Title: MOTION COACHING DEVICE, METHOD AND SYSTEM

Abstract: The present invention relates to a motion coaching device, method and system using subject-specific motion data to generate images of a motion for a user to emulate. The user's motion (204) is captured using a video camera and is displayed on a display device (200). The images of a motion (202) that are generated from subject-specific motion data are also displayed on the display device (200). By observing the images (202) that are displayed and by emulating the motion of the images (202), a user is able to coach itself according to the motion.
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FIELD OF THE INVENTION

The present invention relates to motion coaching. In particular, but not exclusively, the present invention relates to a motion coaching device, method and system using three-dimensional subject-specific motion data or ideal motion data.

BACKGROUND TO THE INVENTION

There are many aspects of human life that require the learning and perfecting of a motion. For example, in sports such as golf and baseball, it is common for players to train to perfect specific swinging motions to improve their game. The key to improving and perfecting a motion lies in the correct practice of that motion. For this reason, users seeking to perfect a motion often resort to a human trainer to teach the motion to the user and to correct the user when the user carries out the motion incorrectly.

As an alternative or as an addition to a human trainer, various training tools have been proposed to allow a user to perfect a motion through a visual system that provides overlays by superimposing two recorded video representations of the same activity. For example, Katayama in US Patent 5,947,742 proposed taking video images of a trainer and trainee separately using a video camera and later displaying the video images on a screen to allow the trainee to compare its movements to the movements of the trainer. These visual systems are difficult to use and to calibrate due to the different sizes and positions of the images. Furthermore, synchronising the recorded images of an instructor and student to proceed through the motion at the same pace is very difficult. Other systems like US Patent 5,249,967 use static images, which allow a user to only exercise the precision of position but not pace. In addition, several of these prior art motions embody one person's subjective interpretation of what motion is ideal and adjust the images of the ideal motion to students of varying size which creates an unnatural and incorrect distortion of the real motion.

Burns in US Patent 6,126,449 proposed a standardised technique to practice a selected motion through comparison against a motion template consisting of stored images of a
moving top performer of the motion having the same gender and approximately the same age and body type as the student. While this maintains the real motion, it results in a variety of different motions which may or may not suit a particular student—since every top performer has a technique—which he or she uses personally to achieve their level of proficiency adapted to his or her specific personal characteristics.

Kim et al. in US Patent 6,554,706 proposed the use of original motion data for a motion game apparatus. The original motion data, which is originally captured from a performer with a nominal body size, is used to generate a main character on a screen for a player to emulate. The player is provided with markers and its motions are tracked. The tracked motions (which are in x, y, z coordinates of markers) are then compared with re-targeted motion data, which is motion data that has been uniformly scaled to suit a user's height (which is in x, y, z coordinates of where the markers should be). The arrangement of Kim et al., which may be suitable for a simple gaming apparatus, is however not suitable for motion coaching. Firstly, there is no visual representation of the player's motion that would assist it in emulating the main character in Kim et al. Also, the uniform scaling of Kim et al. may result in motion that is unnatural, distorted and which do not reflect variations in the human population.

Thus, a need exists for a simple, inexpensive and easy-to-use motion coaching device, method and system which allow the student, with or without an instructor, to learn and practice a selected motion by emulating an execution of the motion that has been adjusted to the student's needs.

In this specification, where reference has been made to patent specifications, other external documents, or other sources of information, this is generally for the purpose of providing a context for discussing the features of the present invention. Unless specifically stated otherwise, reference to such external documents or sources of information is not to be construed as an admission that such documents or sources of information in any jurisdiction are prior art, or form part of the common general knowledge in the art.
SUMMARY OF THE INVENTION

In a first aspect, the present invention broadly relates to a motion coaching device comprising:
- a display device;
- one or more video cameras to capture images of a user's motion; and
- a processor to display on the display device images of a motion based on subject-specific motion data, and to display images of the user's motion such that the user is able to emulate the motion based on the subject-specific motion data.

The term 'motion data' as used in this specification refers to data that represents motion as three-dimensional position and orientation data of human body segments. Data that represents a motion as three-dimensional position and orientation data of human body segments may be obtained using one or more or a combination of motion capture, computer simulation and manual entry techniques, for example.

The term 'subject-specific motion data' as used in this specification refers to motion data that has been modified to take into account a subject's physical characteristics. For instance, the motion data may be scaled to suit a subject's physical dimensions and/or modified to take into account the subject's physical limitations.

