POINT CLOUD ENCODING METHOD, POINT CLOUD DECODING METHOD, ENCODER, AND DECODER

[0001] ~~This application claims priority to Chinese Patent Application No. 201810766911.3, filed with the China National Intellectual Property Administration on July 12, 2018 and entitled "POINT CLOUD ENCODING METHOD, POINT CLOUD DECODING METHOD, ENCODER, AND DECODER", which is incorporated herein by reference in its entirety.~~

TECHNICAL FIELD

[0002] Embodiments of this application relate to the field of coding technologies, and in particular, to a point cloud (point cloud) encoding method, a point cloud decoding method, an encoder, and a decoder.

BACKGROUND

[0003] With continuous development of 3D sensor (for example, 3D scanner) technologies, it is increasingly convenient to collect point cloud data, and the point cloud data is collected on an increasingly large scale. Therefore, how to effectively encode and decode the point cloud data becomes an urgent problem to be resolved.

SUMMARY

[0004] Embodiments of this application provide a point cloud encoding method, a point cloud decoding method, an encoder, and a decoder, to help improve point cloud coding performance.

[0005] According to a first aspect, an embodiment of this application provides a point cloud encoding method. The method includes: acquiring a normal (Normal) axis of a to-be-encoded patch (patch) in a to-be-encoded point cloud and description information of a minimum bounding rectangle corresponding to the to-be-encoded patch, where the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch are used to determine a tangent (Tangent) axis of the to-be-encoded patch and a bitangent (Bi-tangent) axis of the to-be-encoded patch; and encoding a syntax element into a bitstream, where the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element includes an index of the normal axis of the to-be-encoded patch and information

patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch; and projecting the to-be-encoded patch from the three-dimensional space to the two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch.

[0013] In a possible design, the determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include: determining, according to a projection rule, the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, where the projection rule refers to distribution, in the two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space. For example, the projection rule may indicate vertical projection or horizontal projection.

[0014] Optionally, the projection rule may be a preset projection rule (or the projection rule is referred to as a predefined rule, for example, the projection rule may be a rule predefined according to a protocol for an encoder side and a decoder side; or the projection rule may be a default rule).

[0015] Optionally, the projection rule may not be preset. For example, the projection rule may be determined according to a rate-distortion cost criterion. If the projection rule is not preset, further optionally, the syntax element may further include information used to indicate the projection rule. The information used to indicate the projection rule is frame-level information.

[0016] In a possible design, the determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include: determining, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, where the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch. For example, the mapping relationship may be predefined. For example, the mapping relationship is predefined according to a protocol. Specifically, the mapping relationship may be stored, for example but not limited to, in one or more tables. In this case, the possible design may be implemented by looking up a table.

[0017] In a possible design, the determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include: looking up a table based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, where the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch, and the table that is looked up includes a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

[0018] In a possible design, if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch; or if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch. The projection rule refers to distribution, in the two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space. The normal axis of the to-be-encoded patch is perpendicular to the two-dimensional space. This possible design is described by using an example in which "a horizontal axis of a two-dimensional plane is a tangent axis of a patch, and a vertical axis of the two-dimensional plane is a bitangent axis of the patch".

[0019] Alternatively, if the horizontal axis of the two-dimensional plane is the bitangent axis of the patch, and the vertical axis of the two-dimensional plane is the tangent axis of the patch, if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch; or if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located

is the tangent axis of the to-be-encoded patch.

[0020] In an example, in this embodiment of this application, the tangent axis that is of the to-be-encoded patch and that is used in a pre-projection process is referred to as a reference tangent axis of the to-be-encoded patch, and the tangent axis is denoted as a U0 axis; and the bitangent axis that is of the to-be-encoded patch and that is used in the pre-projection process is referred to as a reference bitangent axis of the to-be-encoded patch, and the bitangent axis is denoted as a V0 axis. In addition, the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch that are determined based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch are respectively denoted as a U1 axis and a V1 axis. Based on this, there may be the following cases.

[0021] In a possible design, the U1 axis is the same as the U0 axis, and the V1 axis is the same as the V0 axis.

[0022] In another possible design, the U1 axis is the same as the V0 axis, and the V1 axis is the same as the U0 axis.

[0023] It should be noted that, for ease of description, the example in which "a horizontal axis of a two-dimensional plane is a tangent axis of a patch, and a vertical axis of the two-dimensional plane is a bitangent axis of the patch" is used for description in all specific implementations. A general description is provided herein, and details are not described below.

[0024] According to a second aspect, an embodiment of this application provides a point cloud decoding method. The method includes: parsing a bitstream to obtain a syntax element, where the syntax element includes an index of a normal axis of a to-be-decoded patch in a to-be-decoded point cloud and information used to indicate description information of a minimum bounding rectangle corresponding to the to-be-decoded patch; determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the index and the information are obtained through parsing; and reconstructing geometry (geometry) information of the to-be-decoded point cloud based on one or more ~~a~~tangent axi~~e~~s and one or more~~a~~ bitangent axi~~e~~s of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch. In an example, the method may be performed by a point cloud decoder.

[0025] Geometry information of a point cloud refers to coordinate values of a point in the point cloud (for example, each point in the point cloud) in a three-dimensional space.

[0026] Optionally, the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch includes a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch.

[0027] Optionally, the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch includes an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-decoded patch.

[0028] In a possible design, the determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the index and the information are obtained through parsing includes: determining, according to a projection rule, the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the projection rule refers to distribution, in a two-dimensional space, ~~an~~ one or more occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space.

[0029] In a possible design, the projection rule is preset; or the syntax element further includes information used to indicate the projection rule, and correspondingly, the projection rule is a projection rule indicated by the syntax element that is obtained by parsing the bitstream.

[0030] In a possible design, the determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the index and the information are obtained through parsing includes: determining, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch.

[0031] In a possible design, the determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the index and the information are obtained through parsing includes: looking up a table based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to

the to-be-decoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch, and the table includes a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

[0032] In a possible design, if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch; or if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch. The projection rule refers to distribution, in a two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space. The normal axis of the to-be-decoded patch is perpendicular to the two-dimensional space.

[0033] Any technical solution provided in the second aspect corresponds to the corresponding point cloud encoding method provided in the first aspect. Therefore, for beneficial effects that can be achieved and explanations of related content, refer to the foregoing descriptions.

[0034] According to a third aspect, an embodiment of this application provides a point cloud encoding method. The method includes: obtaining a reference tangent axis of a to-be-encoded patch in a to-be-encoded point cloud and a reference bitangent axis of the to-be-encoded patch; determining a tangent axis of the to-be-encoded patch and a bitangent axis of the to-be-encoded patch based on the reference tangent axis of the to-be-encoded patch and the reference bitangent axis of the to-be-encoded patch, where a rotation angle of the tangent axis of the to-be-encoded patch relative to the reference tangent axis of the to-be-encoded patch is θ, and a rotation angle of the bitangent axis of the to-be-encoded patch relative to the reference bitangent axis of the to-be-encoded patch is θ; and encoding a syntax element into a bitstream, where the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element includes an index of a normal axis of the to-be-encoded patch and information used to indicate the rotation angle θ of the to-be-encoded patch. In an

patch includes an index of the patch that matches the to-be-encoded patch. In an inter prediction mode, the encoder needs to transmit, to a decoder, the identifier of the patch that matches the to-be-encoded patch. Therefore, in this possible design, the information used to indicate the rotation angle θ does not need to be additionally transmitted. Therefore, bitstream transmission overheads can be reduced. In addition, the encoder does not need to obtain the rotation angle θ. Therefore, calculation complexity of the encoder can be reduced.

[0041] In a possible design, the method may further include: projecting the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, to obtain an occupancy map of the to-be-encoded patch; and determining a minimum bounding rectangle of the occupancy map of the to-be-encoded patch; where the syntax element further includes size information of the minimum bounding rectangle of the occupancy map of the to-be-encoded patch.

[0042] According to a fourth aspect, an embodiment of this application provides a point cloud decoding method. The method includes: parsing a bitstream to obtain a syntax element, where the syntax element includes an index of a normal axis of a to-be-decoded patch in a to-be-decoded point cloud and information used to indicate a rotation angle θ of the to-be-decoded patch; obtaining a reference tangent axis of the to-be-decoded patch and a reference bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch, where the index is obtained through parsing; determining a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing; and reconstructing geometry information of the to-be-decoded point cloud based on one or more~~a~~ tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch. In an example, the method may be performed by a decoder.

[0043] In a possible design, the information used to indicate the rotation angle θ of the to-be-decoded patch includes: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-decoded patch.

[0044] In a possible design, the identifier of the patch that matches the to-be-decoded patch is used to indicate an index of the patch that matches the to-be-decoded patch, or used to indicate whether there are the patch that matches the to-be-decoded patch in a decoded point cloud and an index of the patch that matches the to-be-decoded patch.

[0045] In a possible design, the information used to indicate the rotation angle θ of the to-be-decoded patch includes the identifier of the patch that matches the to-be-decoded patch, and the determining a tangent axis of the

patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing includes: determining, based on the identifier that is of the patch matching the to-be-decoded patch and that is obtained through parsing, the patch that matches the to-be-decoded patch, and obtaining a rotation angle θ of the patch that matches the to-be-decoded patch; and determining the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the rotation angle θ.

[0046] In a possible design, the syntax element further includes size information of a minimum bounding rectangle of an occupancy map of the to-be-decoded patch, and the reconstructing geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud includes: reconstructing the geometry information of the to-be-decoded point cloud based on the one or more tangent ax~~i~~es and the one or more bitangent ax~~i~~es of the one or more patches in the to-be-decoded point cloud and the size information of the minimum bounding rectangle of the occupancy map of the to-be-decoded patch, where the size information is obtained by parsing the bitstream.

[0047] Any technical solution provided in the fourth aspect corresponds to the corresponding point cloud encoding method provided in the third aspect. Therefore, for beneficial effects that can be achieved and explanations of related content, refer to the foregoing descriptions.

[0048] According to a fifth aspect, an embodiment of this application provides a point cloud encoding method. The method includes: determining a prediction mode of a to-be-encoded point cloud from a candidate prediction mode set, where the candidate prediction mode set includes an inter prediction mode and an intra prediction mode, and the prediction mode of the to-be-encoded point cloud is used to determine a method for obtaining a tangent axis of a to-be-encoded patch in the to-be-encoded point cloud and a bitangent axis of the to-be-encoded patch; and encoding a syntax element into a bitstream, where the syntax element is used to indicate the method for obtaining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element includes information used to indicate the prediction mode of the to-be-encoded point cloud. In an example, the method may be performed by an encoder. This technical solution provides an implementation solution to determining "a method for obtaining a tangent axis and a bitangent axis of a to-be-encoded patch". This technical solution can support a scenario in which a plurality of methods for obtaining the tangent axis and the bitangent axis of the to-be-encoded patch coexist.

[0049] In a possible design, when the prediction mode of the to-be-encoded point cloud is the inter prediction

module, configured to reconstruct geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch.

[0059] According to a ninth aspect, an embodiment of this application provides an encoder. The encoder includes: a patch information generation module, configured to: obtain a reference tangent axis of a to-be-encoded patch in a to-be-encoded point cloud and a reference bitangent axis of the to-be-encoded patch; and determine a tangent axis of the to-be-encoded patch and a bitangent axis of the to-be-encoded patch based on the reference tangent axis of the to-be-encoded patch and the reference bitangent axis of the to-be-encoded patch, where a rotation angle of the tangent axis of the to-be-encoded patch relative to the reference tangent axis of the to-be-encoded patch is θ, and a rotation angle of the bitangent axis of the to-be-encoded patch relative to the reference bitangent axis of the to-be-encoded patch is θ; and an auxiliary information encoding module, configured to encode a syntax element into a bitstream, where the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element includes an index of a normal axis of the to-be-encoded patch and information used to indicate the rotation angle θ of the to-be-encoded patch.

