Claims

1. An apparatus for converting an object position of an audio object from a Cartesian representation to a spherical representation,

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of associated spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein the apparatus is configured to determine, in which of the base area triangles a projection of the object position of the audio object into the base area is arranged; and

wherein the apparatus is configured to determine a mapped position of the projection of the object position using a linear transform, which maps the base area triangle onto its associated spherical domain triangle,

wherein the apparatus is configured to derive an azimuth angle and an intermediate radius value from the mapped position;

wherein the apparatus is configured to obtain a spherical domain radius value and an elevation angle in dependence on the intermediate radius value and in dependence on a distance of the object position from the base area.

2. The apparatus according to claim 1, wherein the apparatus is configured to determine the mapped position $\tilde{P}$ of the projection P of the object position using a linear transform described by a transform matrix T according to

$$\tilde{P} = \begin{pmatrix} \tilde{x} \\ \tilde{y} \end{pmatrix} = \underline{T}\, P,$$

wherein the apparatus is configured to obtain the transform matrix in dependence the determined base area triangle;

wherein $\tilde{x}$ and $\tilde{y}$ represent mapped coordinates.

3. The apparatus according to claim 2, wherein the transform matrix is defined according to

$$\underline{T} = \begin{bmatrix} t_{11} & t_{12} \\ t_{21} & t_{22} \end{bmatrix} = \frac{1}{P_{1,x}P_{2,y} - P_{2,x}P_{1,y}} \begin{bmatrix} \tilde{P}_{1,x}P_{2,y} - \tilde{P}_{2,x}P_{1,y} & P_{1,x}\tilde{P}_{2,x} - \tilde{P}_{1,x}P_{2,x} \\ \tilde{P}_{1,y}P_{2,y} - \tilde{P}_{2,y}P_{1,y} & P_{1,x}\tilde{P}_{2,y} - \tilde{P}_{1,y}P_{2,x} \end{bmatrix}$$

wherein $P_{1,x}$, $P_{1,y}$, $P_{2,x}$, $P_{2,y}$ are x- and y- coordinates of two corners of the determined base area triangle; and

wherein $\tilde{P}_{1,x}$, $\tilde{P}_{1,y}$, $\tilde{P}_{2,x}$, $\tilde{P}_{2,y}$ are x- and y- coordinates of two corners of the associated spherical domain triangle.

4. The apparatus according to one of claims 1 to 3, wherein the base area triangles comprise

- a first base area triangle which covers an area in front of an origin of the Cartesian representation,

- a second base area triangle which covers an area on a left side of the origin of the Cartesian representation,

- a third base area triangle which covers an area on a right side of the origin of the Cartesian representation, and

- a fourth base area triangle which covers an area behind the origin of the Cartesian representation.

5. The apparatus according to one of claims 1 to 4, wherein the spherical domain triangles comprise

- a first spherical domain triangle which covers an area in front of an origin of the spherical representation,

- a second spherical domain triangle which covers an area on a left side of the origin of the spherical representation,

- a third spherical domain triangle which covers an area on a right side of the origin of the spherical representation, and

- a fourth spherical domain triangle which covers an area behind the origin of the spherical representation.

6. The apparatus according to one of claims 1 to 3, wherein the base area triangles comprise

- a first base area triangle which covers an area in a right front region of an origin of the Cartesian representation,

. a second base area triangle which covers an area in a left front region of the origin of the Cartesian representation

- a third base area triangle which covers an area on a left side of the origin of the Cartesian representation,

- a fourth base area triangle which covers an area on a right side of the origin of the Cartesian representation, and

- a fifth base area triangle which covers an area behind the origin of the Cartesian representation.

7. The apparatus according to one of claims 1 to 4 and 6, wherein the spherical domain triangles comprise

- a first spherical domain triangle which covers an area in a right front area of an origin of the spherical representation,

- a second spherical domain triangle which covers an area in a left front area of the origin of the spherical representation,

- a third spherical domain triangle which covers an area on a left side of the origin of the spherical representation,

- a fourth spherical domain triangle which covers an area on a right side of the origin of the spherical representation, and

- a fifth spherical domain triangle which covers an area behind the origin of the spherical representation.

