Claims

1. Apparatus for sound rendering, configured to

receive information on a listener position and a sound source position;

render an audio signal of the sound source using a room impulse response whose early reflection portion is exclusively determined by an early reflection pattern
which is indicative of a constellation of early reflection positions, and
which is positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in a listener head orientation.

2. Apparatus of claim 1, configured to

receive at least one room acoustical parameter which is representative of an acoustical characteristic of an acoustic environment;

determine the early reflection pattern
in a manner so that a number of the early reflection positions depends on the at least one room acoustical parameter.

3. Apparatus of claim 2, wherein the at least one room acoustical parameter comprises one or more of
room dimensions,
room volume, and
predelay time to the late reverberation.

4. Apparatus of claim 2 or claim 3, wherein the at least one room acoustical parameter comprises merely one parameter selected out of
room dimensions,
room volume, and
predelay time to the late reverberation.

5. Apparatus of any previous claims 2 to 4, configured to, depending on the at least one room acoustical parameter, vary a mutual spacing of the early reflection positions and the number of early reflection positions.

6. Apparatus of any previous claims 2 to 5, configured to, depending on the at least one room acoustical parameter, parameterize one or more spiral functions centered at the listener position, and place the early reflection positions using the one or more spiral functions.

7. Apparatus of any previous claims 2 to 6, configured to read the at least one room acoustical parameter, from a bitstream comprising a representation of an audio signal to be rendered using the early reflection pattern.

8. Apparatus of any previous claims 2 to 7, configured to determine the number of early reflection positions so that

    the number is larger the larger the room dimensions are, or

    the number is larger the larger the room volume is, or

    the number is larger the larger the predelay time to the late reverberation is.

9. Apparatus of any previous claims 2 to 8, configured to determine the number of early reflection positions so that

    a farthest early reflection position from the listener position is larger the larger the room dimensions are or

    a farthest early reflection position from the listener position is larger the larger the room volume is, or

    a farthest early reflection position from the listener position is larger the larger the predelay time to the late reverberation is.

10. Apparatus of any previous claims 1 to 9, configured to determine the early reflection positions so that same are in a substantially uniform manner angularly distributed around the listener position.

11. Apparatus of any previous claims 1 to 10, wherein the early reflection positions lie in a horizontal plane along with the listener position.

12. Apparatus of any previous claims 1 to 11, configured to

receive at least one room acoustical parameter which is representative of an acoustical characteristic of an acoustic environment;

determine the early reflection pattern

by parameterizing one or more spiral functions centered at the listener position, and place the early reflection positions using the one or more spiral functions.

13. Apparatus of claim 12, wherein the one or more spiral functions comprise a first spiral function and a second spiral function wherein the apparatus is configured to place a first set of early reflection positions using the first spiral function and a second set of early reflection positions using the second spiral function so that each of the first set of early reflection positions is associated with a corresponding early reflection position of the second set of early reflection and is positioned on an opposite side of a line perpendicularly crossing a connecting line between the respective early reflection position and the corresponding early reflection position.

14. Apparatus of claim 13, wherein for each of first set of early reflection positions, the corresponding early reflection position of the second set of early reflection is angularly offset relative to the connecting line into an angular direction which is common for all early reflection positions of the first set of early reflection positions.

15. Apparatus of any previous claims 12 to 14, wherein the one or more spiral functions comprise a first spiral function and a second spiral function wherein the apparatus is configured to place a first set of early reflection positions using the first spiral function and a second set of early reflection positions using the second spiral function so that the first set of early reflection positions is determined in polar coordinates as (r1; $\beta 1$) and the second set of early reflection positions is determined in polar coordinates as (r2; $\beta 2$) with

$\beta 1 = n \cdot \frac{\pi}{3}$,

$\beta 2 = \frac{\pi}{8} + n \cdot \frac{\pi}{3}$,

n = [1:nER/2]

$base = 1.85$

$r1 = distfactor * base^{2*\beta 1/\pi}$

$r2 = -distfactor * base^{2*\beta 2/\pi}$

wherein nER is the number of early reflection positions and distfactor is a constant.

16. Apparatus of any previous claims 12 to 15, configured to read the at least one room acoustical parameter, from a bitstream comprising a representation of an audio signal to be rendered using the early reflection pattern.