[0060] According to a tenth aspect, an embodiment of this application provides a decoder. The decoder includes: an auxiliary information decoding module, configured to: parse a bitstream to obtain a syntax element, where the syntax element includes an index of a normal axis of a to-be-decoded patch in a to-be-decoded point cloud and information used to indicate a rotation angle θ of the to-be-decoded patch; obtain a reference tangent axis of the to-be-decoded patch and a reference bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch, where the index is obtained through parsing; and determine a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing; and a point cloud geometry information reconstruction module, configured to reconstruct geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch.

[0061] According to an eleventh aspect, an embodiment of this application provides an encoder. The encoder includes: a prediction mode determining module, configured to determine a prediction mode of a to-be-encoded point cloud from a candidate prediction mode set, where the candidate prediction mode set includes an inter prediction mode and an intra prediction mode, and the prediction mode of the to-be-encoded point cloud is used to determine a method

description information of a minimum bounding rectangle corresponding to the patch, and determining a tangent axis of the patch and a bitangent axis of the patch based on the normal axis of the patch and the description information of the minimum bounding rectangle corresponding to the patch.

[0071] In a possible design, the method may include: obtaining a reference tangent axis of a patch and a reference bitangent axis of the patch in a point cloud; and determining a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the patch and the reference bitangent axis of the patch, where a rotation angle of the tangent axis of the patch relative to the reference tangent axis of the patch is θ, and a rotation angle of the bitangent axis of the patch relative to the reference bitangent axis of the patch is θ.

[0072] For explanations of related content, beneficial effects, and the like of any method provided in the seventeenth aspect, refer to the foregoing corresponding descriptions. Details are not described herein again.

[0073] According to an eighteenth aspect, an embodiment of this application provides an apparatus for determining a tangent axis and a bitangent axis of a patch. The apparatus can be configured to perform any method provided in the seventeenth aspect. In an example, the apparatus may be a chip. In a possible design, functional modules of the apparatus may be obtained through division according to the method provided in the seventeenth aspect. For example, the functional modules may be obtained through division corresponding to functions, or two or more functions may be integrated into one processing module. In a possible design, the apparatus may include a memory and a processor. The memory is configured to store program code, and when the program code is executed by the processor, any method provided in the seventeenth aspect is performed.

[0074] According to a nineteenth aspect, an embodiment of this application provides a processing apparatus, configured to implement functions of the foregoing apparatus for determining a tangent axis and a bitangent axis of a patch, or the encoder, or the decoder. The processing apparatus includes a processor and an interface. The processing apparatus may be a chip. The processor may be implemented by using hardware or software. When the processor is implemented by using hardware, the processor may be a logic circuit, an integrated circuit, or the like. When the processor is implemented by using software, the processor may be a general-purpose processor, and is implemented by reading software code stored in a memory. The memory may be integrated into the processor, or may be located outside the processor and exist independently.

[0075] According to a twentieth aspect, an embodiment of this application provides a point cloud encoding method. The method includes: projecting a to-be-encoded ~~patch patch~~patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch; obtaining a second occupancy map of the to-be-encoded patch, where the second occupancy map of the to-be-encoded patch is obtained by counterclockwise

coordinates of a point P1 in the first occupancy map of the to-be-encoded patch, and θ represents the rotation angle.

[0083] In a possible implementation, the second occupancy map is obtained by counterclockwise or clockwise rotating the first occupancy map of the to-be-encoded patch by the rotation angle θ around a coordinate origin of a coordinate system constituted by a first tangent axis and a first bitangent axis.

[0084] It can be understood that, the first tangent axis corresponds to a reference tangent axis in the embodiments, and the first bitangent axis corresponds to a reference bitangent axis in the embodiments. The descriptions are applicable to any solution (for example, any solution provided in the twentieth aspect to the twenty-third aspect) provided in the embodiments of this application.

[0085] In a possible design, the information used to indicate the rotation angle θ is an index used to indicate the rotation angle θ.

[0086] In a possible design, a rotation angle by which a second tangent axis of the to-be-encoded patch rotates relative to a first tangent axis of the to-be-encoded patch is θ, and a rotation angle by which a second bitangent axis of the to-be-encoded patch rotates relative to a first bitangent axis of the to-be-encoded patch is θ.

[0087] It can be understood that, the second tangent axis corresponds to a tangent axis in the embodiments, and the second bitangent axis corresponds to a bitangent axis in the embodiments.

[0088] According to a twenty-first aspect, an embodiment of this application provides a point cloud decoding method. The method includes: parsing a bitstream to obtain a syntax element, where the syntax element includes information used to indicate a rotation angle θ of ~~the~~ a to-be-decoded patch; obtaining a second occupancy map of the to-be-decoded patch; obtaining a first occupancy map of the to-be-decoded patch, where the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ; and reconstructing geometry information of the to-be-decoded point cloud based on ~~a first occupancy map of one or more~~one or more first occupancy maps of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch.

[0089] In a possible design, coordinates (x1, y1) of a point in the first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in the second occupancy map of the to-be-decoded patch and a rotation matrix, where the rotation matrix corresponds to the rotation angle.

[0090] In a possible design, the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

[0096] In a possible implementation, the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ around a coordinate origin of a coordinate system constituted by a first tangent axis and a first bitangent axis.

[0097] In a possible design, the information used to indicate the rotation angle θ is an index used to indicate the rotation angle θ.

[0098] In a possible design, a rotation angle by which a second tangent axis of the to-be-decoded patch rotates relative to a first tangent axis of the to-be-decoded patch is θ, and a rotation angle by which a second bitangent axis of the to-be-decoded patch rotates relative to a first bitangent axis of the to-be-decoded patch is θ.

[0099] In a possible design, the obtaining a second occupancy map of the to-be-decoded patch includes: parsing the bitstream to obtain the second occupancy map of the to-be-decoded patch; or parsing the bitstream to obtain information (for example, size information of a minimum bounding rectangle of the second occupancy map of the to-be-decoded patch) that is used to indicate the second occupancy map of the to-be-decoded patch, and obtaining the second occupancy map of the to-be-decoded patch based on the information that is used to indicate the second occupancy map of the to-be-decoded patch.

[00100] According to a twenty-second aspect, an embodiment of this application provides a point cloud encoding method. The method includes: projecting a to-be-encoded ~~patch patch~~patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch; obtaining a second occupancy map of the to-be-encoded patch, where coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, where the rotation matrix corresponds to a rotation angle θ; and encoding a syntax element into a bitstream, where the syntax element includes information used to indicate the rotation angle θ.

[00101] In a possible design, the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

[00102] For a possible implementation of the rotation matrix, refer to the corresponding possible design in the twentieth aspect.

[00103] According to the twenty-third aspect, an embodiment of this application provides a point cloud decoding method. The method includes: reconstructing geometry information of a to-be-decoded point cloud based on ~~a~~one or

more first occupancy maps of one or more to-be-decoded ~~patches patches~~patches in the to-be-decoded point cloud, where the one or more patches include ~~the~~ a to-be-decoded patch, coordinates (x1, y1) of a first point of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a second point of the to-be-decoded patch and a rotation matrix, and the rotation matrix corresponds to a rotation angle θ of the to-be-decoded patch.

[00104] In a possible design, that coordinates (x1, y1) of a first point of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a second point of the to-be-decoded patch and a rotation matrix means that coordinates (x1, y1) of a point in a first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in a second occupancy map of the to-be-decoded patch and a rotation matrix.

[00105] In a possible design, the coordinates (x1, y1) of the first point of the to-be-decoded patch are coordinates (x1, y1) of a point in a first occupancy map of the to-be-decoded patch, and the coordinates (x2, y2) of the second point of the to-be-decoded patch are coordinates (x2, y2) of a point in a second occupancy map of the to-be-decoded patch.

[00106] In a possible design, a first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating a second occupancy map of the to-be-decoded patch by the rotation angle θ, or a second occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise rotating a first occupancy map of the to-be-decoded patch by the rotation angle θ.

[00107] In a possible design, the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

[00108] For a possible implementation of the rotation matrix, refer to the corresponding possible design in the twentieth aspect.

[00109] In a possible design, coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-decoded patch satisfy the following formula, where the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta.$$

[00110] According to a twenty-fourth aspect, an embodiment of this application provides an encoding apparatus. The apparatus includes a memory and a processor. The memory is configured to store program code. The processor is configured to invoke the program code to perform any point cloud encoding method in the first aspect, the third aspect, the fifth aspect, the twentieth aspect, or the twenty-second aspect.

storage apparatus that can store the encoded point cloud data generated by the source apparatus 10. The destination apparatus 20 may access the stored point cloud data through streaming transmission or downloading from the storage apparatus 40. The file server may be any type of server that can store the encoded point cloud data and send the encoded point cloud data to the destination apparatus 20. Examples of the file server include a network server (for example, used for a website), a file transfer protocol (file transfer protocol, FTP) server, a network attached storage (network attached storage, NAS) apparatus, or a local disk drive. The destination apparatus 20 may access the encoded point cloud data through any standard data connection (including an internet connection). The standard data connection may include a wireless channel (for example, a Wi-Fi connection), a wired connection (for example, a digital subscriber line (digital subscriber line, DSL) or a cable modem), or a combination thereof that is suitable for access to the encoded point cloud data stored on the file server. Transmission of the encoded point cloud data from the storage apparatus 40 may be streaming transmission, downloading transmission, or a combination thereof.

[00145] The point cloud coding system 1 described in FIG. 1 is merely an example, and technologies in this application are applicable to a point cloud coding (for example, point cloud encoding or point cloud decoding) apparatus that does not necessarily include any data communication between a point cloud encoding apparatus and a point cloud decoding apparatus. In another example, data is retrieved from a local memory, is transmitted on a network in a streaming manner, and the like. The point cloud encoding apparatus may encode the data and store the data to the memory, and/or the point cloud decoding apparatus may retrieve the data from the memory and decode the data. In many examples, apparatuses that only encode data and store the data to the memory and/or retrieve the data from the memory and decode the data but that do not communicate with each other perform encoding and decoding.

[00146] In the example in FIG. 1, the source apparatus 10 includes a data source 120, the encoder 100, and the output interface 140. In some examples, the output interface 140 may include a modulator/demodulator (modem) and/or a transmitter ~~(or referred to as a transmitter)~~. The data source 120 may include a point cloud capture apparatus (for example, a camera), a point cloud archive including previously captured point cloud data, a point cloud feed-in interface configured to receive point cloud data from a point cloud content provider, ~~and/or~~ a computer graphics system configured to generate point cloud data, or a combination of these sources of point cloud data.

[00147] The encoder 100 may encode the point cloud data from the data source 120. In some examples, the source apparatus 10 directly sends the encoded point cloud data to the destination apparatus 20 through the output interface 140. In another example, the encoded point cloud data may be alternatively stored on the storage apparatus 40, so that the destination apparatus 20 subsequently accesses the encoded point cloud data for decoding and/or playing.

[00148] In the example in FIG. 1, the destination apparatus 20 includes the input interface 240, the decoder 200, and a display apparatus 220. In some examples, the input interface 240 includes a receiver and/or a modem. The input

interface 240 may receive the encoded point cloud data over the link 30 and/or from the storage apparatus 40. The display apparatus 220 may be integrated with the destination apparatus 20 or may be located outside the destination apparatus 20. Generally, the display apparatus 220 displays decoded point cloud data. There may be a plurality of types of display apparatuses 220. For example, the display apparatus 220 may be, for example, a liquid crystal display (liquid crystal display, LCD), a plasma display, an organic light-emitting diode (organic light-emitting diode, OLED) display, or another type of display apparatus.

