1) to generate corresponding encoded data (E2), via an encoder including processing hardware. The image and/or video data (D1) is provided in a first data format, characterized in that the method includes:

(i) transforming the image and/or video data (D1) from the first data format into at least a second data format; and

(ii) encoding the transformed data from the at least a second data format to generate the encoded data (E2),

wherein the encoded data (E2) also includes information that is indicative of one ore more transformations employed to transform the image and/or video data (D1) from the first data format into the at least a second data format.

According to an embodiment, the method further includes:

(i) analyzing the image and/or video data (D1); and

(ii) selecting the one or more transformations depending upon content of the image and/or video data (D1).

According to an embodiment, the method further includes transforming the image and/or video data (D1) from the first data format, for example a color space into a plurality of data formats, for example color spaces. Optionally, the aforementioned" data format" is regarded as being a "format space".

According to an embodiment, the encoding the transformed data from the at least a second data format is more efficient than encoding the image and/or video data (D1) from the first data format directly.

According to an embodiment, the method further includes:

(i)   generating residual information that is indicative of one or more errors, namely distortions, arising when transforming the image and/or video data (D1) from the first data format into the at least a second data format;

5   and

(ii)   encoding the residual information into the encoded data (E2) for enabling the encoded data (E2) to be subsequently losslessly decoded.

In a fifth aspect, embodiments of the present disclosure provide a computer

10   program product comprising a non-transitory computer-readable data storage medium having computer-readable instructions stored thereon, the computer-readable instructions being executable by a computerized device comprising processing hardware to execute the aforementioned method of encoding.

15   In a sixth aspect, embodiments of the present disclosure provide a method of decoding encoded data (E2) to generate corresponding decoded data (D3), via a decoder including processing hardware, characterized in that the method includes:

(i)   decoding the encoded data (E2) to generate intermediate data in at least

20   a second data format; and

(ii)   determining from the encoded data (E2) one ore more transformations required for transforming the intermediate data from the at least a second data format into a first data format to generate the decoded data (D3).

25   According to an embodiment, the method further includes transforming the intermediate data from the at least a second data format, for example a color space, into a plurality of data formats, for example color spaces.

According to an embodiment, the method further includes:

30   (i)   extracting, from the encoded data (E2), residual information that is indicative of one or more errors, namely distortions, arising when

transforming image and/or video data (D1) from the first data format into the at least a second data format; and

(ii) applying a correction for the one or more errors, namely distortions, for enabling the encoded data (E2) to be subsequently losslessly decoded to

5 provide the decoded data (D3).

In a seventh aspect, embodiments of the present disclosure provide a computer program product comprising a non-transitory computer-readable data storage medium having computer-readable instructions stored thereon, the computer-

10 readable instructions being executable by a computerized device comprising processing hardware to execute the aforementioned method of decoding.

There will now be described below four solutions that at least partially overcome at least some of the problems of the prior art, as discussed earlier, namely:

15

(1) a first solution, wherein image and/or video data (D1) of a given image and/or video is encoded with a native compression support for multiple color spaces, to generate encoded data (E2);

(2) a second solution, wherein the image and/or video data (D1) is

20 transformed losslessly from a given color space to a more efficient color space with substantially similar or smaller dynamics, and then encoded into the encoded data (E2);

(3) a third solution, wherein the image and/or video data (D1) is transformed losslessly from a given color space to a most efficient color space with

25 higher dynamics, and then encoded into the encoded data (E2); and

(4) a fourth solution, wherein the image and/or video data (D1) is transformed in a lossy manner from a given color space to the most efficient color space, generating residual information that is indicative of one or more errors arising when transforming the image and/or video data (D1) from a

30 given color space to the most efficient color space, both then encoded into the encoded data (E2), and wherein residual information is encoded

additionally for enabling the encoded data (E2) to be subsequently losslessly decoded.

It will be appreciated that aforementioned examples of indexing the methods are beneficially employed. Optionally, either the index, or the selected method in some other form, is delivered, for example in the encoded data (D2) provided from the encoder to the decoder to enable lossless decoding of data. There might also be tables or transformation parameters delivered from the encoder to the decoder within the encoded data (D2) or header data, to enable appropriate inverse operation in the decoder.

