

1. Title

Method for encoding/decoding texture of points of a point cloud

5 2. Field.

The present embodiments generally relate to coding and decoding of 3D image data representing the geometry and colors of point cloud.

10 3. Background.

The present section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present embodiments that are described and/or claimed below. This discussion is
15 believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present embodiments. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

A point cloud is a set of data points in some coordinate system. In a
20 three-dimensional coordinate system (3D space), these points are usually intended to represent the external surface of a 3D object. Each point of a point cloud is often defined by its location (X, Y, and Z coordinates in the 3D space) and possibly by other associated attributes such as a color, represented in the RGB or YUV color space for example, a transparency, a
25 reflectance, a two-component normal vector, etc.

In the following, a colored point cloud considered, i.e. a set of 6-components points (X, Y, Z, R, G, B) or equivalently (X, Y, Z, Y, U, V) where (X,Y,Z) defines the coordinates of a colored point in a 3D space and (R,G,B) or (Y,u,V) defines a color of this colored point.

30 Colored point clouds may be static or dynamic depending on whether or not the cloud evolves with respect to time. It should be noticed that in case of a dynamic point cloud, the number of points is not constant but, on the

contrary, generally evolves with time. A dynamic point cloud is thus a time-ordered list of set of points.

Practically, colored point clouds may be used for various purposes such as culture heritage/buildings in which objects like statues or buildings
5 are scanned in 3D in order to share the spatial configuration of the object without sending or visiting it. Also, it is a way to ensure preserving the knowledge of the object in case it may be destroyed; for instance, a temple by an earthquake. Such point clouds are typically static, colored and huge.

Another use case is in topography and cartography in which using 3D
10 representations, maps are not limited to the plane and may include the relief. Google Maps is now a good example of 3D maps but uses meshes instead of point clouds. Nevertheless, point clouds may be a suitable data format for 3D maps and such point clouds are typically static, colored and huge.

Automotive industry and autonomous car are also domains in which
15 point clouds may be used. Autonomous cars should be able to “probe” their environment to take good driving decision based on the reality of their immediate neighboring. Typical sensors like LIDARs produce dynamic point clouds that are used by the decision engine. These point clouds are not intended to be viewed by a human being and they are typically small, not
20 necessarily colored, and dynamic with a high frequency of capture. They may have other attributes like the reflectance provided by the Lidar as this attribute is a good information on the material of the sensed object and may help the decision.

Virtual Reality and immersive worlds have become a hot topic recently
25 and foreseen by many as the future of 2D flat video. The basic idea is to immerse the viewer in an environment all round him by opposition to standard TV where he can only look at the virtual world in front of him. There are several gradations in the immersivity depending on the freedom of the viewer in the environment. Colored point cloud is a good format candidate to
30 distribute Virtual Reality (or VR) worlds. They may be static or dynamic and are typically of averaged size, say no more than millions of points at a time.

It is crucial to be able to distribute dynamic colored point clouds to the end-user with a reasonable consumption of bit-rate while maintaining an acceptable (or preferably very good) quality of experience. Efficient compression of these dynamic colored point clouds is a key point in order to
5 make the distribution chain of immersive worlds practical.

In the following, a picture contains one or several arrays of samples (pixel values) in a specific picture/video format which specifies all information relative to the pixel values of a picture (or a video) and all information which may be used by a display and/or any other device to visualize and/or decode
10 a picture (or video) for example. A picture comprises at least one component, in the shape of a first array of samples, usually a luma (or luminance) component, and, possibly, at least one other component, in the shape of at least one other array of samples, usually a color component. Or, equivalently, the same information may also be represented by a set of arrays of color
15 samples, such as the traditional tri-chromatic RGB representation.

