GB 2 408 805 B relates to an electromagnetic tracking system which uses a wireless transmitter.

US 6,625,299 B1 relates to a tracking system for determining the relative position between a sensor and an object surface which comprises a sensor for detecting a pattern of markers on the object surface.

US 2015/0343292 A1 relates to a golf aid for communicating golf-related information by means of a head-up display.

It is a task of the present invention to provide as a training aid an improved method and an improved apparatus for analyzing the movement of a piece of sports equipment. In particular a task of the invention is providing a user with simultaneous feedback on the movement of the sports equipment.

This task is solved by methods according to claims 1 and 3 as well as by systems according to claims 26 and 29. Advantageous embodiments are claimed in the subclaims.

A first aspect of the invention relates to a method for analyzing the movement of at least one piece of sports equipment for a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, which comprises the following procedural steps:

Detecting a position and/or an orientation, in particular continuously, of a display device, in particular a head-mounted display, in a reference system;

Calculating a field of view of the display device in the reference system on the basis of its detected position and/or orientation;

Detecting a start position of a ball of the ball sport type, in particular a tee-off position, in the reference system;

Detecting a defined target position for the ball, in particular a golf hole, in the reference system;

Detecting at least one environmental parameter in the reference system, in particular a topographical parameter, which at least partially characterizes an environment, in particular a playing field, within an area between the start position and the target position;

Utilizing the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter;

Generating a first virtual trajectory model of the at least one piece of sports equipment for the field of view on the basis of the calculated trajectory of the at least one piece of sports equipment; and

Reproducing the first virtual trajectory model in the display device such that the first virtual trajectory model displays as a first line in the display device in superimposition with at least one section of the environment which is in particular visible in reality, particularly when the field of view is directed toward the at least one section of the environment visible in reality.

A second aspect of the invention likewise relates to a method for analyzing the movement of at least one piece of sports equipment for a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, which comprises the following procedural steps:

Detecting a start position of a ball of the ball sport type, in particular a tee-off position, in a reference system;

Detecting a defined target position for the ball, in particular a golf hole, and a position of a projector in the reference system;

Detecting at least one environmental parameter in the reference system, in particular a topographical parameter, which at least partially characterizes an environment, in particular a playing field, within an area between the start position and the target position;

Utilizing the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter;

Generating a first virtual trajectory model of the at least one piece of sports equipment in at least one section of the environment on the basis of the calculated trajectory of the piece of sports equipment; and

Reproducing the first virtual trajectory model such that it is projected into the environment by the projector as a first line.

A third aspect of the invention relates to a system for analyzing the movement of at least one piece of sports equipment of a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, comprising:

a display device, in particular a head-mounted display, arranged to generate an augmented reality;

a tracking module, arranged to detect a start position of a ball of the type of ball sport and a defined target position for the ball, in particular a golf hole, in a reference system and to detect a position and/or orientation of the display device in the reference system;

a data interface or a scanning apparatus arranged to detect at least one environmental parameter in the reference system, in particular a topographical parameter, which at least partially characterizes an environment, in particular a playing field, within an area between the start position and the target position; and

a processing unit arranged to utilize the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter in order to calculate a field of view of the display device in the reference system on the basis of the detected position and/or orientation of the display device and to generate a first virtual trajectory model of the piece of sports equipment for the field of view based on the calculated trajectory of the at least one piece of sports equipment, and

wherein the display device is configured so as to display the first virtual trajectory model as a first line in superimposition with at least one section of the environment, particularly one which is visible in reality, particularly when the field of view is directed toward the at least one section of the environment.