[00149] Although not shown in FIG. 1, in some aspects, the encoder 100 and the decoder 200 may be respectively integrated with an audio encoder and an audio decoder, and may include an appropriate multiplexer-demultiplexer (multiplexer-demultiplexer, MUX-DEMUX) unit or other hardware and software, to process encoding of both audio and a video in a same data stream or separate data streams. In some examples, if appropriate, the MUX-DEMUX unit may comply with the ITU H.223 multiplexer protocol or another protocol such as a user datagram protocol (user datagram protocol, UDP).

[00150] The encoder 100 and the decoder 200 each may be implemented, for example, as any one of a plurality of circuits: one or more microprocessors, a digital signal processor (digital signal processor~~processing~~, DSP), an application-specific integrated circuit (application specific integrated circuit, ASIC), a field-programmable gate array (field-programmable gate array, FPGA), discrete logic, hardware, or any combination thereof. If this application is implemented partially through software, the apparatus may store, in an appropriate non-volatile computer-readable storage medium, an instruction used for the software, and may use one or more processors to execute the instruction in hardware, to implement the technologies in this application. Any one of the foregoing content (including hardware, software, a combination of hardware and software, and the like) may be considered as one or more processors. The encoder 100 and the decoder 200 each may be included in one or more encoders or decoders, and the encoder or the decoder may be integrated as a part of a combined encoder/decoder (codec) in a corresponding apparatus.

[00151] In this application, the encoder 100 may be generally an apparatus that "signals" or "sends" some information to another apparatus such as the decoder 200. The term "signal" or "send" may generally refer to transmission of a syntax element and/or other data used for decoding compressed point cloud data. The transmission may occur in real time or almost in real time. Alternatively, the communication may occur after a period of time. For example, the communication may occur when a syntax element in an encoded bitstream is stored into a computer-readable storage medium during encoding, and the decoding apparatus may then retrieve the syntax element at any time after the syntax element is stored in the medium.

[00152] FIG. 2 is a schematic block diagram of an example encoder 100 applicable to an embodiment of this application. An MPEG (Moving Picture Expert Group) point cloud compression (Point Cloud Compression, PCC)

encoding framework is used as an example for description in FIG. 2. In the example in FIG. 2, the encoder 100 may include a patch information generation module 101, a packing module 102, a depth map generation module 103, a texture map generation module 104, an image filling module 105, an image-based or video-based encoding module 106, an occupancy map encoding module 107, an auxiliary information encoding module 108, a multiplexer module 109, and the like.

[00153] The patch information generation module 101 is configured to segment a frame of point cloud into a plurality of patches by using a method, and obtain related information and the like of the generated patches. The patch is a set of some points in one frame of point cloud, and generally one connected component region corresponds to one patch. The related information of the patch may include but is not limited to at least one of the following information: a quantity of patches obtained by segmenting a point cloud, position information of each patch in a three-dimensional space, an index of a tangent axis of each patch, an index of a bitangent axis of each patch, an index of a normal axis of each patch, a depth map generated when each patch is projected from the three-dimensional space to a two-dimensional space, a size of the depth map of each patch (for example, the ~~length~~ width and the height of the depth map), an occupancy map generated when each patch is projected from the three-dimensional space to the two-dimensional space, and the like. Some of the related information, such as the quantity of patches obtained by segmenting the point cloud, the index of the normal axis of each patch, the size of the depth map of each patch, the position information of each patch in the point cloud, and size information of the occupancy map of each patch, may be used as auxiliary information and sent to the auxiliary information encoding module 108 for encoding (that is, compression coding). The occupancy map of each patch may be sent to the packing module 102 for packing. Specifically, patches in the point cloud are sorted in a specific order, for example, sorted in descending (ascending) order of the ~~lengths~~widths/heights of the occupancy maps of the patches; and then the occupancy maps of the patches are successively inserted into an available region of an occupancy map of the point cloud in the order of the sorted patches, to obtain the occupancy map of the point cloud. In addition, information about a specific position of each patch in the occupancy map of the point cloud, the depth map of each patch, and the like may be sent to the depth map generation module 103.

[00154] After obtaining the occupancy map of the point cloud, the packing module 102 may send the occupancy map of the point cloud to the occupancy map encoding module 107 for encoding. In addition, the occupancy map of the point cloud may be used to guide the depth map generation module 103 to generate a depth map of the point cloud and guide the texture map generation module 104 to generate a texture map of the point cloud.

[00155] The depth map generation module 103 is configured to: generate the depth map of the point cloud based on the occupancy map of the point cloud, and the occupancy map and the depth map of each patch of the point cloud, and send the generated depth map to the image filling module 105, so that the image filling module 105 fills empty

an example in which the normal axis of the to-be-encoded patch is one of the X axis, the Y axis, and the Z axis of the world coordinate system is used for description.

[00197] Optionally, the tangent axis and the bitangent axis of the to-be-encoded patch may be determined by performing the following S102.

[00198] S102: Determine the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

[00199] Optionally, an encoder may predefine the following mapping relationship, for example, according to a protocol. The mapping relationship is a mapping relationship between the following items: a plurality of normal axes (or indexes of the plurality of normal axes) of a patch, a plurality of types of description information (or indexes of the plurality of types of description information) of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes (or indexes of the plurality of tangent axes) of the patch, and a plurality of bitangent axes (or indexes of the plurality of bitangent axes) of the patch. Then, after the encoder obtains the normal axis (or an index of the normal axis) of the to-be-encoded patch and the description information (or an index of the description information) of the minimum bounding rectangle corresponding to the to-be-encoded patch, the encoder obtains the tangent axis (or an index of the tangent axis of the to-be-encoded patch) and the bitangent axis (or an index of the bitangent axis) of the to-be-encoded patch based on the foregoing mapping relationship.

[00200] A specific form of the mapping relationship is not limited in this embodiment of this application. For example, the mapping relationship may be in a form of a table, a formula, or a logical judgment (for example, an if else operation or a switch operation) performed based on a condition. The following mainly uses an example in which the mapping relationship is in a form of a table for description. Based on this, when S102 is performed, the encoder may obtain the tangent axis and the bitangent axis of the to-be-encoded patch by looking up the table. It can be understood that the foregoing mapping relationship is embodied in one or more tables. This is not limited in this embodiment of this application. For ease of description, the embodiments of this application are described by using an example in which the foregoing mapping relationship is~~these tables are~~ embodied in one table. A general description is provided herein, and details are not described below.

[00201] When the description information of the minimum bounding rectangle corresponding to the patch includes the relationship between sizes of sides of the minimum bounding rectangle corresponding to the patch, possible description information of the minimum bounding rectangle corresponding to the patch and indexes of the description information may be shown in Table 3.

axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element includes the index of the normal axis of the to-be-encoded patch and information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

[00208] The information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include information 1 or information 2.

[00209] The information 1 is the index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch. For example, if B_{U0} = 10 cm, and B_{V0} = 8 cm, it can be learned from Table 3 that the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include: the index "0" of the relationship (that is, $B_{U0} > B_{V0}$) between the sizes of the sides of the minimum bounding rectangle corresponding to the to-be-encoded patch.

[00210] The information 2 is size information (or side size information) of the minimum bounding rectangle corresponding to the to-be-encoded patch. For example, assuming that B_{U0} = 10 cm and B_{V0} = 8 cm, the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include: B_{U0} = 10 cm and B_{V0} = 8 cm.

[00211] During specific implementation, whether the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch includes the information 1 or the information 2 may be predefined (for example, predefined according to a protocol). Certainly, this application is not limited thereto.

[00212] During specific implementation, information encoded into the bitstream may further include auxiliary information such as size information of a minimum bounding rectangle of an occupancy map of the to-be-encoded patch. Based on this, with reference to the information 1 and the information 2, the following optional implementations~~embodiments~~ are provided in this embodiment of this application.

[00213] Optionally, if the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch includes the information 1, the encoder may further encode the size information of the minimum bounding rectangle of the occupancy map of the to-be-encoded patch into the bitstream.

[00214] Optionally, if the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch includes the information 2, the encoder may not encode the size information of the minimum bounding rectangle of the occupancy map of the to-be-encoded patch into the bitstream. In this way, bitstream transmission overheads can be reduced. In this case, a decoder may determine, based on the size information (that is, B_{U0} and B_{V0}) of the minimum bounding rectangle corresponding to the to-be-encoded patch (a

the patch, and indexes of a plurality of bitangent axes of the patch. The index of the target tangent axis is an index of the tangent axis of the to-be-encoded patch, and the index of the target bitangent axis is an index of the bitangent axis of the to-be-encoded patch. For example, the mapping relationship may be shown in Table 4 or Table 5.

[00229] S102B: Look up a table based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch. The target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch. The table that is looked up includes a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

[00230] S102B may be replaced with the following content: Look up a table based on the index of the normal axis of the to-be-encoded patch and an index of the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, to obtain an index of a target tangent axis and an index of a target bitangent axis that correspond to both the index of the normal axis of the to-be-encoded patch and the index of the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch. The index of the target tangent axis is an index of the tangent axis of the to-be-encoded patch, and the index of the target bitangent axis is an index of the bitangent axis of the to-be-encoded patch. The table that is looked up includes a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch. For example, the table that is looked up may be Table 4 or Table 5. Certainly, this embodiment of this application is not limited thereto.

[00231] S102C: Determine, according to the projection rule, the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch. The projection rule refers to distribution, in the two-dimensional space, of ~~an occupancy map obtained by projecting one or more patches~~one or more occupancy map obtained by projecting one or more patches (for example, all patches) in the to-be-encoded point cloud to the two-dimensional space. For a specific implementation of determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, refer to S102A. Optionally, the projection rule may include vertical projection or horizontal projection.

consistent with information predefined by the encoder. Certainly, this embodiment of this application is not limited thereto.

[00243] S202: Determine a tangent axis and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the index and the information are obtained through parsing.

[00244] Optionally, the decoder may predefine the following mapping relationship, for example, according to a protocol, where the mapping relationship is consistent with a mapping relationship predefined by the encoder. The mapping relationship is a mapping relationship between the following items: a plurality of normal axes (or indexes of the plurality of normal axes) of a patch, a plurality of types of description information (or indexes of the plurality of types of description information) of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes (or indexes of the plurality of tangent axes) of the patch, and a plurality of bitangent axes (or indexes of the plurality of bitangent axes) of the patch. Then, after the decoder parses the bitstream to obtain the index of the normal axis of the to-be-decoded patch and the description information used to indicate the minimum bounding rectangle corresponding to the to-be-decoded patch, the decoder obtains the tangent axis of the to-be-decoded patch (or an index of the tangent axis of the to-be-decoded patch) and the bitangent axis of the to-be-decoded patch (or an index of the bitangent axis of the to-be-decoded patch) based on the foregoing mapping relationship.

[00245] If the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch includes the size information of the minimum bounding rectangle corresponding to the to-be-decoded patch, the decoder may first obtain, based on the size information of the minimum bounding rectangle corresponding to the to-be-decoded patch, the description information (or the index of the description information) of the minimum bounding rectangle corresponding to the to-be-decoded patch, and then obtain the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the foregoing mapping relationship.

[00246] If the decoder stores the foregoing mapping relationship in form of a table, the foregoing mapping relationship may be the mapping relationship shown in Table 4 or Table 5. Based on this, the decoder may obtain the tangent axis and the bitangent axis of the to-be-decoded patch by looking up the table.

[00247] S203: Reconstruct geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches (for example, all patches) in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch.

[00248] For the geometry information of the point cloud and a specific implementation of S203, refer to the

corresponding to the to-be-decoded patch, to obtain an index of a target tangent axis and an index of a target bitangent axis that correspond to both the index of the normal axis of the to-be-decoded patch and the index of the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch. The index of the target tangent axis is an index of the tangent axis of the to-be-decoded patch, and the index of the target bitangent axis is an index of the bitangent axis of the to-be-decoded patch. The table that is looked up includes a mapping relationship between the following items: a plurality of normal axes of the patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch. For example, the table that is looked up may be Table 4 or Table 5. Certainly, this embodiment of this application is not limited thereto.