Image-based point cloud compression techniques are becoming increasingly popular due to their combination of compression efficiency and low complexity. They proceed in two main steps: first, they project (orthogonal projection) the point cloud, i.e. the 3D points, onto 2D images.
20 For example, at least one depth image represents the geometry of the point cloud, i.e. the spatial locations (coordinates) of the 3D points in a 3D space and at least one texture image represents an attribute associated with the 3D points of the point cloud, e.g. a texture/color information associated to those 3D points. Next, these techniques encode such depth and texture images
25 with legacy video encoders. They achieve good compression performance by leveraging the performance of 2D video encoder, like for HEVC ("ITU-T H.265 Telecommunication standardization sector of ITU (10/2014), series H: audiovisual and multimedia systems, infrastructure of audiovisual services - coding of moving video, High efficiency video coding, Recommendation ITU-
30 T H.265"), while at the same time, they keep complexity low by using simple projection schemes.

One of the challenges of Image-based point cloud compression techniques is that a point cloud may not be *suitable* for projection onto images, especially when the point distribution follows a surface with many folds (concave/convex regions, like in clothing) or when the point distribution
5 does not follow a surface at all (like in fur or hair). In these situations, image-based point cloud compression techniques suffer from low compression efficiency (many small projections are required, reducing the efficiency of the 2D video compression) or bad quality (due to the difficulty of projecting the point cloud onto a surface).

10 One of the approaches used in the state of the art to alleviate this problem consists in projecting multiple geometry and texture information onto a same spatial location (pixel) of an image. This means that several depth and/or texture images are generated per 3D point of the point cloud.

This is the case, for example, of the point cloud encoder as defined in
15 ISO/IEC JTC1/SC29/WG11/N17248, Macau, China, October 2017 (TMC2) in which two depth images (representative of the geometry of the point cloud) and two texture images (representative of the color/texture of the point cloud) are encoded.

Compressing efficiently texture images obtained by projecting points
20 of a point cloud onto a projection plane is an issue.

4. Summary.

The following presents a simplified summary of the present
25 embodiments in order to provide a basic understanding of some aspects of the present embodiments. This summary is not an extensive overview of the present embodiments. It is not intended to identify key or critical elements of the present embodiments. The following summary merely presents some aspects of the present embodiments in a simplified form as a prelude to the
30 more detailed description provided below.

The present embodiments relate to a method for generating and encoding in a bitstream an interpolation texture coding mode indicating that

the bitstream contains color information data representative of a texture image and that texture interpolation has to be done on point of a reconstructed point cloud that are not colorized from said color information data.

5 The present embodiments also relate to a method comprising checking if a contains an interpolation texture coding mode indicating that a bitstream contains color information data representative of a texture image and that texture interpolation has to be done on point of a reconstructed point cloud that are not colorized from said color information data, reconstructing a
10 first texture image from said color information data and, and assigning colors are to points of the reconstructed point cloud that are not colorized from said color information data.

 The specific nature of the present embodiments as well as other objects, advantages, features and uses of the present embodiments will
15 become evident from the following description of examples taken in conjunction with the accompanying drawings.

5. Brief Description of Drawings.

20 In the drawings, examples of the present embodiments are illustrated. It shows:

- **Fig. 1** shows an overview of the TMC2 encoder;
- **Fig. 2** illustrates depth values associated with points of a point cloud;
- **Fig. 3** shows an overview of the TMC2 decoder;
- 25 - **Fig. 4** shows examples of decoded texture images;
- **Fig. 5** shows a difference between two texture images;
- **Fig. 6** shows an example of the proposed texture encoding in a path for generating texture;
- **Fig. 7** shows an example of the proposed texture decoding in a path
30 for reconstructing/decoding texture of a point cloud; and
- **Fig. 8** illustrates a block diagram of an example of a system in which various aspects and embodiments are implemented.

Similar or same elements are referenced with the same reference numbers.

5 **6. Description of Example of the present embodiments.**

 The present embodiments will be described more fully hereinafter with reference to the accompanying figures, in which examples of the present embodiments are shown. The present embodiments may, however, be embodied in many alternate forms and should not be construed as limited to the examples set forth herein. Accordingly, while the present embodiments are susceptible to various modifications and alternative forms, specific examples thereof are shown by way of examples in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the present embodiments to the particular forms disclosed, but on the contrary, the disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present embodiments as defined by the claims.