A fourth aspect of the invention relates to a system for analyzing the movement of at least one piece of sports equipment for a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, comprising:

a projector arranged to generate projections of at least one playing field;

a data interface or scanning apparatus arranged to detect in a reference system the position of the projector, a defined start position and a defined target position for the ball of the type of ball sport, in particular a golf hole, and at least one environmental parameter, in particular a topographical parameter, which at least partially characterizes the playing field within an area between the start position and the target position; and

a processing unit arranged to utilize the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter, and to generate a first virtual trajectory model of the at least one piece of sports equipment in at least one section of the environment on the basis of the calculated trajectory of the ball,

wherein the projector is arranged to project the start position of the ball and the first virtual trajectory model onto the playing field as a first line.

The following will describe advantageous method embodiments of the first and second aspect of the invention which, unless expressly excluded, can each be combined with one another.

Detection in the sense of the invention is an importing of data in the broadest sense. This encompasses both importing via a data interface of a data processing system, thus data which already exists and any buffered data there might be, as well as also a measuring and/or receiving of information converted into relevant data, for example by means of a scanning apparatus, in particular a 3D scanner, or a tracking module enabling optical identification of information. Detection in particular also means the furnishing of data, for example when data stored in a memory storage device is accessed in a system.

C l a i m s

1. A method for analyzing the movement of at least one piece of sports equipment for a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, which comprises the following procedural steps:

Detecting a position and/or an orientation, in particular continuously, of a display device, in particular a head-mounted display, in a reference system;

Calculating a field of view of the display device in the reference system on the basis of its detected position and/or orientation;

Detecting a start position of a ball of the ball sport type, in particular a tee-off position, in the reference system;

Detecting a defined target position for the ball, in particular a golf hole, in the reference system;

Detecting at least one environmental parameter in the reference system, in particular a topographical parameter, which at least partially characterizes an environment, in particular a playing field, within an area between the start position and the target position;

Utilizing the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter;

Generating a first virtual trajectory model of the at least one piece of sports equipment for the field of view on the basis of the calculated trajectory of the at least one piece of sports equipment; and

Reproducing the first virtual trajectory model in the display device such that the first virtual trajectory model displays as a first line in the display device in superimposition with at least one section of the environment which is in particular visible in reality, particularly when the

field of view is directed toward the at least one section of the environment visible in reality.

2. The method according to claim 1, further comprising the following procedural steps:
Detecting a position and/or an orientation of the piece of sports equipment in the reference system at least during one period of time when the sports equipment is moving;
Generating a second virtual trajectory model of the piece of sports equipment for the field of view on the basis of the actual trajectory of the piece of sports equipment; and
Reproducing the second virtual trajectory model in the display device such that the second virtual trajectory model displays as a second line in the display device in superimposition with the at least one visible section of the environment and the first line, in particular when the field of view is directed toward the at least one visible part of the section of the environment.

3. A method for analyzing the movement of at least one piece of sports equipment for a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, which comprises the following procedural steps:
Detecting a start position of a ball of the ball sport type, in particular a tee-off position, in a reference system;
Detecting a defined target position for the ball, in particular a golf hole, and a position of a projector in the reference system;
Detecting at least one environmental parameter in the reference system, in particular a topographical parameter, which at least partially characterizes an environment, in particular a playing field, within an area between the start position and the target position;
Utilizing the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment

based on the start position of the ball, the target position of the ball and the at least one environmental parameter;

Generating a first virtual trajectory model of the at least one piece of sports equipment in at least one section of the environment on the basis of the calculated trajectory of the piece of sports equipment; and

Reproducing the first virtual trajectory model such that it is projected into the environment by the projector as a first line.

4. The method according to claim 3, further comprising the following procedural steps:

Detecting a position and/or an orientation of the piece of sports equipment in the reference system at least during one period of time when the sports equipment is moving;

Generating a second virtual trajectory model of the piece of sports equipment in the at least one section of the environment on the basis of an actual trajectory of the piece of sports equipment; and

Reproducing the second virtual trajectory model as a second line in the environment.