8. The apparatus according to one of claims 1 to 5, wherein

coordinates P1, P2 of corners of base area triangles and coordinates $\widetilde{\boldsymbol{P}}_{\boldsymbol{1}}$ and $\widetilde{\boldsymbol{P}}_{\boldsymbol{2}}$ of corners of associated spherical domain triangles are defined as follows:

	$\boldsymbol{P_1}$	$\boldsymbol{P_2}$	$\widetilde{\boldsymbol{P}}_{\boldsymbol{1}}$	$\widetilde{\boldsymbol{P}}_{\boldsymbol{2}}$
Triangle pair 1	(1,1)	(-1,1)	$(\sin 30° = \frac{\sqrt{3}}{2}\ ,\ \cos 30° = \frac{1}{2})$	$(-\frac{\sqrt{3}}{2}, \frac{1}{2})$

Triangle pair 2	(-1,1)	(-1,-1)	$(-\frac{\sqrt{3}}{2}, \frac{1}{2})$	(-0.93969, -0.34202)
Triangle pair 3	(-1,-1)	(1,-1)	$(-\cos(110° - 90°) = -0.93969,\ -\sin(20°) = -0.34202)$	$(0.93969, -0.34202)$
Triangle pair 4	(1,-1)	(1,1)	$(0.93969, -0.34202)$	$(\frac{\sqrt{3}}{2}, \frac{1}{2})$

wherein a third corner of the respective triangles is in an origin of the respective coordinate system.

9. The apparatus according to one of claims 1 to 3 and 6 to 7, wherein

coordinates P1, P2 of corners of base area triangles and coordinates $\widetilde{\boldsymbol{P}}_1$ and $\widetilde{\boldsymbol{P}}_2$ of corners of associated spherical domain triangles are defined as follows:

	$\boldsymbol{P}_1$	$\boldsymbol{P}_2$	$\widetilde{\boldsymbol{P}}_1$	$\widetilde{\boldsymbol{P}}_2$
Triangle pair 1	(0,1)	(-1,1)	φ_{Sp} = 0°, r_{Sp} = 1 $(0, 1)$	φ_{Sp} = 30°, r_{Sp} = 1 $(-\frac{1}{2}, \frac{\sqrt{3}}{2})$
Triangle pair 2	(-1,1)	(-1,-1)	φ_{Sp} = 30°, r_{Sp} = 1 $(-\frac{1}{2}, \frac{\sqrt{3}}{2})$	φ_{Sp} = 110°, r_{Sp} = 1 $(-0.93969, -0.34202)$
Triangle pair 3	(-1,-1)	(1,-1)	φ_{Sp} = 110°, r_{Sp} = 1 $(-0.93969, -0.34202)$	φ_{Sp} = -110°, r_{Sp} = 1 $(0.93969, -0.34202)$
Triangle pair 4	(1,-1)	(1,1)	φ_{Sp} = -110°, r_{Sp} = 1 $(0.93969, -0.34202)$	φ_{Sp} = -30°, r_{Sp} = 1 $(\frac{1}{2}, \frac{\sqrt{3}}{2})$
Triangle pair 5	(1,1)	(0,1)	φ_{Sp} = -30°, r_{Sp} = 1 $(\frac{1}{2}, \frac{\sqrt{3}}{2})$	φ_{Sp} = 0°, r_{Sp} = 1 $(0, 1)$

wherein a third corner of the respective triangles is in an origin of the respective coordinate system.

10. The apparatus according to one of claims 1 to 9,

wherein the apparatus is configured to derive the azimuth angle φ from mapped coordinates $\tilde{x}$ and $\tilde{y}$ of the mapped position according to

$$\varphi = \begin{cases} \tan^{-1}\dfrac{-\tilde{x}}{\tilde{y}} & \text{for } \tilde{y} > 0 \\ -90° & \text{for } \tilde{y} = 0 \ \wedge \ \tilde{x} > 0 \\ 0° & \text{for } \tilde{y} = 0 \ \wedge \ \tilde{x} = 0 \\ 90° & \text{for } \tilde{y} = 0 \ \wedge \ \tilde{x} < 0 \\ -90° + \tan^{-1}\dfrac{\tilde{y}}{\tilde{x}} & \text{for } \tilde{y} < 0 \ \wedge \ \tilde{x} > 0 \\ -180° & \text{for } \tilde{y} < 0 \ \wedge \ \tilde{x} = 0 \\ 90° + \tan^{-1}\dfrac{\tilde{y}}{\tilde{x}} & \text{for } \tilde{y} < 0 \ \wedge \ \tilde{x} < 0 \end{cases}$$

11. The apparatus according to one of claims 1 to 10,

wherein the apparatus is configured to derive the intermediate radius value $\tilde{r}_{xy}$ from mapped coordinates $\tilde{x}$ and $\tilde{y}$ of the mapped position according to

$$\tilde{r}_{xy} = \sqrt{\tilde{x}^2 + \tilde{y}^2}$$

12. The apparatus according to one of claims 1 to 11,

wherein the apparatus is configured to obtain the spherical domain radius value in dependence on the intermediate radius value using a radius adjustment which maps a spherical domain triangle inscribed into the circle onto a circle segment.

13. The apparatus according to one of claims 1 to 12,

wherein the apparatus is configured to obtain the spherical domain radius value in dependence on the intermediate radius value using a radius adjustment,

wherein the radius adjustment is adapted to scale the intermediate radius value obtained before in dependence on the azimuth angle φ.