[00255] S202C: Determine, according to a projection rule (that is, a projection rule used for projecting the to-be-decoded point cloud), the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch. The projection rule refers to distribution, in a two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space. Optionally, the projection rule includes vertical projection or horizontal projection.

[00256] Optionally, the projection rule may be predefined, for example, predefined according to a protocol. In addition, the projection rule is consistent with a projection rule predefined by the encoder.

[00257] Optionally, the projection rule may be obtained by the decoder by parsing the bitstream. The syntax element obtained by parsing the bitstream includes information used to indicate the projection rule. The information used to indicate the projection rule is frame-level information. Specific information used to indicate the projection rule is not limited in this embodiment of this application. For example, the information may be an index of the projection rule. For example, if the projection rule indicates vertical projection, the index of the projection rule may be 0. If the projection rule indicates horizontal projection, the index of the projection rule may be 1. Certainly, this application is not limited thereto.

[00258] In an example, when the projection rule indicates vertical projection, the mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch may be the case in the foregoing Solution 1. In this case, the decoder may obtain the tangent axis and the bitangent axis of the to-be-decoded patch by looking up Table 4. When the projection rule indicates horizontal projection, the mapping relationship may be the case in the foregoing Solution 2. In this case, the d~~en~~coder may obtain the tangent axis and the bitangent axis of the to-be-encoded patch by looking up Table 5.

Therefore, calculation complexity of the encoder can be reduced.

[00296] FIG. 15 is a schematic flowchart of a point cloud decoding method according to an embodiment of this application. The point cloud decoding method provided in this embodiment corresponds to the point cloud encoding method provided in the embodiment shown in FIG. 13. Therefore, for explanations of related content in this embodiment, refer to the embodiment shown in FIG. 13. The method shown in FIG. 15 may include the following steps.

[00297] S401: Parse a bitstream to obtain a syntax element, where the syntax element includes an index of a normal axis of a to-be-decoded patch in a to-be-decoded point cloud and information used to indicate a rotation angle θ of the to-be-decoded patch.

[00298] The to-be-decoded point cloud may be a point cloud that is transmitted by an encoder to a decoder after the encoder encodes the to-be-encoded point cloud in the embodiment shown in FIG. 13. The to-be-decoded patch may be a patch that is transmitted by the encoder to the decoder after the encoder encodes the to-be-encoded patch in the embodiment shown in FIG. 13. With reference to the bitstream structure shown in FIG. 3, if the to-be-decoded point cloud is the 1st frame of point cloud in the GOF, S401 may include: parsing the field 1104, to obtain the index of the normal axis of the to-be-decoded patch and the information used to indicate the rotation angle θ of the to-be-decoded patch.

[00299] Optionally, the information used to indicate the rotation angle θ of the to-be-decoded patch may include: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-decoded patch. A specific type of included information may be predefined, for example, predefined according to a protocol, and the information is consistent with information predefined by the encoder. Certainly, this embodiment of this application is not limited thereto.

[00300] Further, optionally, ~~an~~ the identifier of the patch that matches the to-be-decoded patch is used to indicate an index of the patch that matches the to-be-decoded patch, or used to indicate that there are the patch that matches the to-be-decoded patch in a decoded point cloud and an index of the patch that matches the to-be-decoded patch. A specific type of information that is indicated by the identifier of the patch that matches the to-be-decoded patch may be predefined, for example, predefined according to a protocol, and the information is consistent with information predefined by the encoder. Certainly, this embodiment of this application is not limited thereto.

[00301] S402: Obtain a reference tangent axis of the ~~a~~ to-be-de~~n~~coded patch and a reference bitangent axis of the to-be-encoded patch based on the index of the normal axis of the to-be-decoded patch, where the index is obtained through parsing. For example, an index of the reference tangent axis of the to-be-de~~n~~coded patch and an index of the

reference bitangent axis of the to-be-d~~e~~ncoded patch are obtained by looking up Table 2 based on the index of the normal axis of the to-be-d~~e~~ncoded patch, and then the reference tangent axis and the reference bitangent axis of the to-be-d~~e~~ncoded patch are obtained by looking up Table ~~1~~2.

[00302] S403: Determine a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-encoded patch, the reference bitangent axis of the to-be-d~~e~~ncoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing.

[00303] S403 may be implemented by using one of the following steps S403A to S403C:

[00304] S403A: When the information used to indicate the rotation angle θ of the to-be-decoded patch includes the rotation angle θ, determine the tangent axis and the bitangent axis of the to-be-decoded patch based on the reference tangent axis and the reference bitangent axis of the to-be-d~~e~~ncoded patch and the rotation angle θ. Specifically, the reference tangent axis of the to-be-d~~e~~ncoded patch is counterclockwise rotated, around the coordinate origin (that is, the coordinate origin of a coordinate system constituted by the reference tangent axis and the reference bitangent axis of the to-be-d~~e~~ncoded patch) by $-\theta$ (that is, clockwise rotated by θ), to obtain the tangent axis of the to-be-decoded patch. Correspondingly, the reference bitangent axis of the to-be-d~~e~~ncoded patch is counterclockwise rotated by $-\theta$ (that is, clockwise rotated by θ) around the coordinate origin, to obtain the bitangent axis of the to-be-decoded patch.

[00305] S403B: When the information used to indicate the rotation angle θ of the to-be-decoded patch includes the index of the rotation angle θ, obtain the rotation angle θ indicated by the index of the rotation angle θ, and then determine the tangent axis and the bitangent axis of the to-be-decoded patch based on the reference tangent axis and the reference bitangent axis of the to-be-d~~e~~ncoded patch and the rotation angle θ.

[00306] S403C: When the information used to indicate the rotation angle θ of the to-be-decoded patch includes the identifier of the patch that matches the to-be-decoded patch, determine, based on the identifier that is of the patch matching the to-be-decoded patch and that is obtained through parsing, the patch that matches the to-be-decoded patch, and obtain a rotation angle θ of the patch that matches the to-be-decoded patch; and determine the tangent axis and the bitangent axis of the to-be-decoded patch based on the reference tangent axis and the reference bitangent axis of the to-be-d~~e~~ncoded patch and the rotation angle θ.

[00307] For example, if the identifier of the patch that matches the to-be-decoded patch is used to indicate the

index of the patch that matches the to-be-decoded patch, the patch that matches the to-be-decoded patch may be obtained by looking up a table based on the index. The table that is looked up includes a mapping relationship between the following items: a plurality of patches and indexes of the patches.

[00308] For example, if the identifier of the patch that matches the to-be-decoded patch is used to indicate that there are the patch that matches the to-be-decoded patch in the decoded point cloud and the index of the patch that matches the to-be-decoded patch, optionally, if a value of the identifier is not 0, it indicates that there is the patch that matches the to-be-decoded patch in the decoded point cloud, and a value obtained by subtracting 1 from the value of the identifier is used as the index of the patch that matches the to-be-decoded patch~~to be encoded patch~~.

[00309] S404: Reconstruct geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch.

[00310] For a specific implementation of S404, refer to the foregoing descriptions or a current technology.

[00311] Optionally, the syntax element further includes information used to indicate a size of a minimum bounding rectangle of an occupancy map of the to-be-decoded patch. In this case, S404 may include: reconstructing the geometry information of the to-be-decoded point cloud based on the one or more tangent ax~~i~~es and the one more more bitangent ax~~i~~es of the one or more patches in the to-be-decoded point cloud and the size information of the minimum bounding rectangle of the occupancy map of the to-be-decoded patch, where the size information is obtained by parsing the bitstream. For a specific implementation, refer to the foregoing descriptions or the current technology. For related descriptions such as the geometry information of the point cloud and the size information of the minimum bounding rectangle of the occupancy map of the to-be-decoded patch, refer to the foregoing descriptions.

[00312] Because the point cloud decoding method provided in this embodiment corresponds to the point cloud encoding method provided in the embodiment shown in FIG. 13, for beneficial effects that can be achieved in this embodiment, refer to the related descriptions in the embodiment shown in FIG. 13.

[00313] FIG. 16 is a schematic flowchart of a point cloud encoding method according to an embodiment of this application. The method may include the following steps.

[00314] S501: Determine a prediction mode of a to-be-encoded point cloud from a candidate prediction mode set, where the candidate prediction mode set includes an inter prediction mode and an intra prediction mode, and the prediction mode of the to-be-encoded point cloud is used to determine a method for obtaining a tangent axis and a bitangent axis of a to-be-encoded patch in the to-be-encoded point cloud.

[00315] The inter prediction mode is a mode in which the to-be-encoded patch in the point cloud is encoded based on a correlation between point clouds. For example, the inter prediction mode is a mode in which a to-be-

information encoding module 1802 is configured to encode a syntax element into a bitstream, where the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element includes an index of the normal axis of the to-be-encoded patch and information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch. For example, the patch information generation module 1801 can be configured to perform S101 in FIG. 9 and/or another step described in the embodiments of this application; and the auxiliary information encoding module 1802 can be configured to perform S104 in FIG. 9 and/or another step described in the embodiments of this application.

[00339] In a feasible implementation, the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch may include a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch.

[00340] In a feasible implementation, the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch includes an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

[00341] In a feasible implementation, the patch information generation module 1801 is further configured to: determine the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch; and project the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch. For example, the patch information generation module 1801 can be configured to perform S101 in FIG. 9 and/or another step described in the embodiments of this application; and the auxiliary information encoding module 1802 can be configured to perform S104 in FIG. 9 and/or another step described in the embodiments of this application.

[00342] In a feasible implementation, the patch information generation module 1801 is specifically configured to: determine, according to a projection rule, the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, where the projection rule refers to distribution, in the two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space.

[00343] In a feasible implementation, the projection rule is preset, or the projection rule is determined according to a rate-distortion cost criterion.

[00344] In a feasible implementation, if the projection rule is determined according to the rate-distortion cost criterion, the syntax element further includes information used to indicate the projection rule.

[00345] In a feasible implementation, the patch information generation module 1801 is specifically configured to: determine, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, where the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch.

[00346] In a feasible implementation, the patch information generation module 1801 is specifically configured to: look up a table based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, where the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch, and the table includes a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

[00347] In a feasible implementation, if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch.

[00348] In a feasible implementation, if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch.

[00349] The projection rule refers to distribution, in the two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space. The normal axis of the to-be-encoded patch is perpendicular to the two-dimensional space.

[00350] FIG. 19 is a schematic block diagram of a decoder 190 according to an embodiment of this application.

The decoder 190 may include an auxiliary information decoding module 1901 and a point cloud geometry information reconstruction module 1902. In an example, the auxiliary information decoding module 1901 may correspond to the auxiliary information decoding module 204 in FIG. 4, and the point cloud geometry information reconstruction module 1902 may correspond to the point cloud geometry information reconstruction module ~~204~~ 205 in FIG. 4. Certainly, this application is not limited thereto.

[00351] The following describes a feasible implementation of performing point cloud–based decoding by the decoder 190.

[00352] In a feasible implementation, the auxiliary information decoding module 1901 is configured to: parse a bitstream to obtain a syntax element, where the syntax element includes an index of a normal axis of a to-be-decoded patch in a to-be-decoded point cloud and information used to indicate description information of a minimum bounding rectangle corresponding to the to-be-decoded patch; and determine a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the index and the information are obtained through parsing. The point cloud geometry information reconstruction module 1902 is configured to reconstruct geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch. For example, the auxiliary information decoding module 1901 can be configured to perform S201 and S202 in FIG. 12 and/or another step described in the embodiments of this application, and the point cloud geometry information ~~auxiliary~~ information ~~encoding~~ reconstruction module 1~~8~~902 can be configured to perform S203 in FIG. 12 and/or another step described in the embodiments of this application.

[00353] In a feasible implementation, the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch includes a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch.

