

Claims

1. Apparatus for rendering an audio scene ~~(50)~~ comprising an audio source at an audio source position and a plurality of diffracting objects, comprising:

a diffraction path provider ~~(100)~~ for providing a plurality of intermediate diffraction paths ~~(300, 400)~~ through the plurality of diffracting objects, an intermediate diffraction path having a starting point and an output edge of the plurality of diffracting objects and an associated filter information for the intermediate diffraction path;

a renderer ~~(200)~~ for rendering the audio source at a listener position, wherein the renderer ~~(200)~~ is configured for

determining ~~(216)~~, based on the output edges of the intermediate diffraction paths and the listener position, one or more valid intermediate diffraction paths from the audio source position to the listener position,

determining ~~(218)~~, for each valid intermediate diffraction path of the one or more valid intermediate diffraction paths, a filter representation for a full diffraction path from the audio source position to the listener position corresponding to a valid intermediate diffraction path of the one or more valid intermediate diffraction paths using a combination of the associated filter information for the valid intermediate diffraction path and a filter information describing an audio signal propagation from the output edge of the valid intermediate diffraction path to the listener position, and

calculating ~~(220)~~ audio output signals for the audio scene ~~(50)~~ using an audio signal associated to the audio source and the filter representation for each full diffraction path.

2. Apparatus of claim 1, wherein the audio source position is fixed and the preprocessor is configured to determine each valid intermediate diffraction path so that the starting point of each valid intermediate diffraction path corresponds to the audio source position, or

wherein the audio source position is variable, and wherein the preprocessor is configured to determine, as the starting point of an intermediate diffraction path, an input edge of the plurality of diffracting objects, and

wherein the renderer-~~(200)~~ is configured to determine, additionally based on the input edge(s) of the one or more intermediate diffraction paths and the audio source position of the audio source, the one or more valid intermediate diffraction paths, and to determine the filter representation for the full diffraction path additionally based a further filter information describing an audio signal propagation from the audio source position to the input edge of the valid intermediate diffraction path associated with the full diffraction path.

3. Apparatus of claim 1 or 2, wherein the renderer-~~(200)~~ is configured to perform an occlusion test ~~(212)~~ for a direct path from the source position to the listener position and to only determine the one or more valid intermediate diffraction paths, when the occlusion test indicates that the direct path is occluded.

4. Apparatus of one of the preceding claims,

wherein the renderer-~~(200)~~ is configured to determine ~~(132)~~ the filter representation for the full diffraction path by multiplying a frequency domain representation of the associated filter information and a frequency domain representation of the filter information for the audio signal propagation from the output edge of the valid intermediate diffraction path to the listener position or a frequency domain representation of a further filter information describing an audio signal propagation from the audio source position to the input edge of the valid intermediate diffraction path.

5. Apparatus of one of the preceding claims, wherein the renderer-~~(200)~~ is configured to determine ~~(102)~~ a starting group of potential input edges depending on the audio source position or to determine ~~(104)~~ a final group of potential output edges depending on the listener position,

to retrieve ~~(106)~~ one or more potential valid intermediate diffraction paths from a pre-stored list of intermediate diffraction paths using the starting group or the final group, and

to validate ~~(108)~~ the one or more potential valid intermediate diffraction paths using a source angle criterion ~~(116)~~ and a source angle between the source position and the corresponding input edge or using a final angle criterion ~~(118)~~ and a listener angle between the listener position and a corresponding output edge.

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6. Apparatus of claim 5, wherein the renderer ~~(200)~~ is configured to calculate the source angle ~~(112)~~ and to compare ~~(116)~~ the source angle to a maximum allowable angle for the source ~~(MAAS)~~ as the source angle criterion and to validate ~~(122)~~ a potential intermediate diffraction path to become the valid intermediate diffraction path when the source angle is lower than the maximum allowable angle for the source, or

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wherein the renderer ~~(200)~~ is configured to calculate the listener angle ~~(114)~~ and to compare ~~(118)~~ the listener angle to a minimum allowable angle for the listener ~~(MAAL)~~ as the listener angle criterion and to validate ~~(122)~~ a potential intermediate diffraction path to become the valid intermediate diffraction path, when the listener angle is greater than the minimum allowable angle for the listener.

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7. Apparatus of one of the preceding claims,

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wherein the diffraction path provider ~~(100)~~ is configured to access a memory having stored a list comprising entries for the plurality of intermediate diffraction paths ~~(300, 400)~~, wherein each intermediate diffraction path entry comprises a sequence of edges extending from an input edge to an output edge or a sequence of triangles extending from an input triangle to an output triangle or a sequence of items starting from a source angle criterion, comprising one or more intermediate angles and comprising a listener angle criterion.

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8. Apparatus of claim 7,

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wherein the list entry comprises the associated filter information or a reference to the associated filter information, or

wherein the renderer ~~(200)~~ is configured to derive the associated filter information from data in the list entry.

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9. Apparatus of one of the preceding claims,

5 wherein the plurality of diffraction objects of the sound scene comprises a dynamic object, and wherein the diffraction path provider ~~(100)~~ is configured to provide at least one intermediate diffraction path around the dynamic object.

10. Apparatus of one of the claims 1 to 8,

10 wherein the plurality of diffracting objects of the sound scene comprises two or more dynamic diffraction objects, and wherein the diffraction path provider ~~(100)~~ is configured to provide intermediate diffraction paths around a single dynamic object based on an assumption that a diffraction is not allowed between two different dynamic objects.