14. The apparatus according to one of claims 1 to 13,

wherein the apparatus is configured to obtain the spherical domain radius value in dependence on the intermediate radius value using a mapping of the form

for $|\varphi| \leq 30°$:

$$r_{xy} = \tilde{r}_{xy} \frac{\cos\varphi}{\cos 30°}$$

for $30° < |\varphi| \leq 110°$:

$$r_{xy} = \tilde{r}_{xy} \frac{\cos(70° - |\varphi|)}{\cos 80°}$$

for $110° < |\varphi| \leq 180°$:

$$r_{xy} = \tilde{r}_{xy} \frac{\cos(180° - |\varphi|)}{\cos 140°}$$

wherein r_{xy} is a radius-adjusted version of the intermediate radius value $\tilde{r}_{xy}$; and

wherein φ is an azimuth angle.

15. The apparatus according to one of claims 1 to 14,

wherein the apparatus is configured to obtain the spherical domain radius value r_{xy} in dependence on the intermediate radius value $\tilde{r}_{xy}$ using a mapping of the form

For $\varphi(\tilde{P}_1) < \varphi \leq \varphi(\tilde{P}_2)$:

$$r_{xy} = \tilde{r}_{xy} \frac{\cos\left(\frac{\varphi(\tilde{P}_2) + \varphi(\tilde{P}_1)}{2} - \varphi\right)}{\cos\left(\frac{\varphi(\tilde{P}_2) - \varphi(\tilde{P}_1)}{2}\right)}$$

wherein $\varphi(\tilde{P}_1)$ and $\varphi(\tilde{P}_2)$ are position angles of two corners of a respective spherical domain triangle.

16. The apparatus according to one of claims 1 to 15,

wherein the apparatus is configured to obtain the elevation angle as an angle of a right triangle having legs of the intermediate radius value and of the distance of the object position from the base area.

17. The apparatus according to one of claims 1 to 16,

wherein the apparatus is configured to obtain the spherical domain radius as a hypotenuse length $\tilde{r}$ of a right triangle having legs of the intermediate radius value and of the distance of the object position from the base area, or as an adjusted version thereof.

18. The apparatus according to one of claims 1 to 17,

wherein the apparatus is configured to obtain the elevation angle $\tilde{\theta}$ according to

$$\tilde{\theta} = \tan^{-1}\frac{z}{r_{xy}}$$

and/or to obtain the spherical domain radius $\tilde{r}$ according to

$$\tilde{r} = \sqrt{r_{xy}^2 + z^2},$$

wherein z is the distance of the object position from the base area, and

wherein r_{xy} is the intermediate radius value, or an adjusted version thereof.

19. The apparatus according to one of claims 1 to 18,

wherein the apparatus is configured to obtain an adjusted elevation angle.

20. The apparatus according to claim 19,

wherein the apparatus is configured to obtain the adjusted elevation angle using a non-linear mapping which linearly maps angles in a first angle region onto a first mapped angle region and which linearly maps angles within a second angle region onto a second mapped angle region, wherein the first angle region has a different width when compared to the first mapped angle region.

21. The apparatus according to claim 20,

wherein an angle range covered together by first angle region and the second angle region is identical to an angle range covered together by the first mapped angle region and the second mapped angle region.

22. The apparatus according to one of claims 19 to 21,

wherein the apparatus is configured to mapping the elevation angle $\tilde{\theta}$ onto the adjusted elevation angle θ according to

$$\theta = \begin{cases} \tilde{\theta}\frac{30^\circ}{45^\circ} & \text{for } \tilde{\theta} \leq 45^\circ \\ \left(\tilde{\theta} - 45^\circ\right)\frac{(90^\circ - 30^\circ)}{45^\circ} + 30^\circ & \text{for } 45^\circ < \tilde{\theta} < 90^\circ \end{cases}.$$

23. The apparatus according to one of claims 19 to 22,

wherein the apparatus is configured to mapping the elevation angle $\tilde{\theta}$ onto the adjusted elevation angle θ according to

$$\theta = \begin{cases} \tilde{\theta}\frac{\theta_{\text{Top}}}{\tilde{\theta}_{\text{Top}}} & \text{for } \tilde{\theta} \leq \tilde{\theta}_{\text{Top}} \\ \left(\tilde{\theta} - \tilde{\theta}_{\text{Top}}\right)\frac{\left(90^\circ - \theta_{\text{Top}}\right)}{\tilde{\theta}_{\text{Top}}} + \theta_{\text{Top}} & \text{for } \tilde{\theta}_{\text{Top}} < \tilde{\theta} < 90^\circ \end{cases}$$

wherein θ_{Top} is an elevation angle of height loudspeakers in the Cartesian coordinate system; and

wherein $\tilde{\theta}_{\text{Top}}$ is an elevation angle of height loudspeakers in the spherical coordinate system.

24. The apparatus according to one of claims 1 to 23,

wherein the apparatus is configured to obtain an adjusted spherical domain radius on the basis of a spherical domain radius.