The term 'images of a motion based on subject-specific motion data' refers to two-dimensional or three-dimensional visualisations containing colour and/or transparency that are either: (i) rendered directly from subject-specific motion data or (ii) rendered indirectly from other data that is based on subject-specific motion data.

The term 'comprising' as used in this specification means 'consisting at least in part of', that is to say when interpreting statements in this specification which include that term, the features, prefaced by that term in each statement, all need to be present but other features can also be present.

Preferably, a sequence of images rendered from the subject-specific motion data provides an animation performing the motion. In one form, the animation is a stick figure representation of a human performing the motion. In another form, the animation is an
outline representation of a human performing the motion. In another form, the animation is a full body representation of a human character performing the motion.

Preferably, the images of the motion are overlaid on the images of the user's motion.

Preferably, the prominence of one or more selected portions of the animation changes depending on the importance of the user emulating the motion at the one or more selected portions. In one form, the colour of the one or more selected portion changes depending on the importance of the user emulating the motion at the one or more selected portions.

Preferably, the motion data is continuous in time, allowing the processor to display images of the motion at an arbitrary frame rate, resolution and smoothness.

Preferably, the device is arranged to receive subject-specific information. In one form, the device is connectable to a network to download the subject-specific information. In another form, the device is arranged to retrieve subject-specific information from a portable storage device presented by the user. Non-limiting examples of the portable storage device include a magnetic card, a radio frequency identification (RFID) card, a smart card and a solid-state memory device.

Preferably, the processor anthropometrically scales stored motion data to suit the user's personal characteristics as determined from the subject-specific information. The personal characteristics may be one or more of: height, gender, race, age, weight or volume.

Preferably, the processor manipulates stored motion data such that the images of the motion show a motion that is limited in some way to take into account the user's one or more physical limitations. In a preferred form, the processor manipulates the motion data to take into account the user's one or more physical limitations after anthropometrically scaling the motion data. The user's one or more physical limitations include limited flexibility in joints, such as limited flexibility in the user's pelvis, shoulder and spine, and limited strength.

Preferably, the processor generates the images of the motion from a point of view selected by the processor or selected by the user.
Preferably, the device includes one or more video cameras to image different views of the user. In this form, the processor preferably generates the images of the motion to correspond to one or more views displayed to the user.

Preferably, the device includes a navigation tool. Where the device is used for sport motion coaching, the navigation tool is preferably provided with one central button and at least four buttons surrounding the central button, with the buttons being sized to be depressible using an implement that is used in executing the sport motion. In a preferred form, the implement is a golf club.

Preferably, the subject-specific motion data is ideal motion data.

The term 'ideal motion data' as used in this specification refers to subject-specific motion data that has been manipulated such that the motion being represented accords with a specified ideal execution of the motion. For example, once the subject-specific motion data is obtained, it is manipulated, either manually or automatically, to accord with a specified ideal execution of the motion. Alternatively, motion data may be first manipulated to accord with a specified ideal execution of the motion before the motion data is made subject-specific.

In a second aspect, the present invention broadly relates to a motion coaching method comprising:

- displaying images of a motion based on subject-specific motion data on a display;
- imaging the motion of a user; and
- displaying the motion of the user on the display to allow the user to compare the motion of the user with the images of the subject-specific motion based on the motion data.

The term 'images of a motion based on subject-specific motion data' refers to two-dimensional or three-dimensional visualisations that are either: (i) rendered directly from subject-specific motion data or (ii) rendered indirectly from other data that is based on subject-specific motion data.
In a third aspect, the present invention broadly relates to a motion coaching method comprising allowing a user to compare images of the user performing a motion with images based on ideal motion data that are displayed on a display device as the user performs the motion.

In a fourth aspect, the present invention broadly relates to a motion coaching method comprising the steps of:

- overlaying images of a motion based on ideal motion data on images of a user performing a motion; and
- displaying the overlaid images on a display device for the user.

The term 'images of a motion based on ideal motion data' refers to two-dimensional or three-dimensional visualisations that are either: (i) rendered directly from ideal motion data or (ii) rendered indirectly from other data that is based on ideal motion data.

Preferably, the step of generating images comprises generating sequential images of an animation performing the ideal motion. In one form, the animation is a stick figure representation of a human performing the ideal motion. In another form, the animation is an outline representation of a human performing the ideal motion. In another form, the animation is a partial representation or a full body representation of a human character performing the motion.