[00354] In a feasible implementation, the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch includes an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-decoded patch.

[00355] In a feasible implementation, the auxiliary information decoding module 1901 is specifically configured to determine, according to a projection rule, the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the projection rule refers to distribution,

in a two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space.

[00356] In a feasible implementation, the projection rule is preset; or the syntax element further includes information used to indicate the projection rule, and correspondingly, the projection rule is a projection rule indicated by the syntax element that is obtained by parsing the bitstream.

[00357] In a feasible implementation, the auxiliary information decoding module 1901 is specifically configured to: determine, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch.

[00358] In a feasible implementation, the auxiliary information decoding module 1901 is specifically configured to: look up a table based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, where the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch, and the table includes a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

[00359] In a feasible implementation, if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch; or if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch. The projection rule refers to distribution, in a two-dimensional space, of ~~an~~one or more occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space, and the normal axis

project the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, to obtain an occupancy map of the to-be-encoded patch; and determine a minimum bounding rectangle of the occupancy map of the to-be-encoded patch. The syntax element further includes size information of the minimum bounding rectangle of the occupancy map of the to-be-encoded patch. For example, the patch information generation module 1801 can be configured to perform S303 and S304 in FIG. 13.

[00366] The following describes some other feasible implementations of performing point cloud–based decoding by the decoder 190.

[00367] In a feasible implementation, the auxiliary information decoding module 1901 is configured to: parse a bitstream to obtain a syntax element, where the syntax element includes an index of a normal axis of a to-be-decoded patch in a to-be-decoded point cloud and information used to indicate a rotation angle θ of the to-be-decoded patch; obtain a reference tangent axis of the to-be-decoded patch and a reference bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch, where the index is obtained through parsing; and determine a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing; and the point cloud geometry information reconstruction module 1902 is configured to reconstruct geometry information of the to-be-decoded point cloud based on ~~a~~one or more tangent ax~~i~~es and ~~a~~one or more bitangent ax~~i~~es of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch. For example, the auxiliary information decoding module 1901 can be configured to perform S401, S402, and S403 in FIG. 15 and/or another step described in the embodiments of this application, and the point cloud geometry information reconstruction module 1902~~the auxiliary information decoding module 1901~~ can be configured to perform S404 in FIG. 15 and/or another step described in the embodiments of this application.

[00368] In a feasible implementation, the information used to indicate the rotation angle θ of the to-be-decoded patch includes: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-decoded patch.

[00369] In a feasible implementation, the identifier of the patch that matches the to-be-decoded patch is used to indicate an index of the patch that matches the to-be-decoded patch, or used to indicate whether there are the patch that matches the to-be-decoded patch in a decoded point cloud and an index of the patch that matches the to-be-decoded patch.

[00370] In a feasible implementation, the information used to indicate the rotation angle θ of the to-be-decoded patch includes the identifier of the patch that matches the to-be-decoded patch; and the auxiliary information decoding module 1901 is specifically configured to: determine, based on the identifier that is of the patch matching the to-be-decoded patch and that is obtained through parsing, the patch that matches the to-be-decoded patch, and obtain a rotation angle θ of the patch that matches the to-be-decoded patch; and determine the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the rotation angle θ.

[00371] In a feasible implementation, the syntax element further includes size information of a minimum bounding rectangle of an occupancy map of the to-be-decoded patch; and the point cloud geometry information reconstruction module 1902 is specifically configured to: reconstruct the geometry information of the to-be-decoded point cloud based on ~~the tangent axis and the bitangent axis of the one or more patches~~the one or more tangent axes and the one or more bitangent axes of the one or more patches in the to-be-decoded point cloud and the size information of the minimum bounding rectangle of the occupancy map of the to-be-decoded patch, where the size information is obtained by parsing the bitstream.

[00372] The following describes some other feasible implementations of performing point cloud–based encoding by the encoder 180.

[00373] In a feasible implementation, the patch information generation module 1801 is configured to: project a to-be-encoded patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch; and obtain a second occupancy map of the to-be-encoded patch, where the second occupancy map of the to-be-encoded patch is obtained by counterclockwise or clockwise rotating the first occupancy map of the to-be-encoded patch by a rotation angle θ; and the auxiliary information encoding module 1802 is configured to encode a syntax element into a bitstream, where the syntax element includes information used to indicate the rotation angle θ.

[00374] In a feasible implementation, coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, where the rotation matrix corresponds to the rotation angle.

[00375] In a feasible implementation, the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

[00384] In a feasible implementation, the auxiliary information decoding module 1901 is configured to: parse a bitstream to obtain a syntax element, where the syntax element includes information used to indicate a rotation angle θ of ~~the~~ a to-be-decoded patch; and obtain a second occupancy map of the to-be-decoded patch; and the point cloud geometry information reconstruction module 1902 is configured to: obtain a first occupancy map of the to-be-decoded patch, where the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ; and reconstruct ~~geometry information of the~~ a to-be-decoded point cloud based on ~~a~~one or more first occupancy maps of one or more patches in the to-be-decoded point cloud, where the one or more patches include the to-be-decoded patch.

[00385] In a feasible implementation, coordinates (x1, y1) of a point in the first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in the second occupancy map of the to-be-decoded patch and a rotation matrix, where the rotation matrix corresponds to the rotation angle.

[00386] In a feasible implementation, the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

[00387] In a feasible implementation, the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$, or the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

[00388] In a feasible implementation, when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$; when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$; when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

[00389] In a feasible implementation, when the rotation angle θ is 0°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$; when the rotation angle θ is 90°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$; when the rotation angle θ is 180°, the rotation matrix is represented as an inverse matrix of

[00396] The following describes some other feasible implementations of performing point cloud–based encoding by the encoder 180.

[00397] The patch information generation module 1801 is configured to: project a to-be-encoded ~~patch~~ ~~patch~~patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch; and obtain a second occupancy map of the to-be-encoded patch, where coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, where the rotation matrix corresponds to a rotation angle θ; and the auxiliary information encoding module 1802 is configured to encode a syntax element into a bitstream, where the syntax element includes information used to indicate the rotation angle θ.

[00398] In a feasible implementation, the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

[00399] In a feasible implementation, the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

[00400] In a feasible implementation, when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$; when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$; when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

[00401] In a feasible implementation, coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-encoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-encoded patch satisfy the following formula, where the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta.$$

[00402] In addition, an embodiment of this application ~~further~~ provides a decoding apparatus, including a point cloud memory and a point cloud decoder. The point cloud memory is configured to store point cloud data. The point cloud decoder is configured to reconstruct geometry information of a to-be-decoded point cloud based on ~~a~~one or more first occupancy map~~s~~ of one or more to-be-decoded patches in the to-be-decoded point cloud, where the one or more patches

axis of a to-be-decoded patch in a to-be-decoded point cloud and a bitangent axis of the to-be-decoded patch, the syntax element includes information used to indicate a prediction mode of the to-be-decoded point cloud, and the prediction mode of the to-be-decoded point cloud includes an inter prediction mode or an intra prediction mode; and obtain the method for obtaining the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch according to the method, indicated by the syntax element, for obtaining the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch. For example, the auxiliary information decoding module 2201 can be configured to perform S601 and S602 in FIG. 17 and/or another step described in the embodiments of this application.

[00416] For cases in which the prediction mode of the to-be-dencoded point cloud is the inter prediction mode or the intra prediction mode, for related descriptions of the method for obtaining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, refer to the related designs in the ~~fifth~~sixth aspect in the summary part or the related descriptions in the embodiment shown in FIG. 17.

[00417] It can be understood that the modules in the encoder/decoder in the embodiments of this application are functional entities that implement various execution steps included in the point cloud encoding/decoding method corresponding to this application. To be specific, the modules are functional entities that can implement all steps in the point cloud encoding/decoding method corresponding to this application and extension and transformation of these steps. For details, refer to descriptions of the point cloud encoding/decoding method~~the image filtering method~~ in this specification. For brevity, details are not described in this specification.

[00418] FIG. 22 is a schematic block diagram of an implementation of an encoding device or a decoding device (briefly referred to as a coding device 230 or a point cloud coding device 230) used in an embodiment of this application. The coding device 230 may include a processor 2310, a memory 2330, and a bus system 2350. The processor 2310 is connected to the memory 2330 through the bus system 2350. The memory 2330 is configured to store an instruction, and the processor 2310 is configured to execute the instruction stored in the memory 2330, to perform various point cloud encoding/decoding methods described in this application~~, and particularly a method for performing filtering on a current picture block based on a block size of the current picture block~~. To avoid repetition, details are not described herein again.

[00419] In this embodiment of this application, the processor 2310 may be a central processing unit (central processing unit, CPU), or the processor 2310 may be another general-purpose processor, a DSP, an ASIC, an FPGA, another programmable logic device, a discrete gate, a transistor logic device, a discrete hardware component, or the like. The general-purpose processor may be a microprocessor, or may be any conventional processor or the like.

[00420] The memory 2330 may include a ROM device or a RAM device. Any other appropriate type of storage

device may also be used as the memory 2330. The memory 2330 may include code and data 2331 that are accessed by the processor 2310 through the bus system 2350. The memory 2330 may further include an operating system 2333 and an application program 2335. The application program 2335 includes at least one program that enables the processor 2310 to perform the point cloud encoding/decoding method described in this application ~~(particularly the method for performing filtering on a current picture block based on a block size of the current picture block described in this application)~~. For example, the application program 2335 may include applications 1 to N, and further include a point cloud encoding/decoding application (referred to as a point cloud coding application) for performing the point cloud encoding/decoding method described in this application.

[00421] The bus system 2350 may further include a power bus, a control bus, a status signal bus, and the like, in addition to a data bus. However, for clear description, various types of buses in the figure are denoted as the bus system 2350.

[00422] Optionally, the coding device 230 may further include one or more output devices, such as a display 2370. In an example, the display 2370 may be a touchsensitive display that combines a display and a touch unit that operably senses touch input. The display 2370 may be connected to the processor 2310 through the bus system 2350.

[00423] A person skilled in the art can understand that, the functions described with reference to various illustrative logical blocks, modules, and algorithm steps disclosed and described in this specification can be implemented by hardware, software, firmware, or any combination thereof. If the functions are implemented by software, the functions described with reference to the illustrative logical blocks, modules, and steps may be stored in or transmitted over a computer-readable medium as one or more instructions or code and executed by a hardware-based processing unit. The computer-readable medium may include a computer-readable storage medium, which corresponds to a tangible medium such as a data storage medium, or a communications medium including any medium that facilitates transfer of a computer program from one place to another place (for example, according to a communication protocol). In this manner, the computer-readable medium may generally correspond to: (1) a non-transitory tangible computer-readable storage medium, or (2) a communications medium such as a signal or a carrier. The data storage medium may be any usable medium that can be accessed by one or more computers or one or more processors to retrieve instructions, code, and/or data structures for implementing the technologies described in this application. A computer program product may include a computer-readable medium.

[00424] As an example but not a limitation, such computer-readable storage media may include a RAM, a ROM, an EEPROM, a CD-ROM or another compact disc storage apparatus, a magnetic disk storage apparatus or another magnetic storage apparatus, a flash memory, or any other medium that can be used to store desired program code in a form of an instruction or a data structure and that can be accessed by a computer. In addition, any connection is

CLAIMS

What is claimed is:

1. A point cloud encoding method, comprising:

acquiring a normal axis of a to-be-encoded patch patch in a to-be-encoded point cloud and description information of a minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch are used to determine a tangent axis of the to-be-encoded patch and a bitangent axis of the to-be-encoded patch; and

encoding a syntax element into a bitstream, wherein the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element comprises an index of the normal axis of the to-be-encoded patch and information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

2. The point cloud encoding method according to claim 1, wherein the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch.

3. The point cloud encoding method according to claim 2, wherein the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

4. The point cloud encoding method according to any one of claims 1 to 3, wherein the method further comprises:

determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch; and

projecting the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch.