25. The apparatus according to claim 24,

wherein the apparatus is configured to perform a mapping, which maps boundaries of a square in a Cartesian system onto a circle in a spherical coordinate system, in order to obtain an adjusted spherical domain radius.

26. The apparatus according to claim 24 or claim 25,

wherein the apparatus is configured to map the spherical domain radius $\tilde{r}$ onto the adjusted spherical domain radius r according to:

for $0 \leq \tilde{\theta} \leq 45^{\circ}$:

$r = \tilde{r} \cos\tilde{\theta}$

for $45° < \tilde{\theta} \leq 90°$:

$r = \tilde{r} \sin\tilde{\theta}$

wherein $\tilde{\theta}$ is the elevation angle.

27. An apparatus for converting an object position of an audio object from a spherical representation to a Cartesian representation,

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein the apparatus is configured to obtain a value describing a distance of the object position from the base area and an intermediate radius on the basis of an elevation angle or a mapped elevation angle and on the basis of a spherical domain radius or a mapped spherical domain radius;

wherein the apparatus is configured to determine a position within one of the triangles inscribed into the circle on the basis of the intermediate radius, or a corrected version thereof in which a radius adjustment, which is made because loudspeakers are placed on a square in a Cartesian coordinate system associated with the cartesian representation in contrast to a spherical coordinate system associated with the spherical representation, is reversed, and on the basis of an azimuth angle; and

wherein the apparatus is configured to determine a mapped position of the projection of the object position onto the base plane on the basis of the determined position within one of the triangles inscribed into the circle.

28. The apparatus according to claim 27,

wherein the apparatus is configured to obtain a mapped elevation angle on the basis of an elevation angle, and

wherein the apparatus is configured to obtain the mapped elevation angle using a non-linear mapping which linearly maps angles in a first angle region onto a first mapped angle region and which linearly maps angles within a second angle region onto a second mapped angle region, wherein the first angle region has a different width when compared to the first mapped angle region.

29. The apparatus according to claim 28,

wherein an angle range covered together by the first angle region and the second angle region is identical to an angle range covered together by the first mapped angle region and the second mapped angle region.

30. The apparatus according to claim 28 or claim29,

wherein the apparatus is configured to map the elevation angle θ onto the mapped elevation angle $\tilde{\theta}$ according to

$$\tilde{\theta} = \begin{cases} \theta \dfrac{45°}{30°} & \text{for } \theta \leq 30° \\ (\theta - 30°) \dfrac{45°}{(90° - 30°)} + 45° & \text{for } 30° < \theta < 90° \end{cases}$$

31. The apparatus according to one of claims 28 to 30,

wherein the apparatus is configured to map the elevation angle θ onto the mapped elevation angle $\tilde{\theta}$ according to

$$\tilde{\theta} = \begin{cases} \theta \dfrac{\tilde{\theta}_{\mathrm{Top}}}{\theta_{\mathrm{Top}}} & \text{for } \theta \leq \theta_{\mathrm{Top}} \\ \left(\theta - \theta_{\mathrm{Top}}\right) \dfrac{\tilde{\theta}_{\mathrm{Top}}}{\left(90° - \theta_{\mathrm{Top}}\right)} + \tilde{\theta}_{\mathrm{Top}} & \text{for } \theta_{\mathrm{Top}} < \theta < 90° \end{cases}$$

wherein θ_{Top} is an elevation angle of height loudspeakers in the Cartesian coordinate system; and

wherein $\tilde{\theta}_{\mathrm{Top}}$ is an elevation angle of height loudspeakers in the spherical coordinate system.

32. The apparatus according to one of claims 27 to 31,

wherein the apparatus is configured to obtain a mapped spherical domain radius $\tilde{r}$ on the basis of a spherical domain radius;

wherein the apparatus is configured to scale the spherical domain radius in dependence on the elevation angle or in dependence on the mapped elevation angle,

wherein the apparatus is configured to perform a mapping, which maps a circle in a spherical coordinate system onto boundaries of a square in a Cartesian system,

and/or

wherein the apparatus is configured to obtain the mapped spherical domain radius $\tilde{r}$ on the basis of the spherical domain radius r according to

$$\tilde{r} = \begin{cases} \frac{r}{\cos\tilde{\theta}} & \text{for } \tilde{\theta} \leq 45° \\ \frac{r}{\sin\tilde{\theta}} & \text{for } 45° < \tilde{\theta} < 90° \end{cases}$$

wherein $\tilde{\theta}$ is the elevation angle or the mapped elevation angle,

or

wherein the apparatus is configured to obtain the mapped spherical domain radius $\tilde{r}$ on the basis of the spherical domain radius r according to

$$\tilde{r} = \begin{cases} \frac{r}{\cos\tilde{\theta}} & \text{for } \tilde{\theta} \leq \tilde{\theta}_{\text{Top}} \\ \frac{r}{\sin\tilde{\theta}} & \text{for } \tilde{\theta}_{\text{Top}} < \tilde{\theta} < 90° \end{cases}$$

wherein $\tilde{\theta}$ is the elevation angle or the mapped elevation angle, and

wherein $\tilde{\theta}_{\text{Top}}$ is an elevation angle of height loudspeakers in the spherical coordinate system.