Preferably, the step of displaying the images comprises overlaying the images of the motion on the images of the user's motion.

Preferably, the method further comprises the step of changing the prominence of one or more selected portions of the animation depending on the importance of the user emulating the motion at the one or more selected portions. In one form, the colour of the one or more selected portions changes depending on the importance of the user emulating the motion at the one or more selected portions.

Preferably, the method further comprises the step of displaying images of the motion at an arbitrary frame rate, resolution and smoothness.
Preferably, the method further comprises the step of generating the subject-specific motion data by anthropometrically scaling motion data to suit the user's personal characteristics. The personal characteristics may be one or more of: height, gender, race, age, weight or volume.

Preferably, the method further comprises the step of generating the subject-specific motion data by manipulating motion data such that the images of the motion show a motion that is limited in some way to take into account the user's one or more physical limitations. In a preferred form, the manipulating step comprises manipulating the motion data that has been anthropometrically scaled. The user's one or more physical limitations include limited flexibility in the user's shoulder, limited flexibility in the user's spine and limited strength.

Preferably, the step of displaying the images comprises displaying the images of the motion from a single or multiple points of view selected by the processor or selected by the user.

Preferably, the step of imaging the motion of a user comprises imaging different views of the motion of the user using one or more video cameras. In this form, the step of generating images of a motion comprises generating the images of the motion to correspond to one or more views displayed to the user.

Preferably, the method further comprises one or more video, image, text and audio data for guiding the user through the correct positions of the motion.

In a fifth aspect, the present invention broadly relates to a motion coaching system comprising:

- a display device;
- one or more video cameras to capture images of a user's motion; and
- a processor to display on the display device images of a motion based at least partly on subject-specific motion data, and to display images of the user's motion such that the user is able to emulate the motion.

In a sixth aspect, the present invention broadly relates to a sport motion coaching device comprising:

- a display device;
one or more video cameras to capture images of a user's motion;

a navigation tool having one central button and at least four buttons surrounding
the central button, the buttons being sized to be depressible using an implement that is
used in executing the sport motion; and

a processor to display images of a motion and to display images of the user's
motion based on commands received from the user via the navigation tool.

Preferably, the implement is a golf club. Preferably, the motion is an ideal sport motion.

In a seventh aspect, the present invention broadly relates to a method of providing a
competition comprising:

displaying a motion generated from subject-specific motion data;
imaging one or more users performing a motion such that the one or more users
may emulate the motion generated;

providing an indication as to the accuracy of the one or more users in emulating
the motion generated.
BRIEF DESCRIPTION OF THE FIGURES

Preferred forms of the device, method and system will now be described with reference to the accompanying figures in which:

Figure 1 shows schematically one form of the device of the present invention;

Figures 2A-2C show schematically the images shown to the user of the device of Figure 1;

Figure 3 shows schematically another form of the device of the present invention;

Figures 4A-4C show images of a motion generated from subject-specific motion data that takes into account a user's physical dimensions;

Figures 5A-5D show images of a motion generated from subject-specific motion data that takes into account a user's physical limitations;

Figure 6 shows example rules specified for an ideal golf swing for use in the present invention;

Figure 7 shows schematically images of a motion based on interpolated ideal motion data;

Figure 8 shows an example user interface for the present invention; and

Figures 9A and 9B show schematically the images shown on the user interface.
DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

The Device

Referring to Figure 1, one form of the motion coaching device of the present invention is shown generally as 100. The device 100 includes a display device 102, such as a conventional cathode ray tube (CRT) display, liquid crystal display (LCD) or any form of touch screen display, for example. The device 100 also includes a video camera 104 that is arranged to capture images of a user 105 performing a motion, a storage device 106 and a processor 108. The storage device 106 and the processor 108 may be located inside a housing 110. Skilled persons will appreciate that the arrangement described above is not essential, and the components described can be arranged individually or in separate combinations, and be connected to each other as required.

The storage device 106 is arranged to store, amongst others, motion data. In one form, the storage device 106 stores subject-specific motion data and/or ideal motion data. In another form, the subject-specific motion data and/or ideal motion data is generated from the motion data when the device is in use. The generation and manipulation of the subject-specific motion data and ideal motion data will be described in greater detail later in this specification. It should be noted that the storage device 106 does not need to be a dedicated motion data storage device. Where the device is implemented in a network, it is possible for the motion data to be stored or processed remotely from the device. In this form, the device only requires to receive and display motion data from a remote network.