 The terminology used herein is for the purpose of describing particular examples only and is not intended to be limiting of the present embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising," "includes" and/or "including" when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Moreover, when an element is referred to as being "responsive" or "connected" to another element, it can be directly responsive or connected to the other element, or intervening elements may be present. In contrast, when an element is referred to as being "directly responsive" or "directly connected" to other element, there are no intervening elements present. As

used herein the term "and/or" includes any and all combinations of one or more of the associated listed items and may be abbreviated as"/".

It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element without departing from the teachings of the present embodiments.

Although some of the diagrams include arrows on communication paths to show a primary direction of communication, it is to be understood that communication may occur in the opposite direction to the depicted arrows.

Some examples are described with regard to block diagrams and operational flowcharts in which each block represents a circuit element, module, or portion of code which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that in other implementations, the function(s) noted in the blocks may occur out of the order noted. For example, two blocks shown in succession may, in fact, be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending on the functionality involved.

Reference herein to "in accordance with an example" or "in an example" means that a particular feature, structure, or characteristic described in connection with the example can be included in at least one implementation of the present embodiments. The appearances of the phrase "in accordance with an example" or "in an example" in various places in the specification are not necessarily all referring to the same example, nor are separate or alternative examples necessarily mutually exclusive of other examples.

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

While not explicitly described, the present examples and variants may be employed in any combination or sub-combination.

A pixel value is represented by a vector of **C** values, where **C** is the number of components. Each value of a vector is represented with a number
5 of bits which defines a maximal dynamic range of the pixel values.

A block of a picture means a set of pixels which belong to this picture and the pixel values of a block means the values of the pixels which belong to this block.

One of the approaches (MPEG 3DG/PCC's Test Model for Category
10 2, called TMC2) used in the state of the art to encode a point cloud consists on projecting multiple geometry and texture information onto the same position (pixel) of the 2D image. This means that several 2D geometry and/or 2D texture images are generated per input point cloud. In the case of TMC2 (Category 2 test model of the MPEG 3DG Ad Hoc on Point Cloud
15 Compression) two depth (for geometry) and color (for texture) images are encoded per input point cloud.

Fig. 1 shows an overview of the TMC2 point cloud encoder. The top row (geometry compression) encodes the geometry information of the point cloud by means of a depth image. The middle row (metadata compression)
20 encodes metadata required to reconstruct the geometry of the original point cloud from the depth image. The bottom row (texture compression) encodes the color information of the reconstructed geometry by means of a color image.

As shown in **Fig. 1**, the TMC2 test model keeps two values per
25 coordinate of the projection plane: the smallest (depth0) and the largest (depth1) depth. By doing this, it better captures the distribution of points in 3D space, at the expense of increasing the amount of projected data to be encoded as shown in **Fig. 2**.

Concerning the texture compression, two texture images are
30 generated. From the two geometry images, the encoder is able to reconstruct the point cloud in the 3D space. Then with the source point cloud, a 3D color transfer process is made. It assigned for each reconstructed point a color

according to the algorithm described in the following section entitled 'Color Approximation'.

On the decoder side, as shown in **Fig. 3**, TMC2 decodes depth video stream and color video stream and reconstructs the point cloud using the
5 metadata:

- ▶ Occupancy map and block to patch index
- ▶ Patch metadata: x_0, y_0, z_0 coordinates, projection axis, bounding box

Concerning the texture decoding, two textures images are generated from the source point cloud: T0 is the texture image that contains the color of
10 source points that are put in correspondence during the color transfer process with reconstructed point cloud of Depth 0; T1 is the same for Depth 1 image.

On **Fig. 4**, the example shows that decoded texture images T0 and
15 T1.

What we observe is that T0 and T1 are not too far from each other. The difference between both images is shown in **Fig. 5**.