The aforementioned solutions (1) to (4) are operable to recognize a type of image and/or video content of the image and/or video data (D1), and to create their own file formats. Such file formats are created in a manner that enables easy modification, addition or subtraction of information in various channels, for example, during the transformation and/or the encoding.

Firstly, in respect of embodiments of the present disclosure, the native compression support for multiple color spaces will next be described.

In an embodiment of the present disclosure, image and/or video data (D1) of a given image and/or video is encoded with a native compression support for multiple color spaces and/or multiple pixel formats. Such encoding requires an efficient implementation for many different color spaces and/or for many different pixel formats, in a given codec.

In this regard, one or more color space/pixel format specific parameters are required to be used differently, or with different values, for the different color spaces and/or the different pixel formats. Optionally, the color space/pixel format specific parameters include information indicative of at least one of:

(i) an original color space of the image and/or video data (D1);

(ii) an original pixel format of the image and/or video data (D1);

(iii)   a color space to be used in encoding;

(iv)   a pixel format to be used in encoding;

(v)   a number of channels of the image and/or video data (D1) to be encoded;

5   (vi)   an original order of channels in the image and/or video data (D1); and/or

(vii)   an order of channels to be used in encoding.

Optionally, the pixel format to be used in encoding is similar to the original pixel format, when the native compression support for the original color space and/or

10   pixel format is used.

Optionally, the order of channels to be used in encoding is predetermined in the given codec. In an example of the YUV or YCbCr color spaces, the Y channel includes most information, and therefore, is encoded first. Similarly, in an

15   example of the sRGB color space, the G channel includes most information, and therefore, is encoded first. This potentially enables most efficient channel correlation reduction.

Moreover, initial pixel values are also potentially different for different color

20   spaces. As an example, a black image in the sRGB color space has a value of '0' (zero) for each channel, namely each pixel is expressed with byte values of '0, 0, 0' for the R, G and B channels, while in the YUV color space, a black image has a value of '0' (zero) for the Y channel, and values of '128' for the U and V channels, namely each pixel is expressed with byte values of '0, 128,

25   128' for the Y, U and V channels, respectively.

Moreover, different pixel formats are potentially used within a given color space. For example, pixel formats that are typically used for the YUV color space are I444 (24 bits per pixel), I422 (16 bits per pixel) and I420 (12 bits per pixel). A

30   difference between these pixel formats pertains to a sampling of associated channels. When a lossless image and/or video compression is executed, the

encoding is performed in a pixel format that is similar to the original pixel format of the image and/or video data (D1).

Beneficially, the processing hardware of the encoder is operable to determine the original color space and the original pixel format of the image and/or video data (D1), and to initialize the color space/pixel format specific parameters based on the determined original color space and the determined original pixel format; "initialize" is to provide initial values for the specific parameters. As a result, the processing hardware of the encoder is operable to encode losslessly the image and/or video data (D1) to generate corresponding encoded data (E2) in an optimal color space and pixel format.

Furthermore, the encoder is operable to communicate, to the decoder, at least some of the color space/pixel format specific parameters, for example, including information indicative of the color space and the pixel format used in the encoding. The at least some of the color space/pixel format specific parameters can be communicated in a form of a saved file or a data stream, for example, typically implemented via a use of a header.

Upon receiving the at least some of the color space/pixel format specific parameters, the decoder is operable to initialize the color space/pixel format specific parameters, and to decode the encoded data (E2) to generate corresponding decoded data (D3). The decoded data (D3) can be generated either in the original color space and/or the original pixel format or in any other color space and/or pixel format, as desired. Optionally, the decoder can initialize all needed parameters based on information delivered to it and received by it.

Secondly, lossless transformation from a given color space to a more efficient color space will next be described in relation to embodiments of the present disclosure.