The processor 108 is arranged to display on the display device 102 images of a motion. The images of the motion may be generated by the processor 108 based on the subject-specific motion data stored in the storage device 106, and are displayed to allow the user to emulate the motion. Example ways in which the images can be displayed include overlaying the images of the motion on the images of the user's motion (or vice versa), and displaying the images side-by-side in a synchronised fashion.

Referring to Figure 2A, example forms of the images are shown displayed on a display 200. An image of the motion is shown as 202 and may form one of a number of sequential images of an animation performing the motion. In the illustrated form, the animation 202
is a stick figure representation of a human performing the motion. Skilled persons will appreciate that other representations may be used instead. For example, the animation may be an outline representation or a realistic representation of a human (or other character) performing the motion. Also, the animation may be a partial representation (e.g. only of the arms) or a full representation of the motion. The images of the animation 202 in the form shown are overlaid on the images of the user's motion 204. Depending on how the animation 202 is displayed, it may also be possible to overlay images of the user's motion 204 on the images of the animation 202.

In use, the animation 202 is played to show the user the motion. The user then executes the motion while keeping an eye on the display so as to match its execution with the displayed motion. By repeating this process, the user is able to spot its deviations from the displayed motion, correct such deviations and eventually develop muscle memory to emulate the motion.

To assist the user in identifying particularly important poses or points in the motion, the prominence of one or more selected portions of the images of the motion are changed. For example, during the downswing stage of a golf swing, it is important for the user's left arm to remain straight. Referring to Figure 2B, the line representing the left arm has been thickened to highlight to the user the importance of emulating that line closely. As an alternative or in addition to thickening the line, the colour and/or transparency of the relevant parts of the animation can be changed, or one or more of video, image, text and audio data may be presented for guiding the user through the correct positions.

Where the execution of the motion is unclear from the view being displayed, the present invention allows the user to change the point of view from which the motion is viewed. This is done by manipulating the point of view from which images of the motion are calculated and generating a new sequence of images from the subject-specific motion data. Referring to Figure 2C, the angle of the stick figure animation has been rotated by the user to allow the user to view the motion from the side.

It should be noted that the arrangement of information on the display as illustrated in Figures 2A-2C has been provided in a schematic form. One example arrangement and
function of the information on the display, also known as the user interface, will be described in further detail later in this specification.

A further form of the device of the present invention is shown generally as 300 in Figure 3. The device 300 includes an LCD display 302, three video cameras 304a, 304b, 304c that are arranged to capture different views of a user 303 performing a motion, a navigation tool 305, a storage device 306 and a processor 308. In this form, the LCD display 302, one video camera 304a, the navigation tool 305, the storage device 306 and the processor 308 are located in a single housing 310. The remaining two video cameras are located in individual housings 312 and 314.

The use of more than one camera gives the user the option of viewing the motion from more than one point of view at any one time. Coupled with the ability of the present invention to manipulate the subject-specific motion data to generate images of the motion from any point of view, the form of the present invention illustrated in Figure 3 allows the user to emulate the execution of the motion from more than one point of view at the same time. The ability of display and emulate from different views will be described in detail later in this specification with reference to Figures 8, 9A and 9B.

Referring back to Figure 3, the device 300 also includes one or more ports 316 to receive subject-specific information from a portable storage device presented by the user. The subject-specific information may be one or more of the user's: name, physical characteristics (e.g. physical dimensions and physical limitations), performance history, preferences and billing information such as a prepaid account or credit card details. The port 316 may be, for example, a USB port to receive a solid-state memory device. Alternatively, the port 316 may be operatively connected to a reader to read a magnetic card, a radio frequency identification (RFID) card, a smart card or the like. In embodiments where a central database is provided with required information, which may include subject-specific information, the device 300 may be made connectable to a network to download the information from the central database.

Subject-specific information, where required or desired, is supplied to and used by the device of the present invention to tailor the coaching for the user. In particular, the
coaching can be customised to reflect the user's physical characteristics, such as the physical dimensions or physical limitations of the user.