Even if the video encoder takes advantage of the fact that these images are not too far, it has a cost in term of bitrate and processing time.

The present embodiments relate to a method that interpolates the T1
20 texture image from the T0 texture image rather than transmitting said T1 texture image as in prior art.

This results in a gain in term of bitrate as the texture T1 is not transmitted and in term of computing complexity of both the encoding and decoding.

25 According to the present embodiments, interpolating T1 from T0 only when a color video bitstream indicates that the texture interpolation has to be applied and in that case the color video bitstream also indicates which mode has to be applied.

On the encoder side, at least one interpolation texture coding mode is
30 generated. An interpolation texture coding mode indicates that the color video bitstream contains color information data representative of a first texture image and that texture interpolation has to be done on point of a

reconstructed point cloud that are not colorized from said color information data. A point is considered as being non colorized when a color is not yet assigned to it from said color information data.

In a variant, said interpolation texture coding mode may also indicates
5 which interpolation process to be used.

Fig. 6 shows an example of the proposed texture encoding in a path for generating texture.

On decoder side, if the color video stream contains interpolation texture coding mode indicating that the color video bitstream contains color
10 information data representative of a first texture image and that texture interpolation has to be done on point of a reconstructed point cloud that are not colorized from said color information data, a first texture image is reconstructed from said color information data and, and colors are assigned to points of a reconstructed point cloud that are not colorized from said color
15 information data as shown on **Fig. 7**.

In a variant, said interpolation texture coding mode may also indicates which interpolation process to be used.

According to a first embodiment, said interpolation texture coding mode indicates that the interpolation process uses the color transfer
20 algorithm of TMC2 (see 9.1).

According to a first embodiment, said interpolation texture coding mode indicates that the interpolation process is as follows:

Let:

- $\widehat{P}_{T0}$ be the reconstructed point cloud after texture reconstruction
25 (using decoded T0 and
- p_i be a point of $\widehat{P}_{T0}$ with no assigned color
- $t0_i$ be a point of $\widehat{P}_{T0}$ with a color assigned thanks to the reconstructed texture image T0

For each point p_i , take the N closest neighbors $t0_i$ (a typical value of N
30 is 5) and apply for each neighbor:

if $(Dist(p_i) - Dist(t0_i)) < threshold$, then $Color(p_i) = Color(t0_i)$

$$\text{otherwise, } Color(p_i) = \sum_{k=0}^N \text{weight} * Color(t0_k)$$

$$\text{with weight} = \frac{1}{\sqrt{\text{distance}(p_i, t0_k)^2}}$$

A typical value for the *threshold* is 0.001.

A metadata in the color video bitstream indicates if an interpolation texture process has to be done to reconstruct a texture image, i.e. indicates that the color video bitstream contains color information data representative of a first texture image and that texture interpolation has to be done on point of a reconstructed point cloud that are not colorized from said color information data.

In a variant, said interpolation texture coding mode may also indicates which interpolation process to be used.

Let *itcm* be an interpolation texture mode indicating which interpolation process to be applied.

These values could be coded by image, frame or by group of frames according to the decision process made by encoder.

Examples of *itcm* mode metadata

One first example could be to code the interpolation texture coding mode as flag (on/off) to activate and deactivate the texture interpolation process:

- Off 2 texture images per frame, no texture interpolation
- On: 1 texture image per frame, texture interpolation

Another example could be to code the interpolation texture coding mode as integer and defined several interpolation processes.