17. Apparatus for determining an early reflection pattern for sound rendition, configured to

perform a geometric analysis of an acoustic environment by, at each of one or more analysis positions,

determining a function indicative, for each of different distances from the respective analysis position, a value representative of an early reflection contribution; and

inspecting the function or a further functionderived therefrom with respect to one or more maximato derive one or more control parameters;

determine an early reflection pattern

which is indicative of a constellation of early reflection positions,

by placing the early reflection positions using the one or more control parameters.

18. Apparatus of claim 17, wherein the early reflection pattern is for being positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in listener head orientation.

19. Apparatus of claim 17 or claim 18, configured to determine the function indicative, for each of different distances from the respective analysis position, a value representative of an early reflection contribution by

radially sampling the acoustic environment with respect to a nearest reflective surface distance to obtain a radial sampling result,

performing a radial integration over, and weight according to radial distance so as to decrease the early reflection contribution with increasing distance, the radial sampling result so as to obtain the function.

20. Apparatus of any previous claims 17 to 19, configured to subject the function determined at the one or more analysis positions to a summation to yield the further function.

21. Apparatus of any previous claims 17 to 20, configured to inspect the function or the further function derived therefrom with respect to two largest maxima to derive as the one or more control parameters a first amplitude a1 and a first distance p1 for a nearest of the two largest maxima, and a second amplitude a2 and a second distance p2 for a farthest of the two largest maxima.

22. Apparatus of claim 21, configured to place four early reflection positions so that same are positioned at polar coordinates (r(i); $\beta(i)$) with i = 1 … 4 and
$\beta(1) \approx 5° - 15°$,
$\beta(2) \approx 90° - 110°$,
$\beta(3) \approx 180° - 200°$,
$\beta(4) \approx 270° - 290°$,
$r(i)$ equals +-10% $(0.7 + (i-1) \cdot rstep) \cdot slDistance^{distAlpha} + 0.001 \cdot preDelay \cdot c$

with i=[1..4], slDistance [m] source-listener distance, preDelay [ms], c is speed of sound
wherein $r(i)$ is modified to become $compFac \cdot r(i)$ *with i= [2,4]*
$ampRefl(r) = {}^{1}/_{r^{distAlpha}}$
with the distAlpha values [0.5..1] being estimated from the area distribution based on a1, a2, p1 and p2, such as by e.g.
$distAlpha$ is +-10% equal to $(log10\frac{a2}{p2} - log10\frac{a1}{p1})/4.5$
with setting
if $distAlpha$ *< 0.5;* $distAlpha$ *=0.5;*
if $distAlpha$ *> 1.0;* $distAlpha$ *=1.0.*

23. Apparatus of any of previous claims 17 to 22, configured to place four early reflection positions so that first and second early reflection positions are arranged at opposite sides of a first line crossing the listener position and third and fourth early reflection positions are arranged at opposite sides of a second line, perpendicular to the first line and crossing the listener position.

24. Apparatus of claim 23, configured to
inspect the function or the further function derived therefrom with respect to two largest maxima to derive as the one or more control parameters a first amplitude a1 and a first distance p1 for a nearest of the two largest maxima, and a second amplitude a2 and a second distance p2 for a nearest of the two largest maxima and
set distances of the first and second early reflection positions from the listener position depending on p2, and

set a ratio between the distances of the first and second early reflection positions from the listener position on the one hand and distances of the third and fourth early reflection positions from the listener position on the other hand based on a quotient or difference between a first term depending on a1 and a second term depending on a2.

25. Apparatus of any previous claims 17 to 24, configured to

support a first determination of the early reflection pattern and a second determination of the early reflection pattern, wherein the first determination is different from the second determination and involves the placing the early reflection positions using the one or more control parameters, and

select the first determination in case of the acoustic environment being an outdoor environment or in case of a pattern type index in a bitstream comprising a representation of an audio signal to be rendered assuming a predetermined state.

26. Apparatus of any previous claims 17 to 25, configured to determine the early reflection positions so that same lie in a horizontal plane along with the listener position.