Physical dimensions of the user may be taken into account to generate the subject-specific motion data from motion data that is typically representative of a motion for a user having specific physical dimensions. For instance, the motion data may be representative of a swing for a golfer with a height of 6' 1". In this case, when a golfer with a height of 5' 5" wishes to use the coaching device, the processor of the present invention uses the subject-specific information to anthropometrically scale the motion data based on anthropometric data that can be measured (e.g. forearm length etc.) by a coach or from the captured images of a user's motion or taken from a database. Anthropometric scaling is scaling that takes into account physical variations of the human body. That is to say, the scaling of the swing for a 5' 5" golfer in the example above is not simply 5' 5"/6' 1" or 0.89. Instead, the scaling varies depending on the part of the swing being scaled. The benefit of anthropometric scaling is that the swing can be tailored not only to take into account different heights, but any anthropometrically-measurable attribute. For instance, there may be scaling to take into account anthropometric differences based on gender, race, age, height, weight or volume of the user. One example way in which anthropometric scaling is done in the present invention will be described in greater detail later in this specification.

Physical limitations of the user may be taken into account to generate the subject-specific motion data from motion data that is typically representative of a user having a specific physical ability, such as above- or below-average strength or flexibility. For instance, when a golfer having limited flexibility (e.g. limited joint flexibility) uses the device of the present invention, the swing is scaled down in terms of its range of motion. Where the golfer has limited spinal flexibility, the swing may be scaled to have a shorter backswing. Similar limitations may be provided for users having limitations in terms of shoulder flexibility and strength.

It will be appreciated that the subject-specific motion data need not be generated every time the device is used. In one form, the device is arranged to store the subject-specific motion data for a user once it generated. When the device is used again by this user at a later time, the subject-specific motion data is simply retrieved from storage (which may be local or remote). The storage may be the storage device 306 in Figure 3, a remote storage
device on a network, or a portable storage device that is presented by the user at the port 316 in Figure 3.

In an example embodiment, the processor is adapted to log a user's activity and/or track a user's progress by capturing images or video sequences at the beginning and throughout the motion coaching process. The images or video sequences captured may be stored on the storage device 306, a remote storage device on a network, or a portable storage device that is presented by the user at the port 316. This allows the device to identify the user that is using the device and also may allow the device to learn about a user's usage and activity on the device, which may then be used to customise the coaching experience for the user. The captured images or video sequences may also be used for comparison to the ideal motion and explanation and illustration of coaching concepts.

Subject-Specific Motion Data - Physical Dimensions

As noted earlier, the present invention allows a user's physical dimensions to be taken into account in customising the motion that is displayed to the user. This is made possible given the present invention's ability to manipulate motion data and generate images of the motion dynamically based on the modified motion data. As noted earlier, motion data typically represents the motion for a specified body dimension. For instance, where motion data is obtained by motion-capturing the golf swing of a golf professional having a height of 6'2", it is generally only suitable for users having similar height. Where the motion data is manipulated to fit the rules specified for a golf swing, the manipulated motion data would also generally be suitable only for users having similar height. To adapt such motion for users having differing physical dimensions, the present invention allows the motion data to be anthropometrically scaled to produce subject-specific motion data.

Anthropometric scaling as applied to a golf swing will now be specifically described with reference to Figures 4A-4C. Skilled persons will appreciate that similar scaling can be done for coaching other motion data. In the figures, the golf swing is displayed using a stick figure 400 rendered from motion data. For ease of reference, the path of the golf swing is shown by way of a trajectory 402, which represents the trajectory of the rendered golf club head. While displaying the trajectory 402 can assist a user in emulating the swing, it is not
essential as the user will be able to emulate the motion by emulating the motion of the stick figure 400.

As can be seen in the figures, the stick figure 400 and the swing has specific physical dimensions. These dimensions are the result of rendering motion data in its default (i.e. not subject-specific) form. Given the specific dimensions, the stick figure 400 and the swing displayed will suit only specific users, such as male golfer A.

The stick figure 400 and the swing displayed may not be ideal for male golfer B, who is not as tall as male golfer A. To tailor the swing to male golfer B, the present invention allows the motion data representing the swing to be anthropometrically scaled to produce subject-specific motion data. The subject-specific motion data is then rendered as stick figure 404, as shown in Figure 4A. The resulting scaled swing can be seen by way of trajectory 406. In this form, the anthropometric scaling performed on the motion data is specific to the height difference between male golfer A and male golfer B.

The stick figure 400 and the swing displayed may also not be ideal for female golfer C, who has an overall body size that is smaller than male golfer A. To tailor the swing to female golfer C, the present invention allows the motion data representing the swing to be anthropometrically scaled to produce subject-specific motion data. The subject-specific motion data is then rendered as stick figure 408, as shown in Figure 4B. The resulting scaled swing can be seen by way of trajectory 407. In this form, the anthropometric scaling performed on the motion data is specific to differences in body proportion between male golfer A and female golfer C.