Table 1 – ReadArithmetic() function

itcm_mode	DecodeUInt8
For all patches	
U0	DecodeUInt32(bitCountU0)
V0	DecodeUInt32(bitCountV0)
U1	DecodeUInt32(bitCountU1)
V1	DecodeUInt32(bitCountV1)

D1	DecodeUInt32(bitCountD1)
deltaSizeU0	DecodeExpGolomb()
deltaSizeV0	DecodeExpGolomb()
// Block to patch index decoding	
For all blocks	
If number of candidate patches > 1	
Candidate index	Decode
If Candidate index == maxCandidateCount	
block to patch index	DecodeUInt32(bitCountPatch)
Else	
Block to patch index = Candidate index	
// Occupancy map decoding	
For all blocks	
If Block to patch index > 0	
isFull	decode
If not Full	
bestTraversalOrderIndex	decode
runCountMinusTwo	decode
Occupancy	decode
for (size_t r = 0; r < runCountMinusOne; ++r)	
{	
runLength	decode
for (size_t j = 0; j <= runLength; ++j)	
Block[traversalOrder[i++]] = occupancy;	
occupancy = !occupancy;	
}	
For all remaining blocks	
Block[traversalOrder[i++]] = occupancy;	

Example of *itcm* in a SEI Message in HEVC

Syntax	Descriptor
itcm_info(payloadSize) {	
itcm_mode	u(8)
}	

- itcm_mode contains an identifying number that is used to identify the interpolation texture coding mode. When itcm_mode equals to 0 it means the texture of depth 1 is not interpolated and texture 1 has to be decoded as in TMC2.

The itcm_mode could be also In a SPS ou PPS message.

- On **Fig. 1-7**, the modules are functional units, which may or not be in relation with distinguishable physical units. For example, these modules or some of them may be brought together in a unique component or circuit, or contribute to functionalities of a software. *A contrario*, some modules may potentially be composed of separate physical entities. The apparatus which are compatible with the present embodiments are implemented using either pure hardware, for example using dedicated hardware such ASIC or FPGA or VLSI, respectively « Application Specific Integrated Circuit », « Field-Programmable Gate Array », « Very Large Scale Integration », or from several integrated electronic components embedded in a device or from a blend of hardware and software components.

- FIG. 8** illustrates a block diagram of an example of a system in which various aspects and embodiments are implemented. System 8000 can be embodied as a device including the various components described below and is configured to perform one or more of the aspects described in this application. Examples of such devices, include, but are not limited to, various electronic devices such as personal computers, laptop computers, smartphones, tablet computers, digital multimedia set top boxes, digital television receivers, personal video recording systems, connected home

appliances, and servers. Elements of system 8000, singly or in combination, can be embodied in a single integrated circuit, multiple ICs, and/or discrete components. For example, in at least one embodiment, the processing and encoder/decoder elements of system 8000 are distributed across multiple ICs and/or discrete components. In various embodiments, the system 8000 is communicatively coupled to other similar systems, or to other electronic devices, via, for example, a communications bus or through dedicated input and/or output ports. In various embodiments, the system 8000 is configured to implement one or more of the aspects described in this document.

10 The system 8000 includes at least one processor 8010 configured to execute instructions loaded therein for implementing, for example, the various aspects described in this document. Processor 8010 can include embedded memory, input output interface, and various other circuitries as known in the art. The system 8000 includes at least one memory 8020 (e.g.,
15 a volatile memory device, and/or a non-volatile memory device). System 8000 includes a storage device 8040, which can include non-volatile memory and/or volatile memory, including, but not limited to, EEPROM, ROM, PROM, RAM, DRAM, SRAM, flash, magnetic disk drive, and/or optical disk drive. The storage device 8040 can include an internal storage device, an attached
20 storage device, and/or a network accessible storage device, as non-limiting examples.

System 8000 includes an encoder/decoder module 8030 configured, for example, to process data to provide an encoded video or decoded video, and the encoder/decoder module 8030 can include its own processor and
25 memory. The encoder/decoder module 8030 represents module(s) that can be included in a device to perform the encoding and/or decoding functions. As is known, a device can include one or both of the encoding and decoding modules. Additionally, encoder/decoder module 8030 can be implemented as a separate element of system 8000 or can be incorporated within processor
30 8010 as a combination of hardware and software as known to those skilled in the art.