In an embodiment of the present disclosure, the processing hardware of the encoder is operable to transform losslessly image and/or video data (D1) of a given image and/or video from an original color space to a more efficient color space with substantially similar or smaller dynamics. Thus, the encoding is

5   performed in the more efficient color space and a pixel format associated therewith.

Throughout the present disclosure, the term "dynamics" generally refers to a number of bits per pixel with which a channel is expressed. For example, in the

10   I444 pixel format for the YUV color space, there are 24 bits per pixel, namely 8 bits per pixel for each of the Y, U and V channels. For example, in the I420 pixel format for the YUV color space there are in average 12 bits per pixel namely 8 bits per pixel for the Y channel and 8 bits per every four pixel group of for each of the U and V channels. Similarly, in the RGB16 pixel format has 6 bits per

15   pixel for the G channel and 5 bits for pixel each of the B and R channels. Generally, the "*dynamics*", namely dynamic range, means a value range of any given value, namely a difference between a largest value in the value range and a smallest value in the value range, and a precision of expressing the given value. The dynamics are optionally obtained by, for example, measuring, by

20   executing an A/D conversion, or by otherwise selecting and converting a value range. The more the values vary, or the more precise a variance is expressed, the more bits, namely "dynamics", are needed for expressing the given value, whether the given value indicates color pixels, audio amplitude or any other value that has been obtained by measuring or by converting. The embodiments

25   pursuant to the present disclosure are concerned, for example, with discrete values, and AD/DA conversions can be executed before or after the system. However, it is rarely possible to guarantee losslessness unless analogical signals are used to express, for example, bit values.

30   It will be appreciated that there are only a few cases in which it is possible to transform an image and/or video from a first color space to a second color space in the encoder and to reverse the transformation in the decoder

losslessly, without increasing used dynamics from the first color space to the second color space. As an example, monochrome (namely, greyscale) images are often transformable from one color space to another color space with substantially similar dynamics, whereas color images typically cannot be transformed losslessly without increasing the used dynamics.

In a typical example, a transformation from the sRGB color space to the YUV color space, and back from the YUV color space to the sRGB color space, or vice versa is not lossless for most color images and/or videos. Therefore, it is beneficial to define proprietary transformations that are substantially lossless for certain types of image and/or video content.

In another example, when original image and/or video content of the image and/or video data (D1) does not include full dynamics or the transformation reduces the dynamics, it is possible to use smaller dynamics during the encoding.

Moreover, optionally, the encoder is operable to communicate, to the decoder, information about original dynamics and dynamics used during the encoding.

Moreover, optionally, during the encoding, the processing hardware of the encoder is operable to reuse certain parts from a codec implementation that was originally designed for the first color space and/or the associated pixel format.

Optionally, the encoder employs a pre-color-converter for the lossless transformation. Optionally, the encoder also delivers the pre-color-converter to the decoder, so as to enable support for the second color space during encoding operations and subsequent decoding operations. The pre-color-converter is optionally employed by way of using a natural color space and/or pixel format of the given codec.

It will be appreciated that it is beneficial for the given codec to support multiple native color spaces, both during the encoding operations and during the decoding operations. This enables the encoder to select a more efficient color space, from the multiple native color spaces supported by the given codec, for encoding purposes. Such a selection is beneficially made quite efficiently and accurately, without a need to execute full encoding with different color spaces. Optionally, in this regard, the selection of the more efficient color space is beneficially made by using a color space that gives a smaller entropy sum of data in channels for the entire image and/or video content of the image and/or video data (D1). Entropy, for selection purposes, is beneficially computed using Shannon's Theorem. Optionally, the selection is made directly based on a comparison of encoding results with different formats, even if the use of entropy computations makes the selection quicker and often produces a similar end result; in other words, an achieved quality of encoding is not a selection criteria here, but either the amount of used bits or the amount estimated by using the entropy.

Thirdly, lossless transformation from a given color space to a most efficient color space will next be described, for embodiments of the present disclosure.

In an embodiment of the present disclosure, the processing hardware of the encoder is operable to transform losslessly image and/or video data (D1) of a given image and/or video from an original color space to a most efficient color space with higher dynamics. Thus, the encoding is performed in the most efficient color space and a pixel format associated therewith.