15 11. Apparatus of one of the claims 1 to 8,

20 wherein the plurality of diffracting objects of the sound scene comprises one or more dynamic objects and one or more static objects, and wherein the diffraction path provider ~~(100)~~ is configured to provide intermediate diffraction paths around a dynamic or a static object based on an assumption that a diffraction is not allowed between a static object and a dynamic object.

12. Apparatus of one of the preceding claims,

25 wherein the plurality of diffraction objects comprises at least one dynamic diffraction object,

wherein the renderer ~~(200)~~ is configured

30 to determine ~~(222)~~ whether the at least one dynamic object has been relocated with respect to at least of a translation and a rotation,

to update ~~(222)~~ edges attached to the relocated dynamic object;

35 to examine ~~(216)~~ in the step of determining the one or more valid intermediate diffraction paths, a potential valid intermediate path regarding a visibility between internal edge

pairs, wherein in case of an interruption of the visibility due to the relocation of the relocated dynamic object, the potential valid intermediate diffraction path is augmented ~~(226)~~ by an additional path incurred due to the relocation object to obtain the valid intermediate diffraction path.

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13. Apparatus of one of the preceding claims, wherein the renderer ~~(200)~~ is configured to apply the uniform theory of diffraction ~~(UTD)~~ to determine the associated filter information, or wherein the renderer ~~(200)~~ is configured to determine the associated filter information in a frequency-dependent manner.

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14. Apparatus of one of the preceding claims, wherein the renderer ~~(200)~~ is configured to calculate, depending on the valid intermediate diffraction path or depending on the full diffraction path, a rotated audio source position being different from the audio source position due to a diffraction effect incurred by the valid intermediate diffraction path or depending on the full diffraction path, and to use the rotated position of the audio source in the calculating ~~(220)~~ the audio output signals for the audio scene ~~(50)~~, or

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wherein the renderer ~~(200)~~ is configured to calculate ~~(220)~~ the audio output signals for the audio scene ~~(50)~~ using an edge sequence associated to the full diffraction path, and a diffraction angle sequence associated to the full diffraction path, in addition to the filter representation.

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15. Apparatus of claim 14, wherein the renderer ~~(200)~~ is configured to determine a distance from the listener position to the rotated source position and to use the distance in the calculating ~~(220)~~ the audio output signals for the audio scene ~~(50)~~.

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16. Apparatus of claim 14 or 15, wherein the renderer ~~(200)~~ is configured to select one or more directional filters depending on the rotated source position and a predetermined output format for the audio output signals, and to apply the one or more directional filters and the filter representation to the audio signal in calculating the audio output signals.

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17. Apparatus of claim 14, 15, or 16, wherein the renderer ~~(200)~~ is configured to determine an attenuation value depending on a distance between the rotated source position and the listener position and to apply, in addition to the filter representation

or one or more directional filters depending on the audio source position or the rotated audio source position to the audio signal.

18. Apparatus of one of the claims 14 to 17, wherein the renderer ~~(200)~~ is configured to determine the rotated source position in a sequence of rotation operations comprising at least one rotation operation,

wherein starting at a first diffraction edge of the full diffraction path, a path portion from the first diffraction edge to the source location is rotated in a first rotation operation to obtain a straight line from a second diffraction edge, or the listener position in case the full diffraction path only has the first diffraction edge, to a first intermediate rotated source position, wherein the first intermediate rotated source position is the rotated source position, when the full diffraction path only has the first diffraction edge, or

wherein a result of the first rotation operation is rotated around the second diffraction edge in a second rotation operation to obtain a straight line from a third diffraction edge, or the listener position in case the full diffraction path only has the first and second diffraction edges, to a second intermediate rotated source position, wherein the second intermediate rotated source position is the rotated source position, when the full diffraction path only has the first and the second diffraction edges, and

wherein one or more rotation operations are additionally performed until the full diffraction path is processed and a straight line from the listener position to the then obtained rotated source position is obtained.

19. Method for rendering an audio scene ~~(50)~~ comprising an audio source at an audio source position and a plurality of diffracting objects, comprising:

providing a plurality of intermediate diffraction paths ~~(300, 400)~~ through the plurality of diffracting objects, an intermediate diffraction path having a starting point and an output edge of the plurality of diffracting objects and an associated filter information for the intermediate diffraction path;

rendering the audio source at a listener position, wherein the rendering comprises

determining ~~(216)~~, based on the output edges of the intermediate diffraction paths and the listener position, one or more valid intermediate diffraction paths from the audio source position to the listener position,

5 determining ~~(218)~~, for each valid intermediate diffraction path of the one or more valid intermediate diffraction paths, a filter representation for a full diffraction path from the audio source position to the listener position corresponding to a valid intermediate diffraction path of the one or more valid intermediate diffraction paths using a combination of the associated filter information for the valid intermediate diffraction path and a filter information
10 describing an audio signal propagation from the output edge of the valid intermediate diffraction path to the listener position, and

calculating ~~(220)~~ audio output signals for the audio scene ~~(50)~~ using an audio
15 signal associated to the audio source and the filter representation for each full diffraction path.

20. Computer program for performing, when running on a computer or processor, the method of claim 19.

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