Program code to be loaded onto processor 8010 or encoder/decoder

8030 to perform the various aspects described in this document can be stored in storage device 8040 and subsequently loaded onto memory 8020 for execution by processor 8010. In accordance with various embodiments, one or more of processor 8010, memory 8020, storage device 8040, and
5 encoder/decoder module 8030 can store one or more of various items during the performance of the processes described in this document. Such stored items can include, but are not limited to, the input video, the decoded video, the point cloud or portions of the decoded video, the bitstream, the reconstructed point cloud, matrices, variables, and intermediate or final
10 results from the processing of equations, formulas, operations, and operational logic.

In several embodiments, memory inside of the processor 8010 and/or the encoder/decoder module 8030 is used to store instructions and to provide working memory for processing that is needed during encoding or decoding.

15 In other embodiments, however, a memory external to the processing device (for example, the processing device can be either the processor 8010 or the encoder/decoder module 8030) is used for one or more of these functions. The external memory can be the memory 8020 and/or the storage device 8040, for example, a dynamic volatile memory and/or a non-volatile
20 flash memory. In several embodiments, an external non-volatile flash memory is used to store the operating system of a television. In at least one embodiment, a fast external dynamic volatile memory such as a RAM is used as working memory for video coding and decoding operations, such as for MPEG-2, HEVC, VVC (Versatile Video Coding) or TMC2.

25 The input to the elements of system 8000 can be provided through various input devices as indicated in block 8130. Such input devices include, but are not limited to, (i) an RF portion that receives an RF signal transmitted, for example, over the air by a broadcaster, (ii) a Composite input terminal, (iii) a USB input terminal, and/or (iv) an HDMI input terminal.

30 In various embodiments, the input devices of block 8130 have associated respective input processing elements as known in the art. For example, the RF portion can be associated with elements necessary for (i)

selecting a desired frequency (also referred to as selecting a signal, or band-limiting a signal to a band of frequencies), (ii) down-converting the selected signal, (iii) band-limiting again to a narrower band of frequencies to select (for example) a signal frequency band which can be referred to as a channel in
5 certain embodiments, (iv) demodulating the down-converted and band-limited signal, (v) performing error correction, and (vi) demultiplexing to select the desired stream of data packets. The RF portion of various embodiments includes one or more elements to perform these functions, for example, frequency selectors, signal selectors, band-limiters, channel selectors, filters,
10 downconverters, demodulators, error correctors, and demultiplexers. The RF portion can include a tuner that performs various of these functions, including, for example, down-converting the received signal to a lower frequency (for example, an intermediate frequency or a near-baseband frequency) or to baseband.

15 In one set-top box embodiment, the RF portion and its associated input processing element receives an RF signal transmitted over a wired (for example, cable) medium, and performs frequency selection by filtering, down-converting, and filtering again to a desired frequency band.

Various embodiments rearrange the order of the above-described
20 (and other) elements, remove some of these elements, and/or add other elements performing similar or different functions.

Adding elements can include inserting elements in between existing elements, such as, for example, inserting amplifiers and an analog-to-digital converter. In various embodiments, the RF portion includes an antenna.

25 Additionally, the USB and/or HDMI terminals can include respective interface processors for connecting system 8000 to other electronic devices across USB and/or HDMI connections. It is to be understood that various aspects of input processing, for example, Reed-Solomon error correction, can be implemented, for example, within a separate input processing IC or
30 within processor 8010 as necessary. Similarly, aspects of USB or HDMI interface processing can be implemented within separate interface ICs or within processor 8010 as necessary. The demodulated, error corrected, and

demultiplexed stream is provided to various processing elements, including, for example, processor 8010, and encoder/decoder 8030 operating in combination with the memory and storage elements to process the data stream as necessary for presentation on an output device.

5 Various elements of system 8000 can be provided within an integrated housing. Within the integrated housing, the various elements can be interconnected and transmit data therebetween using suitable connection arrangement, for example, an internal bus as known in the art, including the I2C bus, wiring, and printed circuit boards.