27. Apparatus of any previous claims 17 to 26, configured to determine the early reflection positions with adjusting a azimuthal rotation of the constellation according to a pattern azimuth parameter in a bitstream comprising a representation of an audio signal to be rendered.

28. Apparatus for sound rendering, configured to

receive first information on a listener position and a sound source position;

receive a bitstream comprising a representation of an audio signal of a sound source positioned at the sound source position and one or more early reflection pattern parameters,

determine an early reflection pattern

which is indicative of a constellation of early reflection positions,

depending on the one or more early reflection pattern parameters, and

render the audio signal of the sound source using a room impulse response whose early reflection portion is determined by an early reflection pattern

which is indicative of a constellation of early reflection positions, and

which is positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in listener head orientation.

29. Apparatus of claim 28, wherein the one or more early reflection pattern parameters comprise one or more of

an pattern type index,

a predelay time to late reverberation,

a compression factor,

an amplitude correction factor,

a distance attenuation exponent,

a pattern azimuth,

one or more frequency response parameters.

30. Apparatus of claim 28 or claim 29, configured to perform the determining the early reflection pattern by, depending on the at least one room acoustical parameter, varying a mutual spacing of the early reflection positions and the number of early reflection positions.

31. Apparatus of any previous claims 28 to 30, configured to perform the determining the early reflection pattern by, depending on the at least one room acoustical parameter, parameterizing one or more spiral functions centered at the listener position, and placing the early reflection positions using the one or more spiral functions.

32. Apparatus of any previous claims 28 to 31, configured to perform the determining the early reflection pattern so that the number is larger the larger predelay time to the late reverberation is, which is contained in the one or more early reflection pattern parameters.

33. Apparatus of any previous claims 28 to 32, configured to perform the determining the early reflection pattern so that a farthest early reflection position from the listener position is larger the larger a predelay time to the late reverberation is, which is

contained in the one or more early reflection pattern parameters with the distance being smaller than the predelay time.

34. Apparatus of any previous claims 28 to 33, configured to perform the determining the early reflection pattern so that same are in a substantially uniform manner angularly distributed around the listener position.

35. Apparatus of any previous claims 28 to 34, configured to perform the determining the early reflection pattern so that Connection lines between same and the listener position do mutually not overlap.

36. Apparatus of any previous claims 28 to 35, configured to
place four early reflection positions so that first and second early reflection positions are arranged at opposite sides of a first line crossing the listener position and third and fourth early reflection positions are arranged at opposite sides of a second line, perpendicular to the first line and crossing the listener position, and
set distances of the first and second early reflection positions from the listener position depending on a predelay time to late reverberation, which is contained in the one or more early reflection pattern parameters and
set a ratio between the distances of the first and second early reflection positions from the listener position on the one hand and distances of the third and fourth early reflection positions from the listener position on the other hand based on a compression factor, which is contained in the one or more early reflection pattern parameters.

37. Apparatus of any previous claims 28 to 36, configured to
support a first manner of determination of the early reflection pattern and a second manner of determination of the early reflection pattern, wherein the first manner of determination is different from the second manner of determination, and

use the first manner of determination or the second manner of determination in the determining the early reflection pattern depending on a pattern type index, which is contained in the one or more early reflection pattern parameters.

38. Apparatus of any previous claims 28 to 37, configured to if a pattern type index, which is contained in the one or more early reflection pattern parameters, indicates an encoder-parametrized manner of determination, read from the bitstream as part of the one or more early reflection pattern parameters one or more of

a number of the early reflections of the early reflection pattern,
for each early reflection, an azimuth, an elevation, a radius,
for each early reflection, an amplitude correction factor,
for each early reflection, a distance attenuation exponent,
for each early reflection, a frequency response description.

39. Apparatus for sound rendering, configured to

receive first information on a listener position and a sound source position;

render an audio signal of the sound source using a room impulse response whose early reflection portion is determined by an early reflection pattern
which is indicative of a constellation of early reflection positions, and
which is positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in listener head orientation,

the apparatus comprising an apparatus for determining the early reflection pattern according to any of claims 17 to 27.

40. Apparatus of any of claims 1 to 16 and 28 to 39, further configured to generate a diffuse late reverberation portion of the room impulse response.