5. The method according to claim 3 or 4, wherein to generate the first and/or second virtual trajectory model, an alignment and/or an orientation of the projector is additionally taken into account, wherein to determine the alignment and/or orientation of the projector, an actual position of at least one object with a known position, in particular an object in the close vicinity of the projector, is aligned with the projected position of the at least one object and/or an actual position of the at least one object is detected and aligned with a position in the reference system.

6. The method according to one of claims 3 to 5, wherein at least one intrinsic projector parameter, in particular a projection matrix of the projector, is factored in.

7. The method according to one of the preceding claims, wherein the calculated trajectory of the ball is used to calculate the calculated trajectory of a club.

8. The method according to one of the preceding claims, wherein the first trajectory model represents the calculated trajectory of the ball and/or a theoretical trajectory in a flat topography with the starting direction of the calculated trajectory.

9. The method according to one of the preceding claims, further comprising the following procedural step:
Utilizing the reference system in calculating a first virtual chronological sequence of a position of the piece of sports equipment on the calculated trajectory as a function of the start position, the target position and the at least one environmental parameter, wherein the first virtual chronological sequence of the position of the piece of sports equipment is displayed when the first virtual trajectory model is reproduced.

10. The method according to one of claims 2 or 4 to 9, further comprising the following procedural step:
Calculating a second virtual chronological sequence of a position of the piece of sports equipment in the second virtual trajectory model on the basis of the actual trajectory of the piece of sports equipment, wherein the second virtual chronological sequence of the position of the sports equipment is displayed when the second virtual trajectory model is reproduced.

11. The method according to claim 9 or 10, wherein the first virtual chronological sequence is synchronized to the actual chronological

sequence and/or the second virtual chronological sequence relative to a point in time at which the ball is struck.

12. The method according to one of claims 9 to 11, wherein the display of the first virtual chronological sequence and/or a second virtual chronological sequence occurs in real time.

13. The method according to one of claims 9 to 12, wherein the displaying of the first virtual chronological sequence and/or a second virtual chronological sequence is implemented by a forming of the first line or the second line respectively and/or by a characterization, in particular a schematic illustration of the piece of sports equipment.

14. The method according to one of the preceding claims, wherein a defined standing position for a player is additionally indicated during reproduction, in particular by a third line.

15. The method according to one of the preceding claims, wherein the method is in each case realized, particularly in parallel and/or simultaneously, for the club as the first piece of sports equipment and the ball as the second piece of sports equipment.

16. The method according to one of the preceding claims, wherein the first virtual trajectory model and/or the second virtual trajectory model for a club additionally factors in at least one orientation of the club.

17. The method according to claim 16, wherein a deviation in the position and/or orientation of the club from the ideal trajectory is depicted during reproduction, in particular prior to the point of impact, in particular by means of an arrow.

18. The method according to one of the preceding claims, further comprising the following procedural step:
Filming the field of view, wherein the filmed field of view is reproduced as the visible section of the environment.

19. The method according to one of the preceding claims, further comprising the following procedural steps:
Detecting a position and/or orientation of the piece of sports equipment in the reference system at least during one period of time when the sports equipment is moving;
Determining an actual trajectory of the piece of sports equipment on the basis of the data collected; and
Comparing an actual trajectory to the calculated trajectory; and
wherein the first and/or second virtual trajectory model is additionally dependent on the degree of concurrence between the actual trajectory and the calculated trajectory as determined in the comparison.

20. The method according to one of the preceding claims, further comprising the following procedural steps:
Detecting a position and/or orientation of the piece of sports equipment in the reference system at least during one period of time when the sports equipment is moving;
Displaying an actual trajectory of the piece of sports equipment based on the data collected; and
Comparing an actual trajectory to the calculated trajectory; and
Adapting a training method based on the degree of concurrence between the actual trajectory to the calculated trajectory as determined in the comparison.

21. The method according to one of the preceding claims, wherein the at least one environmental parameter is metrologically recorded by means of a scanning apparatus and/or a tracking module, in particular by means of a sensor, preferably via a camera of a head-mounted display, and/or determined from another metrologically recorded parameter.