10 The system 8000 includes communication interface 8050 that enables communication with other devices via communication channel 8060. The communication interface 8050 can include, but is not limited to, a transceiver configured to transmit and to receive data over communication channel 8060. The communication interface 8050 can include, but is not limited to, a
15 modem or network card and the communication channel 8060 can be implemented, for example, within a wired and/or a wireless medium.

 Data is streamed to the system 8000, in various embodiments, using a Wi-Fi network such as IEEE 802.11. The Wi-Fi signal of these embodiments is received over the communications channel 8060 and the communications
20 interface 8050 which are adapted for Wi-Fi communications. The communications channel 8060 of these embodiments is typically connected to an access point or router that provides access to outside networks including the Internet for allowing streaming applications and other over-the-top communications.

25 Other embodiments provide streamed data to the system 8000 using a set-top box that delivers the data over the HDMI connection of the input block 8130.

 Still other embodiments provide streamed data to the system 8000 using the RF connection of the input block 8130.

30 The system 8000 can provide an output signal to various output devices, including a display 8100, speakers 8110, and other peripheral devices 8120. The other peripheral devices 8120 include, in various

examples of embodiments, one or more of a stand-alone DVR, a disk player, a stereo system, a lighting system, and other devices that provide a function based on the output of the system 8000.

5 In various embodiments, control signals are communicated between the system 8000 and the display 8100, speakers 8110, or other peripheral devices 8120 using signaling such as AV.Link, CEC, or other communications protocols that enable device-to-device control with or without user intervention.

10 The output devices can be communicatively coupled to system 8000 via dedicated connections through respective interfaces 8070, 8080, and 8090.

Alternatively, the output devices can be connected to system 8000 using the communications channel 8060 via the communications interface 8050. The display 8100 and speakers 8110 can be integrated in a single unit
15 with the other components of system 8000 in an electronic device such as, for example, a television.

In various embodiments, the display interface 8070 includes a display driver, such as, for example, a timing controller (T Con) chip.

20 The display 8100 and speaker 8110 can alternatively be separate from one or more of the other components, for example, if the RF portion of input 8130 is part of a separate set-top box. In various embodiments in which the display 8100 and speakers 8110 are external components, the output signal can be provided via dedicated output connections, including, for example, HDMI ports, USB ports, or COMP outputs.

25 Implementations of the various processes and features described herein may be embodied in a variety of different equipment or applications. Examples of such equipment include an encoder, a decoder, a post-processor processing output from a decoder, a pre-processor providing input to an encoder, a video coder, a video decoder, a video codec, a web server,
30 a set-top box, a laptop, a personal computer, a cell phone, a PDA, and any other device for processing a picture or a video or other communication

devices. As should be clear, the equipment may be mobile and even installed in a mobile vehicle.

Additionally, the methods may be implemented by instructions being performed by a processor, and such instructions (and/or data values
5 produced by an implementation) may be stored on a computer readable storage medium. A computer readable storage medium can take the form of a computer readable program product embodied in one or more computer readable medium(s) and having computer readable program code embodied thereon that is executable by a computer. A computer readable storage
10 medium as used herein is considered a non-transitory storage medium given the inherent capability to store the information therein as well as the inherent capability to provide retrieval of the information therefrom. A computer readable storage medium can be, for example, but is not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. It
15 is to be appreciated that the following, while providing more specific examples of computer readable storage mediums to which the present embodiments can be applied, is merely an illustrative and not exhaustive listing as is readily appreciated by one of ordinary skill in the art: a portable
20 computer diskette; a hard disk; a read-only memory (ROM); an erasable programmable read-only memory (EPROM or Flash memory); a portable compact disc read-only memory (CD-ROM); an optical storage device; a magnetic storage device; or any suitable combination of the foregoing.

The instructions may form an application program tangibly embodied
25 on a processor-readable medium.

