

Claims

1. Apparatus for rendering a sound scene having reflection objects and a sound source at a sound source position, comprising.
- 5 a geometry data provider (10) for providing an analysis of the reflection objects of the sound scene to determine a reflection object represented by a first polygon (2) and a second adjacent polygon (3) having associated a first image source position (62) for the first polygon and a second image source position (63) for the second
- 10 polygon, wherein the first and second image source positions result in a sequence comprising a first visible zone (72) related to the first image source position (62), an invisible zone (80) and a second visible zone (73) related to the second image source position (63);
- 15 an image source position generator (20) for generating an additional image source position (90) such that the additional image source position (90) is placed between the first image source position and the second image source position; and
- 20 a sound renderer (30) for rendering the sound source at the sound source position and, additionally
- for rendering the sound source at the first image source position, when a listener position (130) is located within the first visible zone,
- 25 for rendering the sound source at the additional image source position (90), when the listener position is located within the invisible zone (80), or
- for rendering the sound source at the second image source position, when the listener position is located within the second visible zone.
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2. Apparatus of claim 1, wherein the geometry data provider (10) is configured to retrieve pre-stored information on the reflection objects stored during an initialization stage, and wherein the image source position generator (20) is configured to generate the additional image source position (90) in response to the pre-stored
- 35 information indicating the reflection object.
3. Apparatus of claim 1 or 2, wherein the geometry data provider (10) is configured to detect, during runtime or during an initialization stage and using geometry data on

the sound scene delivered by a computer added design (CAD) application, the reflection object.

4. Apparatus of one of the preceding claims, wherein the geometry data provider (10)
5 is configured to detect, during runtime or during an initialization stage, as the reflection object, an object having a round geometry, a curved geometry, or a geometry derived from a spline interpolation.

5. Apparatus of one of claims 1 or 2, wherein the geometry data provider (10) is
10 configured

to compute an angle between two adjacent polygons of a reflection object and to mark the two adjacent polygons as a specific pair of polygons, when the angle is below a threshold,

15 to compute a further angle between two further adjacent polygons of the reflection object and to mark the two further adjacent polygons as a further specific pair of polygons, when the further angles below the threshold, and

20 to detect the reflection object, when the further adjacent polygons and the adjacent polygons have an edge in common, or belong to the same corner.

6. Apparatus of one of the preceding claims,

25 wherein the image source position generator (20) is configured to analyze, whether the listener position (130) is in the invisible zone (80), and to generate the additional image source position (90) only when the listener position (130) is located in the invisible zone (80).

30 7. Apparatus of claim 6, wherein the image source position generator (20) is configured to determine a first geometrical range associated with the first polygon or a second geometrical range associated with the second polygon, or a third geometrical range between the first geometrical range and the second geometrical range,

35 wherein the first geometrical range determines the first visible zone or wherein the second geometrical range determines the second visible zone, or wherein the third geometrical range determines the invisible zone (80), and

wherein the first or the second geometrical range is determined such that a condition that an incidence angle from the source position to the first or the second polygon is equal to a reflection angle from the first or the second polygon is fulfilled for a position in the first or the second geometrical zone, or

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wherein the third geometrical range is determined such that the condition of a reflection angle being equal to the incidence angle is not fulfilled for a position in the invisible zone (80).

10 8. Apparatus of claim 6 or 7,

wherein the image source position generator (20) is configured to calculate (26) a first frustum for the first polygon and to determine (27), whether the listener position is located within the first frustum, or

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wherein the image source position generator (20) is configured to calculate (26) a second frustum for the second polygon and to determine (27), whether the listener position (130) is located within the second frustum, or

20 wherein the image source position generator (20) is configured to calculate (26) an invisible zone frustum and to determine (27), whether the listener is located within the invisible zone frustum.

25 9. Apparatus of claim 8, wherein the image source position generator (20) is configured to define four planes having normal vectors pointing inside the first frustum, the second frustum or the invisible zone frustum, and

30 wherein the image source position generator (20) is configured to determine (27), whether a distance of the listener position (130) to each plane is greater than or equal to 0, and to detect that the listener is located within a frustum of the first frustum, the second frustum or the invisible zone frustum, when the distance of the listener to each plane is greater than or equal to 0.