33. The apparatus according to one of claims 27 to 32,

wherein the apparatus is configured to obtain the value z describing a distance of the object position from the base area according to

$$z = \tilde{r}\ \sin\tilde{\theta}$$

and/or

wherein the apparatus is configured to obtain the intermediate radius r_{xy} according to

$$r_{xy} = \tilde{r}\ \cos\tilde{\theta},$$

wherein $\tilde{r}$ is the spherical domain radius or the mapped spherical domain radius; and

wherein $\tilde{\theta}$ is the elevation angle or the mapped elevation angle.

34. The apparatus according to one of claims 27 to 33,

wherein the apparatus is configured to scale the intermediate radius in dependence on the azimuth angle, to obtain a corrected radius;

wherein the apparatus is configured to obtain the corrected radius $\tilde{r}_{xy}$ on the basis of the intermediate radius r_{xy} according to

$$\tilde{r}_{xy} = \begin{cases} r_{xy}\dfrac{\cos 30°}{\cos\varphi} & \text{for } |\varphi| \le 30° \\ r_{xy}\dfrac{\cos 80°}{\cos(70° - |\varphi|)} & \text{for } 30° < |\varphi| \le 110° \\ r_{xy}\dfrac{\cos 140°}{\cos(180° - |\varphi|)} & \text{for } 110° < |\varphi| \le 180° \end{cases}$$

wherein φ is the azimuth angle;

and/or

wherein the apparatus is configured to obtain the corrected radius $\tilde{r}_{xy}$ on the basis of the intermediate radius r_{xy} according to

$$\tilde{r}_{xy} = r_{xy}\frac{\cos\left(\dfrac{\varphi(\tilde{P}_2) - \varphi(\tilde{P}_1)}{2}\right)}{\cos\left(\dfrac{\varphi(\tilde{P}_2) + \varphi(\tilde{P}_1)}{2} - \varphi\right)}$$

wherein φ is the azimuth angle, and

wherein $\varphi(\tilde{P}_1)$ and $\varphi(\tilde{P}_2)$ are position angles of two corners of a respective spherical domain triangle.

35. The apparatus according to one of claims 27 to 34,

wherein the apparatus is configured to determine a position within one of the triangles inscribed into the circle according to

$$\tilde{x} = \begin{cases} -\tilde{r}_{xy}\ \sin\varphi & \text{for } |\varphi| \le 90° \\ -\tilde{r}_{xy}\sin(180° - \varphi) & \text{for } 90° < |\varphi| \le 180° \end{cases}$$

$$\tilde{y} = \begin{cases} \tilde{r}_{xy}\ \cos\varphi & \text{for } |\varphi| \leq 90° \\ -\tilde{r}_{xy}\cos(180° - |\varphi|) & \text{for } 90° < |\varphi| \leq 180° \end{cases}$$

wherein $\tilde{x}$ and $\tilde{y}$ are coordinate values;

wherein $\tilde{r}_{xy}$ is the intermediate radius or the corrected radius; and

wherein φ is the azimuth angle.

36. The apparatus according to one of claims 27 to 35,

wherein the apparatus is configured to determine the mapped position of the projection of the object position onto the base plane on the basis of the determined position within one of the triangles inscribed into the circle using a linear transform mapping the triangle in which the determined position lies, onto an associated triangle in the base plane.

37. The apparatus according to one of claims 27 to 36,

wherein the apparatus is configured to determine the mapped position of the projection P of the object position onto the base plane according to

$$P = \begin{pmatrix} x \\ y \end{pmatrix} = \underline{T}^{-1}\,\tilde{P}$$

wherein T is a transform matrix, and

wherein $\tilde{P}$ is a vector representing the projection of the object position onto the base plane.

38. The apparatus according to claim 37, wherein the transform matrix is defined according to

$$\underline{T} = \begin{bmatrix} t_{11} & t_{12} \\ t_{21} & t_{22} \end{bmatrix} = \frac{1}{P_{1,x}P_{2,y} - P_{2,x}P_{1,y}} \begin{bmatrix} \tilde{P}_{1,x}P_{2,y} - \tilde{P}_{2,x}P_{1,y} & P_{1,x}\tilde{P}_{2,x} - \tilde{P}_{1,x}P_{2,x} \\ \tilde{P}_{1,y}P_{2,y} - \tilde{P}_{2,y}P_{1,y} & P_{1,x}\tilde{P}_{2,y} - \tilde{P}_{1,y}P_{2,x} \end{bmatrix}$$

wherein $P_{1,x}$, $P_{1,y}$, $P_{2,x}$, $P_{2,y}$ are x- and y- coordinates of two corners of the determined base area triangle; and

wherein $\tilde{P}_{1,x}$, $\tilde{P}_{1,y}$, $\tilde{P}_{2,x}$, $\tilde{P}_{2,y}$ are x- and y- coordinates of two corners of the associated spherical domain triangle.