Instructions may be, for example, in hardware, firmware, software, or a combination. Instructions may be found in, for example, an operating system, a separate application, or a combination of the two. A processor may be characterized, therefore, as, for example, both a device configured to carry
30 out a process and a device that includes a processor-readable medium (such as a storage device) having instructions for carrying out a process. Further, a

processor-readable medium may store, in addition to or in lieu of instructions, data values produced by an implementation.

As will be evident to one of skill in the art, implementations may produce a variety of signals formatted to carry information that may be, for example, stored or transmitted. The information may include, for example, instructions for performing a method, or data produced by one of the described implementations. For example, a signal may be formatted to carry as data the rules for writing or reading the syntax of a described example of the present embodiments, or to carry as data the actual syntax-values written by a described example of the present embodiments. Such a signal may be formatted, for example, as an electromagnetic wave (for example, using a radio frequency portion of spectrum) or as a baseband signal. The formatting may include, for example, encoding a data stream and modulating a carrier with the encoded data stream. The information that the signal carries may be, for example, analog or digital information. The signal may be transmitted over a variety of different wired or wireless links, as is known. The signal may be stored on a processor-readable medium.

A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made. For example, elements of different implementations may be combined, supplemented, modified, or removed to produce other implementations. Additionally, one of ordinary skill will understand that other structures and processes may be substituted for those disclosed and the resulting implementations will perform at least substantially the same function(s), in at least substantially the same way(s), to achieve at least substantially the same result(s) as the implementations disclosed. Accordingly, these and other implementations are contemplated by this application.

CLAIMS

1. A method for generating and encoding in a bitstream an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be executed on at least one other point of the point cloud that is not colorized from said color information.
5
- 10 2. A method comprising checking if a bitstream contains an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color
15 information.
3. The method of claim 2, wherein the method further comprises colorizing at least one point of the point cloud from said texture image and assigning a color to at least one point of the point cloud that is not colorized from said
20 color information, said color being derived from said texture interpolation coding mode.
4. The method of claim 1-3, wherein said interpolation texture coding mode indicates which texture interpolation to be used.
25
5. The method of claim 4, wherein the interpolation texture coding mode indicates that a texture interpolation used to colorize a point of the point cloud is a function of already colorized neighbors points of the point of the point cloud.
30
6. The method of claim 1-4, wherein the method further comprises transmitting said interpolation texture coding mode.

7. The method of claim 6, wherein said an interpolation texture coding mode is transmitted as an image or a metadata.

8. A signal carrying a bitstream comprising an interpolation texture coding
5 mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information.

10 9. A computer program product including instructions which, when the program is executed by one or more processors, causes the one or more processors to carry out a method comprising checking if a bitstream contains an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one
15 point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information.

10. A non-transitory computer-readable medium including instructions for
20 causing one or more processors to perform checking if a bitstream contains an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from
25 said color information.

11. A computer-readable medium including instructions for causing one or more processors to perform generating and encoding in a bitstream an interpolation texture coding mode indicating that the bitstream contains color
30 information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be executed

on at least one other point of the point cloud that is not colorized from said color information.

5 12. A non-transitory computer-readable medium comprising a bitstream comprising an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not
10 colorized from said color information.

13. A device comprising at least one processor configured to generating and encoding in a bitstream an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image
15 from which at least one point of a point cloud is colorized, and that a texture interpolation has to be executed on at least one other point of the point cloud that is not colorized from said color information.

14. A device comprising at least one processor configured to checking if a
20 bitstream contains an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information.

25

15. A device comprising:
- an accessing unit configured to access data including a bitstream comprising an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at
30 least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information; and

- a transmitter configured to transmit the data including an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information.

16. A method comprising:

- accessing data including a bitstream comprising an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information; and
- transmitting data including an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information.

20

17. A non-transitory computer-readable medium including instructions for causing one or more processors to perform:

- accessing data including a bitstream comprising an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information; and
- transmitting data including an interpolation texture coding mode indicating that the bitstream contains color information representative of a texture image from which at least one point of a point cloud is colorized, and

that a texture interpolation has to be done on at least one other point of the point cloud that is not colorized from said color information.