5. The point cloud encoding method according to claim 4, wherein the determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises:

determining, according to a projection rule, the tangent axis of the to-be-encoded patch and the bitangent axis of

the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the projection rule refers to distribution, in the two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space.

6. The point cloud encoding method according to claim 5, wherein the projection rule is preset, or the projection rule is determined according to a rate-distortion cost criterion.

7. The point cloud encoding method according to claim 6, wherein if the projection rule is determined according to the rate-distortion cost criterion, the syntax element further comprises information used to indicate the projection rule.

8. The point cloud encoding method according to any one of claims 4 to 7, wherein the determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises:

determining, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch.

9. The point cloud encoding method according to any one of claims 4 to 7, wherein the determining the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises:

looking up a table based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch, and the table comprises a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality

of tangent axes of the patch, and a plurality of bitangent axes of the patch.

10. The point cloud encoding method according to any one of claims 1 to 3, wherein

if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch; or

if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch; wherein

the projection rule refers to distribution, in a two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space, and the normal axis of the to-be-encoded patch is perpendicular to the two-dimensional space.

11. A point cloud decoding method, comprising:

parsing a bitstream to obtain a syntax element, wherein the syntax element comprises an index of a normal axis of a to-be-decoded patch patch in a to-be-decoded point cloud and information used to indicate description information of a minimum bounding rectangle corresponding to the to-be-decoded patch;

determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the index and the information are obtained through parsing; and

reconstructing geometry information of the to-be-decoded point cloud based on a tangent axis and a bitangent axis of one or more patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch.

12. The point cloud decoding method according to claim 11, wherein the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch comprises a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch.

13. The point cloud decoding method according to claim 12, wherein the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch comprises an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-decoded patch.

14. The point cloud decoding method according to any one of claims 11 to 13, wherein the determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the index and the information are obtained through parsing comprises:

determining, according to a projection rule, the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the projection rule refers to distribution, in a two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space.

15. The point cloud decoding method according to claim 14, wherein the projection rule is preset; or the syntax element further comprises information used to indicate the projection rule, and correspondingly, the projection rule is a projection rule indicated by the syntax element that is obtained by parsing the bitstream.

16. The point cloud decoding method according to any one of claims 11 to 15, wherein the determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the index and the information are obtained through parsing comprises:

determining, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch.

17. The point cloud decoding method according to any one of claims 11 to 15, wherein the determining a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the index and the information are obtained through parsing comprises:

looking up a table based on the normal axis of the to-be-decoded patch and the description information of the

minimum bounding rectangle corresponding to the to-be-decoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch, and the table comprises a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

18. The point cloud decoding method according to any one of claims 11 to 13, wherein

if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch; or

if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch; wherein

the projection rule refers to distribution, in a two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space, and the normal axis of the to-be-decoded patch is perpendicular to the two-dimensional space.

19. A point cloud encoding method, comprising:

obtaining a reference tangent axis of a to-be-encoded patch patch in a to-be-encoded point cloud and a reference bitangent axis of the to-be-encoded patch;

determining a tangent axis of the to-be-encoded patch and a bitangent axis of the to-be-encoded patch based on the reference tangent axis of the to-be-encoded patch and the reference bitangent axis of the to-be-encoded patch, wherein a rotation angle of the tangent axis of the to-be-encoded patch relative to the reference tangent axis of the to-be-encoded patch is θ, and a rotation angle of the bitangent axis of the to-be-encoded patch relative to the reference bitangent axis of the to-be-encoded patch is θ; and

encoding a syntax element into a bitstream, wherein the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element comprises an index of a normal axis of the to-be-encoded patch and information used to indicate the rotation angle θ of the to-be-encoded

patch.

20. The point cloud encoding method according to claim 19, wherein the information used to indicate the rotation angle θ of the to-be-encoded patch comprises: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-encoded patch.

21. The point cloud encoding method according to claim 20, wherein the identifier of the patch that matches the to-be-encoded patch is used to indicate an index of the patch that matches the to-be-encoded patch, or used to indicate that there are the patch that matches the to-be-encoded patch in an encoded point cloud and an index of the patch that matches the to-be-encoded patch.

22. The point cloud encoding method according to any one of claims 19 to 21, wherein the method further comprises:

determining the rotation angle θ from a plurality of candidate rotation angles according to a rate-distortion cost criterion; or

obtaining a rotation angle of the patch that matches the to-be-encoded patch from the encoded point cloud, and using the obtained rotation angle as the rotation angle θ of the to-be-encoded patch.

23. The point cloud encoding method according to any one of claims 19 to 22, wherein the method further comprises:

projecting the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, to obtain an occupancy map of the to-be-encoded patch; and

determining a minimum bounding rectangle of the occupancy map of the to-be-encoded patch; wherein

the syntax element further comprises size information of the minimum bounding rectangle of the occupancy map of the to-be-encoded patch.

24. A point cloud decoding method, comprising:

parsing a bitstream to obtain a syntax element, wherein the syntax element comprises an index of a normal axis of a to-be-decoded patch patch in a to-be-decoded point cloud and information used to indicate a rotation angle θ of the to-be-decoded patch;

obtaining a reference tangent axis of the to-be-decoded patch and a reference bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch, wherein the index is obtained through parsing;

determining a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to

indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing; and

reconstructing geometry information of the to-be-decoded point cloud based on a tangent axis and a bitangent axis of one or more patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch.

25. The point cloud decoding method according to claim 24, wherein the information used to indicate the rotation angle θ of the to-be-decoded patch comprises: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-decoded patch.

26. The point cloud decoding method according to claim 25, wherein the identifier of the patch that matches the to-be-decoded patch is used to indicate an index of the patch that matches the to-be-decoded patch, or used to indicate whether there are the patch that matches the to-be-decoded patch in a decoded point cloud and an index of the patch that matches the to-be-decoded patch.

27. The point cloud decoding method according to claim 25 or 26, wherein the information used to indicate the rotation angle θ of the to-be-decoded patch comprises the identifier of the patch that matches the to-be-decoded patch, and the determining a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing comprises:

determining, based on the identifier that is of the patch matching the to-be-decoded patch and that is obtained through parsing, the patch that matches the to-be-decoded patch, and obtaining a rotation angle θ of the patch that matches the to-be-decoded patch; and

determining the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the rotation angle θ.

28. The point cloud decoding method according to any one of claims 24 to 27, wherein the syntax element further comprises size information of a minimum bounding rectangle of an occupancy map of the to-be-decoded patch, and the reconstructing geometry information of the to-be-decoded point cloud based on a tangent axis and a bitangent axis of one or more patches in the to-be-decoded point cloud comprises:

reconstructing the geometry information of the to-be-decoded point cloud based on the tangent axis and the bitangent axis of the one or more patches in the to-be-decoded point cloud and the size information of the minimum bounding rectangle of the occupancy map of the to-be-decoded patch, wherein the size information is obtained by

parsing the bitstream.

29. An encoder, comprising:

a patch patch information generation module, configured to acquire a normal axis of a to-be-encoded patch in a to-be-encoded point cloud and description information of a minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch are used to determine a tangent axis of the to-be-encoded patch and a bitangent axis of the to-be-encoded patch; and

an auxiliary information encoding module, configured to encode a syntax element into a bitstream, wherein the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element comprises an index of the normal axis of the to-be-encoded patch and information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

30. The encoder according to claim 29, wherein the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch.

31. The encoder according to claim 30, wherein the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch comprises an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-encoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-encoded patch.

32. The encoder according to any one of claims 29 to 31, wherein

the patch information generation module is further configured to: determine the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch; and project the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch.

33. The encoder according to claim 32, wherein

the patch information generation module is specifically configured to: determine, according to a projection rule, the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the projection rule refers to distribution, in the two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space.

34. The encoder according to claim 33, wherein the projection rule is preset, or the projection rule is determined according to a rate-distortion cost criterion.

35. The encoder according to claim 34, wherein if the projection rule is determined according to the rate-distortion cost criterion, the syntax element further comprises information used to indicate the projection rule.

36. The encoder according to any one of claims 32 to 35, wherein

the patch information generation module is specifically configured to: determine, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch.

37. The encoder according to any one of claims 32 to 35, wherein

the patch information generation module is specifically configured to: look up a table based on the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-encoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-encoded patch, wherein the target tangent axis is the tangent axis of the to-be-encoded patch, and the target bitangent axis is the bitangent axis of the to-be-encoded patch, and the table comprises a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

38. The encoder according to any one of claims 29 to 31, wherein

if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the bitangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch; or

if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located is the tangent axis of the to-be-encoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-encoded patch is located

is the bitangent axis of the to-be-encoded patch; wherein

the projection rule refers to distribution, in a two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-encoded point cloud to the two-dimensional space, and the normal axis of the to-be-encoded patch is perpendicular to the two-dimensional space.

39. A decoder, comprising:

an auxiliary information decoding module, configured to: parse a bitstream to obtain a syntax element, wherein the syntax element comprises an index of a normal axis of a to-be-decoded patch patch in a to-be-decoded point cloud and information used to indicate description information of a minimum bounding rectangle corresponding to the to-be-decoded patch; and determine a tangent axis of the to-be-decoded patch and a bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch and the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the index and the information are obtained through parsing; and

a point cloud geometry information reconstruction module, configured to reconstruct geometry information of the to-be-decoded point cloud based on a tangent axis and a bitangent axis of one or more patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch.

40. The decoder according to claim 39, wherein the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch comprises a relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch.

41. The decoder according to claim 40, wherein the information used to indicate the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch comprises an index of the relationship between sizes of sides of the minimum bounding rectangle corresponding to the to-be-decoded patch, or size information of the minimum bounding rectangle corresponding to the to-be-decoded patch.

42. The decoder according to any one of claims 39 to 41, wherein

the auxiliary information decoding module is specifically configured to determine, according to a projection rule, the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the projection rule refers to distribution, in a two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space.

43. The decoder according to claim 42, wherein the projection rule is preset; or the syntax element further comprises information used to indicate the projection rule, and correspondingly, the projection rule is a projection rule indicated by the syntax element that is obtained by parsing the bitstream.

44. The decoder according to any one of claims 39 to 43, wherein

the auxiliary information decoding module is specifically configured to: determine, based on a mapping relationship, a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the mapping relationship is a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch; and the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch.

45. The decoder according to any one of claims 39 to 43, wherein

the auxiliary information decoding module is specifically configured to: look up a table based on the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, to obtain a target tangent axis and a target bitangent axis that correspond to both the normal axis of the to-be-decoded patch and the description information of the minimum bounding rectangle corresponding to the to-be-decoded patch, wherein the target tangent axis is the tangent axis of the to-be-decoded patch, and the target bitangent axis is the bitangent axis of the to-be-decoded patch, and the table comprises a mapping relationship between the following items: a plurality of normal axes of a patch, a plurality of types of description information of a minimum bounding rectangle corresponding to the patch, a plurality of tangent axes of the patch, and a plurality of bitangent axes of the patch.

46. The decoder according to any one of claims 39 to 41, wherein

if a projection rule indicates vertical projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch; or

if a projection rule indicates horizontal projection, an axis on which a longest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the tangent axis of the to-be-decoded patch, and an axis on which a shortest side of the minimum bounding rectangle corresponding to the to-be-decoded patch is located is the bitangent axis of the to-be-decoded patch; wherein

the projection rule refers to distribution, in a two-dimensional space, of an occupancy map obtained by projecting one or more patches in the to-be-decoded point cloud to the two-dimensional space, and the normal axis of the to-be-decoded patch is perpendicular to the two-dimensional space.