39. The apparatus according to one of claims 27 to 38, wherein the base area triangles comprise

- a first base area triangle which covers an area in front of an origin of the Cartesian representation,

- a second base area triangle which covers an area on a left side of the origin of the Cartesian representation,

- a third base area triangle which covers an area on a right side of the origin of the Cartesian representation, and

- a fourth base area triangle which covers an area behind the origin of the Cartesian representation.

40. The apparatus according to one of claims 27 to 39, wherein the spherical domain triangles comprise

- a first spherical domain triangle which covers an area in front of an origin of the spherical representation,

- a second spherical domain triangle which covers an area on a left side of the origin of the spherical representation,

- a third spherical domain triangle which covers an area on a right side of the origin of the spherical representation, and

- a fourth spherical domain triangle which covers an area behind the origin of the spherical representation.

41. The apparatus according to one of claims 27 to 40, wherein the base area triangles comprise

- a first base area triangle which covers an area in a right front region of an origin of the Cartesian representation,

- a second base area triangle which covers an area in a left front region of the origin of the Cartesian representation

- a third base area triangle which covers an area on a left side of the origin of the Cartesian representation,

- a fourth base area triangle which covers an area on a right side of the origin of the Cartesian representation, and

- a fifth base area triangle which covers an area behind the origin of the Cartesian representation.

42. The apparatus according to one of claims 27 to 38 and 41, wherein the spherical domain triangles comprise

- a first spherical domain triangle which covers an area in a right front area of an origin of the spherical representation,

- a second spherical domain triangle which covers an area in a left front area of the origin of the spherical representation,

- a third spherical domain triangle which covers an area on a left side of the origin of the spherical representation,

- a fourth spherical domain triangle which covers an area on a right side of the origin of the spherical representation, and

- a fifth spherical domain triangle which covers an area behind the origin of the spherical representation.

43. The apparatus according to one of claims 27 to 42, wherein

coordinates P1, P2 of corners of base area triangles and coordinates of corners of associated spherical domain triangles $\widetilde{\boldsymbol{P}}_{\boldsymbol{1}}$ and $\widetilde{\boldsymbol{P}}_{\boldsymbol{2}}$ are defined as follows:

	$\boldsymbol{P_1}$	$\boldsymbol{P_2}$	$\widetilde{\boldsymbol{P}}_{\boldsymbol{1}}$	$\widetilde{\boldsymbol{P}}_{\boldsymbol{2}}$
Triangle pair 1	(1,1)	(-1,1)	$(\sin 30° = \frac{\sqrt{3}}{2}\ ,\ \cos 30° = \frac{1}{2})$	$(-\frac{\sqrt{3}}{2}, \frac{1}{2})$
Triangle pair 2	(-1,1)	(-1,-1)	$(-\frac{\sqrt{3}}{2}, \frac{1}{2})$	(-0.93969, -0.34202)
Triangle pair 3	(-1,-1)	(1,-1)	$(-\cos(110° - 90°) = -0.93969,\ -\sin(20°) = -0.34202)$	$(0.93969, -0.34202)$

Triangle pair 4	(1,-1)	(1,1)	$(0.93969, -0.34202\ )$	$(\frac{\sqrt{3}}{2}\ ,\ \frac{1}{2})$

wherein a third corner of the respective triangles is in an origin of the respective coordinate system.

5

44. An audio stream provider for providing an audio stream,

wherein the audio stream provider is configured to receive input object position information describing a position of an audio object in a Cartesian representation and

to provide an audio stream comprising output object position information describing the position of the object in a spherical representation,

wherein the audio stream provider comprises an apparatus according to one of claims 1 to 26 in order to convert the Cartesian representation into the spherical representation.

45. An audio content production system,

wherein the audio content production system is configured to determine an object position information describing a position of an audio object in a Cartesian representation, and

wherein the audio content production system comprises an apparatus according to one of claims 1 to 26 in order to convert the Cartesian representation into the spherical representation, and

wherein the audio content production system is configured to include the spherical representation into an audio stream.

46. An audio playback apparatus,

wherein the audio playback apparatus is configured to receive an audios stream comprising a spherical representation of an object position information, and

wherein the audio playback apparatus comprises an apparatus according to one of claims 27 to 43, which is configured to convert the spherical representation into a Cartesian representation of the object position information, and

wherein the audio playback apparatus comprises a renderer configured to render an audio object to a plurality of channel signals associated with sound transducers in dependence on the Cartesian representation of the object position information.