22. The method according to one of the preceding claims, wherein the at least one environmental parameter, in particular the topographical parameter, preferably a 3D grid used in the generating of the virtual trajectory model, is corrected on the basis of a position determination of a single object, in particular the ball, from two different perspectives at least in the surroundings of the object.

23. The method (according to one of the preceding claims, further comprising the following procedural steps:
Detecting a position of the ball in the reference system at least during one period of time when the ball is moving;
Displaying an actual trajectory of the ball on the basis of the data collected; and
Correcting the at least one environmental parameter based on the actual trajectory.

24. A computer program comprising commands which, when run on a computer, cause same to execute a method in accordance with one of the preceding claims.

25. A computer-readable storage medium on which a computer program in accordance with claim 24 is stored.

26. A system for analyzing the movement of at least one piece of sports equipment of a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, comprising:

a display device, in particular a head-mounted display, arranged to generate an augmented reality;

a tracking module, arranged to detect a start position of a ball of the type of ball sport and a defined target position for the ball, in particular a golf hole, in a reference system and to detect a position and/or orientation of the display device in the reference system;

a data interface or a scanning apparatus arranged to detect at least one environmental parameter in the reference system, in particular a topographical parameter, which at least partially characterizes an environment, in particular a playing field, within an area between the start position and the target position; and

a processing unit arranged to utilize the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter in order to calculate a field of view of the display device in the reference system on the basis of the detected position and/or orientation of the display device and to generate a first virtual trajectory model of the piece of sports equipment for the field of view based on the calculated trajectory of the at least one piece of sports equipment, and

wherein the display device is configured so as to display the first virtual trajectory model as a first line in superimposition with at least one section of the environment, particularly one which is visible in reality, particularly when the field of view is directed toward the at least one section of the environment.

27. The system according to claim 26, wherein the tracking module utilizes inside-out tracking starting from the display device and the system preferably further comprises at least one marker arranged to be positioned in the environment as a reference point for the inside-out tracking.

28. The system according to claim 26 or 27, wherein the display device comprises a camera and the tracking module utilizes at least optical tracking.

29. A system for analyzing the movement of at least one piece of sports equipment for a type of ball sport, in particular a racket, preferably a golf club, or a ball, preferably a golf ball, comprising:
a projector arranged to generate projections of at least one playing field;
a data interface or scanning apparatus arranged to detect in a reference system the position of the projector, a defined start position and a defined target position for the ball of the type of ball sport, in particular a golf hole, and at least one environmental parameter, in particular a topographical parameter, which at least partially characterizes the playing field within an area between the start position and the target position; and
a processing unit arranged to utilize the reference system in calculating an in particular ideal trajectory of the at least one piece of sports equipment based on the start position of the ball, the target position of the ball and the at least one environmental parameter, and to generate a first virtual trajectory model of the at least one piece of sports equipment in at least one section of the environment on the basis of the calculated trajectory of the ball,
wherein the projector is arranged to project the start position of the ball and the first virtual trajectory model onto the playing field as a first line.

30. The system for analyzing movement according to claim 29 further comprising:

a user interface arranged to detect a start position of the ball of the type of ball sport in a reference system, in particular by means of input by a user.

31. The system according to one of claims 26 to 30, wherein the tracking module is further arranged to determine an actual position of the piece of sports equipment and/or wherein the system further comprises a radiolocation device in order to determine an actual position and/or an actual trajectory of the piece of sports equipment, and wherein the projector or the display device is preferably further arranged to display the actual position and/or actual trajectory of the piece of sports equipment.

32. The system according to one of claims 26 to 31, wherein the display device further comprises at least one accelerometer and one gyrosensor in order to measure movement in six degrees of freedom and wherein the processing unit is further arranged to determine, by means of coupling, an actual position and/or orientation of the display device based on a position and/or orientation of the display device determined by the tracking module.