As the given image and/or video is encoded with higher dynamics, it is possible to transform from the original color space to the most efficient color space in the encoder and to reverse the transformation in the decoder losslessly.

Moreover, optionally, the encoder is operable to communicate, to the decoder, information about original dynamics and dynamics used during the encoding.

Fourthly, lossy transformation from a given color space to a most efficient color space in embodiments of the present disclosure will next be described.

5   In an embodiment of the present disclosure, the processing hardware of the encoder is operable to transform image and/or video data (D1) of a given image and/or video from an original color space to a most efficient color space in a lossy manner. Additionally, in this embodiment, the processing hardware of the encoder is operable to generate and encode residual information and to deliver

10   the encoded residual information to the decoder, so as to enable a lossless implementation to be achieved.

The fourth solution is particularly beneficial when the native compression support for the original color space is not available or is not efficient enough. In

15   such a case, the solution improves an associated compression ratio considerably, as compared to a compression ratio associated with the native compression support.

The encoding of the transformed data is performed in the most efficient color

20   space and a pixel format associated therewith. Optionally, the residual information is entropy encoded with a most advanced entropy-modifying encoder.

As described earlier, the residual information is indicative of one or more errors,

25   namely distortions, arising when transforming the image and/or video data (D1) from the original color space into the most efficient color space. Thus, the residual information enables lossless image and/or video compression, even when the transformation from the original color space to the most efficient color space and the reverse of the transformation are not lossless.

30

The errors arising from the transformation typically include values of '0', '-1' and '+1' in a structured manner. Therefore, it is advantageous to encode the

residual information by using, for example, a modified ODelta operator, as described in the patent document GB 1412937.3. In some examples, the residual information is encoded by using Run Length Encoding (RLE) or Split RLE (SRLE), the latter being described in the patent document GB 2507603.

It will be appreciated that when different sampling is used for generating, for example via executing computations within a data processing arrangement, different channels in a given color image and/or video, for example, as in the I422 or I420 pixel formats for the YUV color space (or Bayer sampling for B, G, and R pixel values), the color image and/or video is typically encoded in a native format using the native compression support, namely the aforementioned first solution. Otherwise, optionally, up-sampling (or de-mosaicing) is performed in the encoder before the transformation and down-sampling (mosaicing) is performed in the decoder after the transformation back to the original pixel format. Sampling is known in the art, and is described in databases such as Wikipedia.

As an example of other than image and/or video data, an embodiment of the present disclosure is provided, wherein audio data is quantized starting from 48 kHz 16-bit samples to generate 16 kHz 8-bit samples, for example for purposes of coding speech data. Correspondingly, this is then recovered back into the original sampling rate and dynamics after coding and residual coding.

Sometimes, an amount of data in upsampled channels is increased so much that it is potentially not efficient to compress, as compared to the native compression support that can compress images in a sub-sampled format. In such a case, the aforementioned fourth method is optionally used. When the fourth method is used, it is potentially advantageous to subsample at least some channels in another color space, namely the most efficient color space, before the encoding. Later, in the decoder, a corresponding upsampling is performed before reversing the transformation to the original color space.

Thereafter, a downsampling is performed to return the image and/or video back to the original pixel format, including sampling.

Next, embodiments of the present disclosure will be described with reference to
5   figures.

Referring to FIG. 1, there is shown a block diagram of a codec **10**, pursuant to embodiments of the present disclosure. The codec **10** includes a color space converter **20**, a color space selector **30**, a channel splitter **40**, a channel
10   encoder **50**, a channel decoder **60**, a channel combiner **70**, and optionally, a color space deconverter **80**. The color space converter **20**, the color space selector **30**, the channel splitter **40** and the channel encoder **50** form a part of an encoder of the codec **10**, while the channel decoder **60**, the channel combiner **70** and the color space deconverter **80** form a part of a decoder of the
15   codec **10**.

The color space converter **20** is operable to transform image and/or video data (D1) from a first color space to at least a second color space.