47. An encoder, comprising:

a patch patch information generation module, configured to: obtain a reference tangent axis of a to-be-encoded patch in a to-be-encoded point cloud and a reference bitangent axis of the to-be-encoded patch; and determine a tangent axis of the to-be-encoded patch and a bitangent axis of the to-be-encoded patch based on the reference tangent axis of the to-be-encoded patch and the reference bitangent axis of the to-be-encoded patch, wherein a rotation angle of the tangent axis of the to-be-encoded patch relative to the reference tangent axis of the to-be-encoded patch is θ, and a rotation angle of the bitangent axis of the to-be-encoded patch relative to the reference bitangent axis of the to-be-encoded patch is θ; and

an auxiliary information encoding module, configured to encode a syntax element into a bitstream, wherein the syntax element is used to indicate the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, and the syntax element comprises an index of a normal axis of the to-be-encoded patch and information used to indicate the rotation angle θ of the to-be-encoded patch.

48. The encoder according to claim 47, wherein the information used to indicate the rotation angle θ of the to-be-encoded patch comprises: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-encoded patch.

49. The encoder according to claim 48, wherein the identifier of the patch that matches the to-be-encoded patch is used to indicate an index of the patch that matches the to-be-encoded patch, or used to indicate that there are the patch that matches the to-be-encoded patch in an encoded point cloud and an index of the patch that matches the to-be-encoded patch.

50. The encoder according to any one of claims 47 to 49, wherein

the patch information generation module is further configured to: determine the rotation angle θ from a plurality of candidate rotation angles according to a rate-distortion cost criterion; or obtain a rotation angle of the patch that matches the to-be-encoded patch from the encoded point cloud, and use the obtained rotation angle as the rotation angle θ of the to-be-encoded patch.

51. The encoder according to any one of claims 47 to 50, wherein

the patch information generation module is further configured to: project the to-be-encoded patch from a three-dimensional space to a two-dimensional space based on the tangent axis of the to-be-encoded patch and the bitangent axis of the to-be-encoded patch, to obtain an occupancy map of the to-be-encoded patch; and determine a minimum bounding rectangle of the occupancy map of the to-be-encoded patch; wherein the syntax element further comprises

size information of the minimum bounding rectangle of the occupancy map of the to-be-encoded patch.

52. A decoder, comprising:

an auxiliary information decoding module, configured to: parse a bitstream to obtain a syntax element, wherein the syntax element comprises an index of a normal axis of a to-be-decoded patch patch in a to-be-decoded point cloud and information used to indicate a rotation angle θ of the to-be-decoded patch; obtain a reference tangent axis of the to-be-decoded patch and a reference bitangent axis of the to-be-decoded patch based on the index of the normal axis of the to-be-decoded patch, wherein the index is obtained through parsing; and determine a tangent axis of the patch and a bitangent axis of the patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the information that is used to indicate the rotation angle θ of the to-be-decoded patch and that is obtained through parsing; and

a point cloud geometry information reconstruction module, configured to reconstruct geometry information of the to-be-decoded point cloud based on a tangent axis and a bitangent axis of one or more patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch.

53. The decoder according to claim 52, wherein the information used to indicate the rotation angle θ of the to-be-decoded patch comprises: the rotation angle θ, or an index of the rotation angle θ, or an identifier of a patch that matches the to-be-decoded patch.

54. The decoder according to claim 53, wherein the identifier of the patch that matches the to-be-decoded patch is used to indicate an index of the patch that matches the to-be-decoded patch, or used to indicate whether there are the patch that matches the to-be-decoded patch in a decoded point cloud and an index of the patch that matches the to-be-decoded patch.

55. The decoder according to claim 53 or 54, wherein the information used to indicate the rotation angle θ of the to-be-decoded patch comprises the identifier of the patch that matches the to-be-decoded patch; and

the auxiliary information decoding module is specifically configured to: determine, based on the identifier that is of the patch matching the to-be-decoded patch and that is obtained through parsing, the patch that matches the to-be-decoded patch, and obtain a rotation angle θ of the patch that matches the to-be-decoded patch; and determine the tangent axis of the to-be-decoded patch and the bitangent axis of the to-be-decoded patch based on the reference tangent axis of the to-be-decoded patch, the reference bitangent axis of the to-be-decoded patch, and the rotation angle θ.

56. The decoder according to any one of claims 52 to 55, wherein the syntax element further comprises size

information of a minimum bounding rectangle of an occupancy map of the to-be-decoded patch; and

the point cloud geometry information reconstruction module is specifically configured to: reconstruct the geometry information of the to-be-decoded point cloud based on the tangent axis and the bitangent axis of the one or more patches in the to-be-decoded point cloud and the size information of the minimum bounding rectangle of the occupancy map of the to-be-decoded patch, wherein the size information is obtained by parsing the bitstream.

57. A point cloud encoding method, comprising:

projecting a to-be-encoded patch patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch;

obtaining a second occupancy map of the to-be-encoded patch, wherein the second occupancy map of the to-be-encoded patch is obtained by counterclockwise or clockwise rotating the first occupancy map of the to-be-encoded patch by a rotation angle θ; and

encoding a syntax element into a bitstream, wherein the syntax element comprises information used to indicate the rotation angle θ.

58. The method according to claim 57, wherein coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, wherein the rotation matrix corresponds to the rotation angle.

59. The method according to claim 58, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

60. The method according to claim 58 or 59, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

61. The method according to claim 60, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

62. The method according to claim 57, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-encoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-encoded patch satisfy the following formula, wherein the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta.$$

63. The method according to claim 57, wherein coordinates (x2, y2) of P2 in the second occupancy map of the to-be-encoded patch are obtained according to the following formula:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta$$, wherein

(x1, y1) represents coordinates of a point P1 in the first occupancy map of the to-be-encoded patch, and θ represents the rotation angle.

64. The method according to any one of claims 57 to 63, wherein the second occupancy map is obtained by counterclockwise or clockwise rotating the first occupancy map of the to-be-encoded patch by the rotation angle θ around a coordinate origin of a coordinate system constituted by a first tangent axis and a first bitangent axis.

65. The method according to any one of claims 57 to 64, wherein the information used to indicate the rotation angle θ is an index used to indicate the rotation angle θ.

66. The method according to claim 57, wherein a rotation angle by which a second tangent axis of the to-be-encoded patch rotates relative to a first tangent axis of the to-be-encoded patch is θ, and a rotation angle by which a second bitangent axis of the to-be-encoded patch rotates relative to a first bitangent axis of the to-be-encoded patch is θ.

67. A point cloud decoding method, comprising:

parsing a bitstream to obtain a syntax element, wherein the syntax element comprises information used to indicate a rotation angle θ of the to-be-decoded patch;

obtaining a second occupancy map of the to-be-decoded patch;

obtaining a first occupancy map of the to-be-decoded patch, wherein the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ; and

reconstructing geometry information of the to-be-decoded point cloud based on a first occupancy map of one or more patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch.

68. The method according to claim 67, wherein coordinates (x1, y1) of a point in the first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in the second occupancy map of the to-be-decoded patch and a rotation matrix, wherein the rotation matrix corresponds to the rotation angle.

69. The method according to claim 68, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

70. The method according to claim 68 or 69, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$, or the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

71. The method according to claim 70, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

72. The method according to claim 70, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

73. The method according to claim 67, wherein coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-decoded patch and coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch satisfy the following formula, wherein the coordinates (x1, y1) of the point P1 are obtained through counter-rotation:

$$\begin{aligned} x2 &= x1\cos\theta - y1\sin\theta \\ y2 &= x1\sin\theta - y1\cos\theta \end{aligned} \quad \text{or} \quad \begin{aligned} x1 &= x2\cos\theta + y2\sin\theta \\ y1 &= -x2\sin\theta - y2\cos\theta \end{aligned}.$$

74. The method according to claim 67, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch are obtained according to the following formula:

$$\begin{aligned} x2 &= x1\cos\theta - y1\sin\theta \\ y2 &= x1\sin\theta - y1\cos\theta \end{aligned} \quad \text{or} \quad \begin{aligned} x1 &= x2\cos\theta + y2\sin\theta \\ y1 &= -x2\sin\theta - y2\cos\theta \end{aligned}, \text{ wherein}$$

(x2, y2) represents coordinates of a point P2 in the second occupancy map of the to-be-decoded patch, and θ represents the rotation angle.

75. The method according to any one of claims 67 to 74, wherein the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ around a coordinate origin of a coordinate system constituted by a first tangent axis and a first bitangent axis.

76. The method according to any one of claims 67 to 75, wherein the information used to indicate the rotation angle θ is an index used to indicate the rotation angle θ.

77. The method according to claim 67, wherein a rotation angle by which a second tangent axis of the to-be-decoded patch rotates relative to a first tangent axis of the to-be-decoded patch is θ, and a rotation angle by which a second bitangent axis of the to-be-decoded patch rotates relative to a first bitangent axis of the to-be-decoded patch is θ.

78. The method according to any one of claims 67 to 77, wherein the obtaining a second occupancy map of the to-be-decoded patch comprises:

parsing the bitstream to obtain the second occupancy map of the to-be-decoded patch; or

parsing the bitstream to obtain information that is used to indicate the second occupancy map of the to-be-decoded patch, and obtaining the second occupancy map of the to-be-decoded patch based on the information that is used to indicate the second occupancy map of the to-be-decoded patch.

79. A point cloud encoding method, comprising:

projecting a to-be-encoded patch patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch;

obtaining a second occupancy map of the to-be-encoded patch, wherein coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, wherein the rotation matrix corresponds to a rotation angle θ; and

encoding a syntax element into a bitstream, wherein the syntax element comprises information used to indicate the rotation angle θ.

80. The method according to claim 79, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

81. The method according to claim 79 or 80, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

82. The method according to claim 81, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

83. The method according to any one of claims 79 to 82, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-encoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-encoded patch satisfy the following formula, wherein the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta.$$

84. A point cloud decoding method, comprising:

reconstructing geometry information of a to-be-decoded point cloud based on a first occupancy map of one or

more to-be-decoded patches patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch, coordinates (x1, y1) of a first point of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a second point of the to-be-decoded patch and a rotation matrix, and the rotation matrix corresponds to a rotation angle θ of the to-be-decoded patch.

85. The method according to claim 84, wherein that coordinates (x1, y1) of a first point of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a second point of the to-be-decoded patch and a rotation matrix means that coordinates (x1, y1) of a point in a first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in a second occupancy map of the to-be-decoded patch and a rotation matrix.

86. The method according to claim 84, wherein the coordinates (x1, y1) of the first point of the to-be-decoded patch are coordinates (x1, y1) of a point in a first occupancy map of the to-be-decoded patch, and the coordinates (x2, y2) of the second point of the to-be-decoded patch are coordinates (x2, y2) of a point in a second occupancy map of the to-be-decoded patch.

87. The method according to claim 84, wherein a first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating a second occupancy map of the to-be-decoded patch by the rotation angle θ, or a second occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise rotating a first occupancy map of the to-be-decoded patch by the rotation angle θ.

88. The method according to any one of claims 84 to 87, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

89. The method according to any one of claims 84 to 88, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

90. The method according to claim 89, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

91. The method according to any one of claims 84 to 90, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-decoded patch satisfy the following formula, wherein the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta.$$

92. An encoder, comprising:

a patch patch information generation module, configured to: project a to-be-encoded patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch; and obtain a second occupancy map of the to-be-encoded patch, wherein the second occupancy map of the to-be-encoded patch is obtained by counterclockwise or clockwise rotating the first occupancy map of the to-be-encoded patch by a rotation angle θ; and

an auxiliary information encoding module, configured to encode a syntax element into a bitstream, wherein the syntax element comprises information used to indicate the rotation angle θ.

93. The encoder according to claim 92, wherein coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, wherein the rotation matrix corresponds to the rotation angle.