41. Apparatus of any of claims 1 to 16 and 28 to 40, further configured to in rendering the audio signal, generate a set of loudspeaker signals by forming a summation over direct sound contribution loudspeaker signals relating to a direct sound source portion of the room impulse response and early reflection contribution loudspeaker signals relating to the early reflection portion of the room impulse response.

42. Apparatus of any of claims 1 to 16 and 28 to 41, further configured to generating early reflection contribution loudspeaker signals relating to the early reflection portion of the room impulse response by performing a rendition of the audio signal of the sound source from the early reflection positions.

43. Apparatus of claim 42, further configured to

in generating the early reflection contribution loudspeaker signals relating to the early reflection portion of the room impulse response by performing a rendition of the audio signal of the sound source from the early reflection positions,
render the audio signal of the sound source from each early reflection position in a manner level adjusted according to a distance of the respective early reflection position to the listener position.

44. Apparatus of claim 43, further configured to, in rendering the audio signal of the sound source from each early reflection position in a manner level adjusted according to a distance of the respective early reflection position to the listener position,

offset a level at which the audio signal of the sound source is rendered from the respective early reflection position, using a level offset, or amplify same with a level factor, which offset or factor is common for all early reflection positions, and

set the level offset or level factor according to an amplitude correction factor.

45. Apparatus of claims 43 or 44, further configured to, in rendering the audio signal of the sound source from each early reflection position in a manner level adjusted according to the distance of the respective early reflection position to the listener position, modify the level adjustment according to the distance of the respective early reflection position to the listener position relative to a level adjustment used by the apparatus for rendering of the audio signal from the sound source positon according to a distance attenuation exponent.

46. Apparatus of any of claims 42 to 45, further configured to, in generating the early reflection contribution loudspeaker signals relating to the early reflection portion of the room impulse response by performing a rendition of the audio signal of the sound source from the early reflection positions, render the audio signal of the sound source from each early reflection position in a manner spectrally shaped according to one or more frequency response parameters.

47. Apparatus of any of claims 1 to 16 and 28 to 46, further configured to, in performing the rendition of an audio signal of the sound source from the early reflection positions, use HRTFs specific for a listener head orientation.

48. Bitstream for being subject to sound rendition according to any of the previous claims 1 to 16 and 28 to 47.

49. Digital storage medium storing a bitstream for being subject to sound rendition according to claim 48.

50. Method for sound rendering, comprising

receiving information on a listener position and a sound source position;

rendering an audio signal of the sound source using a room impulse response whose early reflection portion is exclusively determined by an early reflection pattern

which is indicative of a constellation of early reflection positions, and

which is positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in a listener head orientation.

51. Method for determining an early reflection pattern for sound rendition, comprising

performing a geometric analysis of an acoustic environment by, at each of one or more analysis positions,

determining a function indicative, for each of different distances from the respective analysis position, a value representative of an early reflection contribution; and

inspecting the function or a further function derived therefrom with respect to one or more maxima to derive one or more control parameters;

determining an early reflection pattern

which is indicative of a constellation of early reflection positions,

by placing the early reflection positions using the one or more control parameters

52. Method for sound rendering, comprising

receiving first information on a listener position and a sound source position;

receiving a bitstream comprising a representation of an audio signal of a sound source positioned at the sound source position and one or more early reflection pattern parameters,

determining an early reflection pattern

which is indicative of a constellation of early reflection positions,

depending on the one or more early reflection pattern parameters, and

rendering the audio signal of the sound source using a room impulse response whose early reflection portion is determined by an early reflection pattern

which is indicative of a constellation of early reflection positions, and

which is positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in listener head orientation.

53. Method for sound rendering, comprising

receiving first information on a listener position and a sound source position;

rendering an audio signal of the sound source using a room impulse response whose early reflection portion is determined by an early reflection pattern

which is indicative of a constellation of early reflection positions, and

which is positioned at the listener position in a manner so that the early reflection positions are located around the listener position and at angular directions from the listener position which are invariant with respect to changes in listener head orientation,

the method comprising the method for determining the early reflection pattern according to claim 51.

54. Computer program for causing a computer, when executing the computer program, to perform the method of one of claims 50 to 53.