20   The color space selector **30** is operable to select an efficient color space to be used for the transformation, namely the at least a second color space.

Optionally, the color space selector **30** is operable to generate residual information corresponding to the transformation.
25

The channel splitter **40** is operable to split the transformed data into a plurality of channels, represented by '1... N' in FIG. 1. The channel splitter **40** is optionally implemented by way of a demultiplexer. Multiplexing and demultiplexing techniques are described in greater detail at:
30

http://en.wikipedia.org/wiki/Multiplexer

Optionally, the channel splitter **40** is also fed with other data, for example, such as metadata and other critical data.

The channel encoder **50** is operable to encode the transformed data to generate corresponding encoded data (E2).

Optionally, the channel encoder **50** is operable to encode channels of the transformed data one-by-one. Optionally, in this regard, the channel encoder **50** is operable to encode more-relevant channels before encoding less-relevant channels.

In an embodiment, the channel encoder **50** is operable to encode the residual information into the encoded data (E2).

In the decoder, the channel decoder **60** is operable to decode the encoded data (E2) to generate the aforesaid channels of the transformed data.

The channel combiner **70** is then operable to combine the channels together to produce the aforesaid transformed data. The channel combiner **70** is optionally implemented by way of a multiplexer.

The color space deconverter **80** is operable to reverse the one or more transformations to generate corresponding decoded data (D3).

In an embodiment, the color space deconverter **80** is operable to decode the residual information to enable lossless retrieval of the decoded data (D3).

Additionally, optionally, the codec **10** includes a header extractor (not shown in FIG. 1). The header extractor is employed to extract an original header of the image and/or video data (D1). The header extractor is typically employed before the color space converter **20** and the color space selector **30** of the encoder.

Additionally, optionally, the codec **10** includes an output image and/or video formatter (not shown in FIG. 1). The output image and/or video formatter is employed, when it is desired to store the decoded data (D3) to an image and/or video file, or the usage of the decoded data (D3) requires a specific file format.

5 The output image and/or video formatter is typically employed after the color space deconverter **80** of the decoder.

It will be appreciated that FIG. 1 is a high level abstraction of the codec **10**. Components related to data transmission between the encoder and the

10 decoder, for example, such as a file formatter, a stream formatter and similar, are not shown in FIG. 1. Moreover, other components of the encoder and the decoder, for example, such as analysis units, temporal and spatial redundancy reduction units, entropy encoders and corresponding entropy decoders, a bit stream generation unit and a corresponding bit stream degeneration unit, are

15 also not shown in FIG. 1. Furthermore, sub-sampling and up-sampling features are also not shown in FIG. 1.

FIG. 1 is merely an example, which should not unduly limit the scope of the claims herein. It is to be understood that the specific designation for the codec

20 **10** is provided as an example and is not to be construed as limiting the codec **10** to specific numbers, types, or arrangements of its components. A person skilled in the art will recognize many variations, alternatives, and modifications of embodiments of the present disclosure.

25 Referring next to FIG. 2, embodiments of the present disclosure concern:

(i) an encoder **110** for encoding image and/or video data (D1) to generate corresponding encoded data (E2), and corresponding methods of encoding the image and/or video data (D1) to generate the corresponding encoded data (E2);

30 (ii) a decoder **120** for decoding the encoded data (E2) to generate corresponding decoded data (D3), and corresponding methods of decoding the encoded data (E2) to generate the decoded data (D3); and

(iii) a codec **130** including a combination of at least one encoder and at least one decoder, namely a combination of the encoder **110** and the decoder **120**.

5 Optionally, the decoded data (D3) is exactly similar to the image and/or video data (D1), as in a lossless mode of operation. Alternatively, optionally, the decoded data (D3) is approximately similar to the image and/or video data (D1), as in a lossy mode of operation. Yet alternatively, optionally, the decoded data (D3) is different to the image and/or video data (D1), for example by way of at 10 least one transformation, but retains substantially similar information present in the image and/or video data (D1); for example, the decoded data (D3) is usefully made different to the image and/or video data (D1) when reformatting of the decoded data (D3) is also required, for example to be compatible with different types of communication platforms, software layers, communication 15 devices, and so forth.