94. The encoder according to claim 93, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

95. The encoder according to claim 93 or 94, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

96. The encoder according to claim 95, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

97. The encoder according to claim 92, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-encoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-encoded patch satisfy the following formula, wherein the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta.$$

98. The encoder according to claim 92, wherein coordinates (x2, y2) of P2 in the second occupancy map of the to-be-encoded patch are obtained according to the following formula:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta,$$ wherein

(x1, y1) represents coordinates of a point P1 in the first occupancy map of the to-be-encoded patch, and θ represents the rotation angle.

99. The encoder according to any one of claims 92 to 98, wherein the second occupancy map is obtained by counterclockwise or clockwise rotating the first occupancy map of the to-be-encoded patch by the rotation angle θ around a coordinate origin of a coordinate system constituted by a first tangent axis and a first bitangent axis.

100. The encoder according to any one of claims 92 to 99, wherein the information used to indicate the rotation angle θ is an index used to indicate the rotation angle θ.

101. The encoder according to claim 92, wherein a rotation angle by which a second tangent axis of the to-be-encoded patch rotates relative to a first tangent axis of the to-be-encoded patch is θ, and a rotation angle by which a second bitangent axis of the to-be-encoded patch rotates relative to a first bitangent axis of the to-be-encoded patch is θ.

102. A decoder, comprising:

an auxiliary information decoding module, configured to: parse a bitstream to obtain a syntax element, wherein the syntax element comprises information used to indicate a rotation angle θ of the to-be-decoded patch; and obtain a second occupancy map of the to-be-decoded patch; and

a point cloud geometry information reconstruction module, configured to: obtain a first occupancy map of the

to-be-decoded patch, wherein the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ; and reconstruct geometry information of the to-be-decoded point cloud based on a first occupancy map of one or more patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch.

103. The decoder according to claim 102, wherein coordinates (x1, y1) of a point in the first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in the second occupancy map of the to-be-decoded patch and a rotation matrix, wherein the rotation matrix corresponds to the rotation angle.

104. The decoder according to claim 103, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

105. The decoder according to claim 103 or 104, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$, or the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

106. The decoder according to claim 105, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

107. The decoder according to claim 105, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as an inverse matrix of $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

108. The decoder according to claim 102, wherein coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-decoded patch and coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch satisfy the following formula, wherein the coordinates (x1, y1) of the point P1 are obtained through counter-rotation:

$$x2 = x1\cos\theta - y1\sin\theta \quad y2 = x1\sin\theta - y1\cos\theta \text{ or } x1 = x2\cos\theta + y2\sin\theta \quad y1 = -x2\sin\theta - y2\cos\theta.$$

109. The decoder according to claim 102, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch are obtained according to the following formula:

$$x2 = x1\cos\theta - y1\sin\theta \quad y2 = x1\sin\theta - y1\cos\theta \text{ or } x1 = x2\cos\theta + y2\sin\theta \quad y1 = -x2\sin\theta - y2\cos\theta$$, wherein

(x2, y2) represents coordinates of a point P2 in the second occupancy map of the to-be-decoded patch, and θ represents the rotation angle.

110. The decoder according to any one of claims 102 to 109, wherein the first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating the second occupancy map of the to-be-decoded patch by the rotation angle θ around a coordinate origin of a coordinate system constituted by a first tangent axis and a first bitangent axis.

111. The decoder according to any one of claims 102 to 110, wherein the information used to indicate the rotation angle θ is an index used to indicate the rotation angle θ.

112. The decoder according to claim 105, wherein a rotation angle by which a second tangent axis of the to-be-decoded patch rotates relative to a first tangent axis of the to-be-decoded patch is θ, and a rotation angle by which a second bitangent axis of the to-be-decoded patch rotates relative to a first bitangent axis of the to-be-decoded patch is θ.

113. The decoder according to any one of claims 102 to 112, wherein the auxiliary information decoding module is specifically configured to:

parse the bitstream to obtain the second occupancy map of the to-be-decoded patch; or

parse the bitstream to obtain information that is used to indicate the second occupancy map of the to-be-decoded patch, and obtain the second occupancy map of the to-be-decoded patch based on the information that is used to

indicate the second occupancy map of the to-be-decoded patch.

114. An encoder, comprising:

a patch patch information generation module, configured to: project a to-be-encoded patch patch from a three-dimensional space to a two-dimensional space, to obtain a first occupancy map of the to-be-encoded patch; and obtain a second occupancy map of the to-be-encoded patch, wherein coordinates (x2, y2) of a point in the second occupancy map of the to-be-encoded patch are obtained based on coordinates (x1, y1) of a point in the first occupancy map of the to-be-encoded patch and a rotation matrix, wherein the rotation matrix corresponds to a rotation angle θ; and

an auxiliary information encoding module, configured to encode a syntax element into a bitstream, wherein the syntax element comprises information used to indicate the rotation angle θ.

115. The encoder according to claim 114, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

116. The encoder according to claim 114 or 115, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

117. The encoder according to claim 116, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

118. The encoder according to any one of claims 114 to 117, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-encoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-encoded patch satisfy the following formula, wherein the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta$$

119. A decoding apparatus, comprising:

a point cloud memory, configured to store point cloud data; and

a point cloud decoder, configured to reconstruct geometry information of a to-be-decoded point cloud based on a first occupancy map of one or more to-be-decoded patches patches in the to-be-decoded point cloud, wherein the one or more patches comprise the to-be-decoded patch, coordinates (x1, y1) of a first point of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a second point of the to-be-decoded patch and a rotation matrix, and the rotation matrix corresponds to a rotation angle θ of the to-be-decoded patch.

120. The decoding apparatus according to claim 119, wherein that coordinates (x1, y1) of a first point of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a second point of the to-be-decoded patch and a rotation matrix means that coordinates (x1, y1) of a point in a first occupancy map of the to-be-decoded patch are obtained based on coordinates (x2, y2) of a point in a second occupancy map of the to-be-decoded patch and a rotation matrix.

121. The decoding apparatus according to claim 119, wherein the coordinates (x1, y1) of the first point of the to-be-decoded patch are coordinates (x1, y1) of a point in a first occupancy map of the to-be-decoded patch, and the coordinates (x2, y2) of the second point of the to-be-decoded patch are coordinates (x2, y2) of a point in a second occupancy map of the to-be-decoded patch.

122. The decoding apparatus according to claim 119, wherein a first occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise counter-rotating a second occupancy map of the to-be-decoded patch by the rotation angle θ, or a second occupancy map of the to-be-decoded patch is obtained by counterclockwise or clockwise rotating a first occupancy map of the to-be-decoded patch by the rotation angle θ.

123. The decoding apparatus according to any one of claims 119 to 122, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

124. The decoding apparatus according to any one of claims 119 to 123, wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix}$.

125. The decoding apparatus according to claim 124, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

126. The decoding apparatus according to any one of claims 119 to 125, wherein coordinates (x1, y1) of a point P1 in the first occupancy map of the to-be-decoded patch and coordinates (x2, y2) of a point P2 in the second occupancy map of the to-be-decoded patch satisfy the following formula, wherein the coordinates (x2, y2) of the point P2 are obtained through rotation:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta - y1\cos\theta$$

.

127. An encoding apparatus, wherein the apparatus comprises a memory and a processor, wherein the memory is configured to store program code, and the processor is configured to invoke the program code to execute the point cloud encoding method according to any one of claims 1 to 10, any one of claims 19 to 23, any one of claims 57 to 66, or any one of claims 79 to 83.

128. A decoding apparatus, wherein the apparatus comprises a memory and a processor, wherein the memory is configured to store program code, and the processor is configured to invoke the program code to perform the point cloud decoding method according to any one of claims 11 to 18, any one of claims 24 to 28, any one of claims 67 to 78, or any one of claims 84 to 91.

129. A computer-readable storage medium, comprising program code, wherein the program code comprises an instruction used to perform a portion of or all steps of the point cloud encoding method according to any one of claims 1 to 10, any one of claims 19 to 23, any one of claims 57 to 66, or any one of claims 79 to 83.

130. A computer-readable storage medium, comprising program code, wherein the program code comprises an instruction used to perform a portion of or all steps of the point cloud decoding method according to any one of claims 11 to 18, any one of claims 24 to 28, any one of claims 67 to 78, or any one of claims 84 to 91.

CLAIMS

1. A point cloud encoding method, comprising:

projecting a current patch from a three-dimensional space to a two-dimensional space;

transforming first coordinates (x1, y1) of a point of the current patch in a first coordinate system to second coordinates (x2, y2) of the point of the current patch in a second coordinate system, wherein the second coordinates (x2, y2) of the point of the current patch are obtained based on the first coordinates (x1, y1) of the point of the current patch and a transform matrix; and

encoding a syntax element into a bitstream, wherein the syntax element indicates a transform matrix for the current patch.

2. The method according to claim 1, wherein the transform matrix is a rotation matrix and the rotation matrix corresponds to a rotation angle θ of the current patch.

3. The method according to claim 2, wherein the rotation matrix is determined based on the rotation angle θ, or is determined based on a functional relationship of the rotation angle θ.

4. The method according to claim 3 , wherein

the rotation matrix is represented as $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$.

5. The method according to claim 4, wherein

when the rotation angle θ is 0°, the rotation matrix is represented as $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$;

when the rotation angle θ is 90°, the rotation matrix is represented as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

when the rotation angle θ is 180°, the rotation matrix is represented as $\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$; and/or

when the rotation angle θ is 270°, the rotation matrix is represented as $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

6. The method according to claim 1, wherein the first coordinates (x1, y1) of the point of the current patch and the second coordinates (x2, y2) of the point of the current patch satisfy the following formula:

$$x2 = x1\cos\theta - y1\sin\theta$$
$$y2 = x1\sin\theta + y1\cos\theta$$

.

7. A point cloud decoding method, comprising:

reconstructing a point cloud comprising one or more patches,

wherein the one or more patches comprise a current patch,

wherein the reconstructing process comprises:

transforming coordinates (x2, y2) of a point of the current patch in a second coordinate system to coordinates (x1, y1) of the point of the current patch in a first coordinate system,

wherein the coordinates (x1, y1) of the point of the current patch in the first coordinate system are obtained based on the coordinates (x2, y2) of the point of the current patch in the second coordinate system and a transform matrix.

8. The method according to 7, wherein the transform matrix is a rotation matrix and the rotation matrix corresponds to a rotation angle θ of the current patch.

9. The method according to claim 8, wherein

the rotation matrix is represented as $\begin{bmatrix}\cos\theta & -\sin\theta \\ \sin\theta & \cos\theta\end{bmatrix}$.

10. The method according to claim 9, wherein

the rotation matrix is represented as $\begin{bmatrix}1 & 0 \\ 0 & 1\end{bmatrix}$, wherein the rotation angle θ is 0°;

the rotation matrix is represented as $\begin{bmatrix}0 & -1 \\ 1 & 0\end{bmatrix}$, wherein the rotation angle θ is 90°,;

the rotation matrix is represented as $\begin{bmatrix}-1 & 0 \\ 0 & -1\end{bmatrix}$, wherein the rotation angle θ is 180°; and/or

the rotation matrix is represented as $\begin{bmatrix}0 & 1 \\ -1 & 0\end{bmatrix}$, wherein the rotation angle θ is 270°.

11. An encoding apparatus, wherein the apparatus comprises a memory and a processor, wherein the memory is configured to store program code, and the processor is configured to invoke the program code to execute the point cloud encoding method according to any one of claims 1 to 6.

12. A decoding apparatus, wherein the apparatus comprises a memory and a processor, wherein the memory is configured to store program code, and the processor is configured to invoke the program code to perform the point cloud decoding method according to any one of claims 7 to 10.

13. A computer-readable storage medium, comprising program code, wherein the program code comprises an instruction used to perform steps of the point cloud encoding method according to any one of claims 1 to 6.

14. A computer-readable storage medium, comprising program code, wherein the program code comprises an instruction used to perform steps of the point cloud decoding method according to any one of claims 7 to 10.