35 10. Apparatus of one of the preceding claims,

wherein the image source position generator (20) is configured to calculate the additional image source position (90) as a position between the first image source position (62) and the second image source position (63).

11. Apparatus of claim 10, wherein the image source position generator (20) is configured to calculate the additional image source position (90) on a connection line (91) between the first image source position (62) and the second image source position (63).
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12. Apparatus of claim 10, wherein the image source position generator (20) is configured to calculate the additional image source position (90) as a position on a circular arc with radius r_1 around reflection point (92), where r_1 denotes the distance between the source position (100) and the reflection point (92).
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13. Apparatus of claim 10 or 11 or 12, wherein the image source position generator (20) is configured to calculate the additional image source position (90), so that a distance between the additional image source position (90) and the second image source position (63) is proportional to a distance of the listener position (130) to the second visible zone (73), or so that a distance between the additional image source position (90) and the first image source position (62) is proportional to a distance of the listener position (130) to the first visible zone (72).
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14. Apparatus of claim 11 or 12 or 13,
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- wherein the image source position generator (20) is configured to determine a reflection point (92) using an orthogonal projection of the vector for the sound source position (100) and an orthogonal projection of the vector for the listener position (130) with respect to the first polygon (2) or the second polygon (3) or the adjacent edge between the first polygon (2) and the second polygon (3) or to determine a point where the first polygon (2) and the second polygon (3) are connected to each other as the reflection point (92) and,
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- wherein the image source position generator (20) is configured to determine a section point of a line (93) connecting the listener position (130) and the reflection point (92) and the connection line (91) between the first image source position (62) and the second image source position (63) as the additional image source position (90).
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15. Apparatus of one of the preceding claims,
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wherein the image source position generator (20) is configured to calculate the first image source position (62) by mirroring the sound source position (100) at a plane (2) defined by the first polygon, or

5 wherein the image source position generator (20) is configured to calculate the second image source position (63) by mirroring the sound source position (100) at a plane (3) defined by the second polygon.

10 16. Apparatus of one of the preceding claims,

wherein the sound renderer (30) is configured to render the sound source so that a sound source signal is filtered using a rendering filter (31, 32, 33) defined by at least one of a distance between a corresponding image sound source position to the listener position and a delay time incurred by the distance, and an absorption coefficient or a reflection coefficient associated with the first polygon or the second polygon, or a frequency-selective absorption or reflection characteristic associated with the first polygon or the second polygon.

20 17. Apparatus of one of the preceding claims,

wherein the sound renderer (30) is configured to render the sound source using the sound source signal and the sound source position (100) and the listener position using a direct sound filter stage (31), and to render the sound source using the sound source signal and a corresponding additional sound source position and the listener position (130) as a first order reflection in a first order reflection filter stage, wherein the corresponding image sound source position comprises the first image sound source position, or the second image sound source position or the additional image sound source position (90).

30 18. Method of rendering a sound scene having reflection objects and a sound source at a sound source position, comprising.

35 providing an analysis of the reflection objects of the sound scene to determine a reflection object represented by a first polygon (2) and a second adjacent polygon (3) having associated a first image source position (62) for the first polygon and a second image source position (63) for the second polygon, wherein the first and second image source positions result in a sequence comprising a first visible zone

(72) related to the first image source position (62), an invisible zone (80) and a second visible zone (73) related to the second image source position (63);

5 generating an additional image source position (90) such that the additional image source position (90) is placed between the first image source position and the second image source position; and

rendering the sound source at the sound source position and, additionally

10 rendering the sound source at the first image source position, when a listener position (130) is located within the first visible zone,

rendering the sound source at the additional image source position (90), when the listener position is located within the invisible zone (80), or

15 rendering the sound source at the second image source position, when the listener position is located within the second visible zone.

19. Computer program for performing, when running on a computer or a processor, the
20 method of claim 18.