FIG. 2 is merely an example, which should not unduly limit the scope of the claims herein. It is to be understood that the specific designation for the codec **130** is provided as an example and is not to be construed as limiting the codec 20 **130** to specific numbers, types, or arrangements of encoders and decoders. A person skilled in the art will recognize many variations, alternatives, and modifications of embodiments of the present disclosure

Optionally, the codec **130** is implemented within a single device. Alternatively, 25 optionally, the codec **130** is effectively implemented between multiple devices. Optionally, the codec **130** is implemented as custom-design digital hardware, for example, via use of one or more Application-Specific Integrated Circuits (ASIC's). Alternatively, or additionally, the codec is implemented in computer software instructions executable upon processing hardware.

30

Referring now to FIG. 3, there is provided a flow chart depicting steps of a method of encoding image and/or video data (D1) to generate corresponding

encoded data (E2), in accordance with an embodiment of the present disclosure. The method is depicted as a collection of steps in a logical flow diagram, which represents a sequence of steps that can be implemented in hardware, software, or a combination thereof, for example as aforementioned.

The method is implemented via an encoder including processing hardware. The image and/or video data (D1) is provided in a first data format.

At a step **302**, the image and/or video data (D1) is transformed from the first data format into at least a second data format.

At a step **304**, the transformed data from the at least a second data format is encoded to generate the encoded data (E2).

The steps **302** to **304** are only illustrative and other alternatives can also be provided where one or more steps are added, one or more steps are removed, or one or more steps are provided in a different sequence without departing from the scope of the claims herein. In an embodiment, the method includes an additional step at which residual information is generated and encoded, for enabling the encoded data (E2) to be subsequently losslessly decoded.

Referring now to FIG. 4, there is provided a flow chart depicting steps of a method of decoding encoded data (E2) to generate corresponding decoded data (D3), in accordance with an embodiment of the present disclosure. The method is depicted as a collection of steps in a logical flow diagram, which represents a sequence of steps that can be implemented in hardware, software, or a combination thereof, for example as aforementioned.

The method is implemented via a decoder including processing hardware.

At a step **402**, the encoded data (E2) is decoded to generate intermediate data in at least a second data format.

At a step **404**, one or more transformations required for transforming the intermediate data from the at least a second data format into a first data format is determined from the encoded data (E2).

5

At a step **406**, the intermediate data is transformed to generate the decoded data (D3).

The steps **402** to **406** are only illustrative and other alternatives are also
10 optionally provided where one or more steps are added, one or more steps are removed, or one or more steps are provided in a different sequence without departing from the scope of the claims herein. In an embodiment, the method includes one or more additional steps at which residual information is extracted from the encoded data (E2), and a corresponding correction is applied for
15 enabling the encoded data (E2) to be subsequently losslessly decoded to provide the decoded data (D3).

Modifications to embodiments of the present disclosure described in the foregoing are possible without departing from the scope of the present
20 disclosure as defined by the accompanying claims. Expressions such as "including", "comprising", "incorporating", "consisting of", "have", "is" used to describe and claim embodiments of the present disclosure are intended to be construed in a non-exclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular
25 is also to be construed to relate to the plural. Numerals included within parentheses in the accompanying claims are intended to assist understanding of the claims and should not be construed in any way to limit subject matter claimed by these claims.

REFERENCES

[1] YUV - Wikipedia, the free encyclopedia (accessed September 30, 2014).
5 URL: http://en.wikipedia.org/wiki/YUV

CLAIMS

We claim:

1.   An encoder (110) including processing hardware for encoding input data (D1) to generate corresponding encoded data (E2), wherein the input data (D1) includes image and/or video data, the input data (D1) is provided in a first data format, characterized in that

the processing hardware of the encoder (110) is operable to analyze the input data (D1), to select one or more transformations depending upon a content of the input data (D1), to transform the input data (D1) from the first data format into at least a second data format by utilizing the selected one or more transformations, and to encode the input data in a lossless manner utilizing the at least a second data format to generate the encoded data (E2), wherein the first data format includes a first colour space, and the second data format includes a second colour space, selected from a plurality of colour spaces, wherein the encoded data (E2) includes information that is indicative of the one or more transformations employed to transform the input data (D1) from the first data format into the at least a second data format, and in addition includes information indicative of the second data format used in the encoding, wherein encoding of the transformed data from the at least a second data format is more efficient than encoding the input data (D1) from the first data format directly, and wherein a selection of the at least a second data format is made based on a comparison of encoding results with different formats.