47. An audio stream provider for providing an audio stream,

wherein the audio stream provider is configured to receive input object position information describing a position of an audio object in a spherical representation and

to provide an audio stream comprising output object position information describing the position of the object in a Cartesian representation,

wherein the audio stream provider comprises an apparatus according to one of claims 27 to 43 in order to convert the spherical representation into the Cartesian representation.

48. An audio content production system,

wherein the audio content production system is configured to determine an object position information describing a position of an audio object in a spherical representation, and

wherein the audio content production system comprises an apparatus according to one of claims 27 to 43 in order to convert the spherical representation into a Cartesian representation, and

wherein the audio content production system is configured to include the Cartesian representation into an audio stream.

49. An audio playback apparatus,

wherein the audio playback apparatus is configured to receive an audio stream comprising a Cartesian representation of an object position information, and

wherein the audio playback apparatus comprises an apparatus according to one of claims 1 to 26, which is configured to convert the Cartesian representation into a spherical representation of the object position information, and

wherein the audio playback apparatus comprises a renderer configured to render an audio object to a plurality of channel signals associated with sound transducers in dependence on the spherical representation of the object position information.

50. A method for converting an object position of an audio object from a Cartesian representation to a spherical representation,

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of associated spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein the method comprises determining, in which of the base area triangles a projection of the object position of the audio object into the base area is arranged; and

wherein the method comprises determining a mapped position of the projection of the object position using a linear transform, which maps the base area triangle onto its associated spherical domain triangle,

wherein the method comprises deriving an azimuth angle [φ] and an intermediate radius value from the mapped position;

wherein the method comprises obtaining a spherical domain radius value and an elevation angle in dependence on the intermediate radius value and in dependence on a distance of the object position from the base area.

51. A method for converting an object position of an audio object from a spherical representation to a Cartesian representation,

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein the method comprises obtaining a value describing a distance of the object position from the base area and an intermediate radius on the basis of an elevation angle or a mapped elevation angle and on the basis of a spherical domain radius or a mapped spherical domain radius;

wherein the method comprises determining a position within one of the triangles inscribed into the circle on the basis of the intermediate radius, or a corrected version thereof in which a radius

adjustment, which is made because loudspeakers are placed on a square in a Cartesian coordinate system associated with the cartesian representation in contrast to a spherical coordinate system associated with the spherical representation, is reversed, and on the basis of an azimuth angle [φ]; and

wherein the method comprises determining a mapped position of the projection of the object position onto the base plane on the basis of the determined position within one of the triangles inscribed into the circle.

52. A method for providing an audio stream,

wherein the method comprises receiving input object position information describing a position of an audio object in a Cartesian representation and

providing an audio stream comprising output object position information describing the position of the object in a spherical representation,

wherein the method comprises converting the Cartesian representation into the spherical representation using the method according to claim 50.

53. A method for producing an audio content,

wherein the method comprises determining an object position information describing a position of an audio object in a Cartesian representation, and

wherein the method comprises converting the Cartesian representation into the spherical representation using the method according to claim 50, and

wherein the method comprises including the spherical representation into an audio stream.

54. A method for audio playback,

wherein the method comprises receiving an audios stream comprising a spherical representation of an object position information, and

wherein the method comprises converting the spherical representation into a Cartesian representation of the object position information according to claim 51, and

wherein the method comprises rendering an audio object to a plurality of channel signals associated with sound transducers in dependence on the Cartesian representation of the object position information.

55. A method for providing an audio stream,

wherein the method comprises receiving input object position information describing a position of an audio object in a spherical representation and

providing an audio stream comprising output object position information describing the position of the object in a Cartesian representation,

wherein the method comprises converting the spherical representation into the Cartesian representation using the method according to claim 51.

56. A method for producing an audio content,

wherein the method comprises determining an object position information describing a position of an audio object in a spherical representation, and

wherein the method comprises converting the spherical representation into the Cartesian representation using the method according to claim 51, and

wherein the method comprises including the Cartesian representation into an audio stream.

57. A method for audio playback,

wherein the method comprises receiving an audios stream comprising a Cartesian representation of an object position information, and

wherein the method comprises converting the Cartesian representation into a spherical representation of the object position information according to claim 50, and

wherein the method comprises rendering an audio object to a plurality of channel signals associated with sound transducers in dependence on the spherical representation of the object position information.

58. A computer program for performing a method according to one of claims 50 to 57 when the computer program runs on a computer.

59. An apparatus for converting an object position of an audio object from a Cartesian representation to a spherical representation, in which the object position is described using an azimuth angle, an elevation angle and a spherical domain radius,

wherein loudspeakers are placed on a square in a Cartesian coordinate system associated with the Cartesian representation and loudspeakers are placed on a circle in a spherical coordinate system associated with the spherical representation;

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein each of the spherical-domain triangles is associated to a base area triangle;

wherein positions of corners of at least some of the base area triangles correspond to positions of loudspeakers in the Cartesian coordinate system, and

wherein positions of corners of at least some of the spherical-domain triangles correspond to positions of loudspeakers in the spherical coordinate system;

wherein the apparatus is configured to determine, in which of the base area triangles a projection of the object position of the audio object into the base area is arranged; and

wherein the apparatus is configured to determine a mapped position of the projection of the object position using a linear transform, which maps the base area triangle onto an associated spherical domain triangle,

wherein the apparatus is configured to derive an azimuth angle and an intermediate radius value from the mapped position;

wherein the apparatus is configured to obtain a spherical domain radius value and an elevation angle in dependence on the intermediate radius value and in dependence on a distance of the object position from the base area.