2.   An encoder (110) as claimed in claim 1, characterized in that the encoder utilizes at least one of:

(i)   a lossless transformation wherein:

(a)   the data (D1) is transformed losslessly from the first data format having a first dynamic into the at least one second data format having a second dynamic, wherein the second dynamics is similar or smaller than the first dynamics, and then encoded into the encoded data (E2); or

(b)   the data (D1) is transformed losslessly from the first data format having a first dynamic into the at least one second data format having a second dynamic, wherein the second dynamics have higher dynamics than the first dynamics, thereby enlarging original dynamics of the data (D1), and then encoded into the encoded data (E2);

(ii)   a lossy transformation wherein:

(c)   the processing hardware is operable to generate residual information that is indicative of one or more distortions arising when transforming the input data (D1) from the first data format into the at least a second data format in a lossy manner, and the processing hardware of the encoder (110) is operable to encode the residual information into the encoded data (E2) for enabling the encoded data (E2) to be subsequently losslessly decoded; or

(d)   the processing hardware is operable to combine different distortions arising from employing lossy transformations and/or lossy coding, when transforming the input data (D1) from the second format to generate the encoded data (E2), and to include information indicative of the combined different distortions in the encoded data (E2) so that lossless encoding is thereby provided.

3.   An encoder (110) as claimed in claim 1, characterized in that the processing hardware of the encoder (110) is operable to transform the input data (D1) from the first data format into a plurality of data formats.

4.   An encoder (110) as claimed in claim 3, characterized in that the processing hardware of the encoder (110) is operable to transform the input

data (D1) including image and/or video data from a first data format into a plurality of data formats.

5.   An encoder (110) as claimed in claim 1, characterized in that the processing hardware of the encoder (110) is operable to generate residual information that is indicative of one or more distortions arising when transforming the input data (D1) from the first data format into the at least a second data format in a lossy manner, and the processing hardware of the encoder (110) is operable to encode the residual information into the encoded data (E2) for enabling the encoded data (E2) to be subsequently losslessly decoded.

6.   A method of encoding input data (D1) to generate corresponding encoded data (E2), via an encoder (110) including processing hardware, wherein the input data (D1) includes image and/or video data, the input data (D1) is provided in a first data format, characterized in that the method includes:

(i)   analysing the input data (D1);

(ii)   selecting one or more transformations depending upon a content of the input data (D1),

(iii)   transforming the input data (D1) from the first data format into at least a second data format by utilizing the selected one or more transformations; and

(iv)   encoding the input data (D1) in a lossless manner utilizing the at least a second data format to generate the encoded data (E2),

wherein the first data format includes a first colour space, and the second data format includes a second colour space selected from a plurality of colour spaces, wherein the encoded data (E2) also includes information that is indicative of the one or more transformations employed to transform the input data (D1) from the first data format into the at least a second data format, and in addition includes information indicative of the second data format used in the encoding, wherein encoding of the transformed data from the at least a second data format is more efficient than encoding the input data (D1) from the first

data format directly, and wherein a selection of the at least a second data format is made based on a comparison of encoding results with different formats.

7.   A method as claimed in claim 6, characterized in that the method includes utilizing at least one of:

(i)   a lossless transformation wherein:

(a)   the data (D1) is transformed losslessly from the first data format having a first dynamic into the at least one second data format having a second dynamic, wherein the second dynamics is similar or smaller than the first dynamics, and then encoded into the encoded data (E2); or

(b)   the data (D1) is transformed losslessly from the first dataformat having a first dynamic into the at least one second data format having a second dynamic, wherein the second dynamics have higher dynamics than the first dynamics, thereby enlarging original dynamics of the data (D1), and then encoded into the encoded data (E2);

(ii)   a lossy transformation wherein:

(c)   the processing hardware is operable to generate residual information that is indicative of one or more distortions arising when transforming the input data (D1) from the first data format into the at least a second data format in a lossy manner, and the processing hardware of the encoder (110) is operable to encode the residual information into the encoded data (E2) for enabling the encoded data (E2) to be subsequently losslessly decoded; or

(d)   the processing hardware is operable to combine different distortions arising from employing lossy transformations and/or lossy coding, when transforming the input data (D1) from the second format to generate the encoded data (E2), and to include

information indicative of the combined different distortions in the encoded data (E2) so that lossless encoding is thereby provided.

8. A method as claimed in claim 6, characterized in that the method includes transforming the input data (D1) from the first data format into a plurality of data formats.

9. A method as claimed in claim 6, characterized in that the method includes:

(i) generating residual information that is indicative of one or more distortions arising when transforming the input data (D1) from the first data format into the at least a second data format in a lossy manner; and

(ii) encoding the residual information into the encoded data (E2) for enabling the encoded data (E2) to be subsequently losslessly decoded.

10. A decoder (120) including processing hardware for decoding, in a lossless manner, losslessly-encoded data (E2) to generate corresponding decoded data (D3), characterized in that the processing hardware of the decoder (120) is operable to decode the encoded data (E2) to generate intermediate data in at least a second data format, and to determine from the encoded data (E2) one or more transformations required for transforming the intermediate data from the at least a second data format into a first data format to generate the decoded data (D3) and information indicative of the second data format used in the encoding, wherein the decoded data (D3) includes image and/or video data, the first data format includes a first colour space, and the second data format includes a second colour space selected from a plurality of colour spaces.

11. A decoder (120) as claimed in claim 10, characterized in that the processing hardware of the decoder (120) is operable to transform the intermediate data from the at least a second data format into a plurality of data formats.

12. A decoder (120) as claimed in claim 10, characterized in that the processing hardware of the decoder (120) is operable to extract, from the

encoded data (E2), residual information that is indicative of one or more distortions arising when transforming input data (D1) from the first data format into the at least a second data format, and the processing hardware of the decoder (120) is operable to apply a correction for the one or more distortions
5   for enabling the encoded data (E2) to be subsequently losslessly decoded to provide the decoded data (D3).

13.   A method of decoding, in a lossless manner, losslessly-encoded data (E2) to generate corresponding decoded data (D3), via a decoder (120) including processing hardware, characterized in that the method includes:

10   (i)   decoding the encoded data (E2) in a lossless manner to generate intermediate data in at least a second data format; and

       (ii)   determining from the encoded data (E2) one or more transformations required for transforming the intermediate data from the at least a second data format into a first data format to generate the decoded data (D3)
15   and information indicative of the second data format used in the encoding, wherein the decoded data (D3) includes image and/or video data, the first data format includes a first colour space, and the second data format includes a second colour space selected from a plurality of colour spaces.

20   14.   A method as claimed in claim 13, characterized in that the method includes transforming the intermediate data from the at least a second data format into a plurality of data formats.

15.   A method as claimed in claim 14, characterized in that the method includes:

25   (i)   extracting, from the encoded data (E2), residual information that is indicative of one or more distortions arising when transforming input data (D1) from the first data format into the at least a second data format; and

       (ii)   applying a correction for the one or more distortions for enabling the encoded data (E2) to be subsequently losslessly decoded to provide the
30   decoded data (D3).

16. A codec (130) including at least one encoder (110) as claimed in claim 1, and at least one decoder (120) as claimed in claim 10.

17. A computer program product comprising a non-transitory computer-readable storage medium having computer-readable instructions stored thereon, the computer-readable instructions being executable by a computerized device comprising processing hardware to execute a method as claimed in claim 6 or claim 13.