60. A method for converting an object position of an audio object from a Cartesian representation to a spherical representation, in which the object position is described using an azimuth angle, an elevation angle and a spherical domain radius,

wherein loudspeakers are placed on a square in a Cartesian coordinate system associated with the Cartesian representation and loudspeakers are placed on a circle in a spherical coordinate system associated with the spherical representation;

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein each of the spherical-domain triangles is associated to a base area triangle;

wherein positions of corners of at least some of the base area triangles correspond to positions of loudspeakers in the Cartesian coordinate system, and

wherein positions of corners of at least some of the spherical-domain triangles correspond to positions of loudspeakers in the spherical coordinate system;

wherein the method comprises determining, in which of the base area triangles a projection of the object position of the audio object into the base area is arranged; and

wherein the method comprises determining a mapped position of the projection of the object position using a linear transform, which maps the base area triangle onto its associated spherical domain triangle,

wherein the method comprises deriving an azimuth angle [φ] and an intermediate radius value from the mapped position;

wherein the method comprises obtaining a spherical domain radius value and an elevation angle in dependence on the intermediate radius value and in dependence on a distance of the object position from the base area.

61. An apparatus for converting an object position of an audio object from a spherical representation, in which the object position is described using an azimuth angle, an elevation angle and a spherical domain radius, to a Cartesian representation,

wherein loudspeakers are placed on a square in a Cartesian coordinate system associated with the Cartesian representation and loudspeakers are placed on a circle in a spherical coordinate system associated with the spherical representation;

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of spherical-domain triangles are inscribed into a circle of the spherical representation,

wherein positions of corners of at least some of the base area triangles correspond to positions of loudspeakers in the Cartesian coordinate system, and

wherein positions of corners of at least some of the spherical-domain triangles correspond to positions of loudspeakers in the spherical coordinate system;

wherein the apparatus is configured to obtain a value describing a distance of the object position from the base area and an intermediate radius on the basis of the elevation angle or a mapped elevation angle and on the basis of the spherical domain radius or a mapped spherical domain radius;

wherein the apparatus is configured to determine a position within one of the triangles inscribed into the circle on the basis of the intermediate radius, or a corrected version thereof in which a radius adjustment, which is made because the loudspeakers are placed on a square in the Cartesian coordinate system in contrast to the spherical coordinate system, is reversed, and on the basis of the azimuth angle; and

wherein the apparatus is configured to determine a mapped position of the projection of the object position onto the base plane on the basis of the determined position within one of the triangles inscribed into the circle, using a linear transform mapping the triangle in which the determined position lies, onto an associated triangle in the base plane,

wherein the value describing the distance of the object position from the base area and the mapped position describe the object position in the Cartesian representation.

62. A method for converting an object position of an audio object from a spherical representation, in which the object position is described using an azimuth angle, an elevation angle and a spherical domain radius, to a Cartesian representation,

wherein loudspeakers are placed on a square in a Cartesian coordinate system associated with the Cartesian representation and loudspeakers are placed on a circle in a spherical coordinate system associated with the spherical representation;

wherein a base area of the Cartesian representation is subdivided into a plurality of base area triangles, and wherein a plurality of spherical-domain triangles are inscribed into a circle of a spherical representation,

wherein positions of corners of at least some of the base area triangles correspond to positions of loudspeakers in the Cartesian coordinate system, and

wherein positions of corners of at least some of the spherical-domain triangles correspond to positions of loudspeakers in the spherical coordinate system;

wherein the method comprises obtaining a value describing a distance of the object position from the base area and an intermediate radius on the basis of an elevation angle or a mapped elevation angle and on the basis of a spherical domain radius or a mapped spherical domain radius;

wherein the method comprises determining a position within one of the triangles inscribed into the circle on the basis of the intermediate radius, or a corrected version thereof in which a radius adjustment, which is made because the loudspeakers are placed on a square in the Cartesian coordinate system in contrast to the spherical coordinate system, is reversed, and on the basis of an azimuth angle [φ]; and

wherein the method comprises determining a mapped position of the projection of the object position onto the base plane on the basis of the determined position within one of the triangles inscribed into the circle, using a linear transform mapping the triangle in which the determined position lies, onto an associated triangle in the base plane;

wherein the value describing the distance of the object position from the base area and the mapped position describe the object position in the Cartesian representation.