The stick figure 400 and the swing displayed may also not be ideal for male golfer D, who has a smaller body size as compared to male golfer A. Male golfer D may be, for instance, a younger golfer as compared to male golfer A. To tailor the swing to male golfer D, the present invention allows the motion data representing the swing to be anthropometrically scaled to produce subject-specific motion data. The subject-specific motion data is then rendered as stick figure 410, as shown in Figure 4C. The resulting scaled swing can be seen by way of trajectory 412. In this form, the scaling performed on the motion data is specific to the differences in body proportion between male golfer A and male golfer D.
To carry out the anthropometric scaling, the present invention recognises that motion consists of a co-ordinated interaction of all body parts. This translates to a specific temporal and spatial interaction of segments represented by motion data. To maintain this co-ordinated interaction, the present invention maintains regional and global constraints when scaling the motion data. These constraints also include using an implement for executing the sport motion of similar or identical size for users with a variety of physical dimensions and limitations while maintaining a natural and undistorted motion.

The scaling comprises a two-step process: (1) maintaining regional constraints/features and (2) maintaining the overall co-ordinated interaction of all body parts. In the first step, regional features such as knee flexion or elbow extension are maintained using local geometrical constraints in order to retain a relative orientation of body segments. This first step is required to alter the lengths of each segment to fit the user's physical dimensions. The application of kinematic constraints alone, however, will not preserve the correct pose and movement of the motion data when applied to a scaled kinematic chain. Therefore, in the second step, the local changes/adjustments are refined using a least-squares optimisation process with adjustable weighting factors to maintain a co-ordinated and achievable motion that is representative of the motion data. Weighting factors are introduced to enable different objective criteria to be met when producing the co-ordinated movement. These criteria may depend upon other factors, such as physical limitations.

**Subject-Specific Motion Data - Physical Limitations**

As an alternative or an addition to generating subject-specific motion data to take into account a user's physical dimensions, the present invention also allows subject-specific motion data to take into account a user's physical limitations. Motion data typically represents the motion when executed by a user who is at a certain level of physical fitness. Where a user seeking coaching is not of the same level of physical fitness, it can be both difficult and frustrating for the user to emulate the motion displayed. The present invention may address this by limiting in some way the motion that is displayed.

One example physical limitation may be limited flexibility. For instance, the user may be a golfer who has limited spinal flexibility. With this physical limitation, the golfer will not be physically able to move the golf club as far back during the backswing stage as normally
required. It is therefore appropriate for the motion data to be manipulated such that the motion displayed has a shorter backswing. Referring to Figure 5A, a golf swing is represented in part as the trajectory 500 of a golf club held by a stick figure 502. The stick figure 502, its poses and movements throughout the swing are rendered from motion data. To take into account a golfer with limited spinal flexibility, the motion data may be manipulated or customised to produce subject-specific motion data that results in the top $T$ of the backswing being reduced to the point $T'$ in Figure 5B. The stick figure 504 of Figure 5B, its poses and movements throughout the swing are thus rendered from such a subject-specific motion data. It should be noted that the exact points of $T$ and $T'$ in the figures will vary depending on the motion data used and the extent to which the user's flexibility is limited. The difference between the motion of Figure 5A and the subject-specific motion of Figure 5B can be seen in Figures 5C and 5D. As compared to the extent of the backswing of the ideal motion in Figure 5C, shown by the stick figure 506, the extent of the backswing of the subject-specific motion in Figure 5D, shown by the stick figure 508, is clearly reduced to take into account a golfer's limited flexibility.

In one form, to produce the subject-specific motion data, the present invention manipulates motion data representing continuous trajectories of individual joints to take into account a user's limited flexibility. While each trajectory defines the positional information of joints, the positional change between adjacent or consecutive joints/segments as defined by the kinematic chain dictates the flexibility necessary to execute the ideal motion. By manipulating the motion data as to refine the positional change, the flexibility required for the ideal motion can be adapted for the user.

Two example scenarios where the present invention may manipulate the motion data to suit a user's flexibility are: (1) one or more poses cannot be achieved at all by the user, or (2) one or more poses can only be achieved by the user through compensation by additional movement through other joints/segments. In the first scenario, the present invention manipulates the motion data to re-define the one or more poses based on a user's flexibility. In the second scenario, local and global changes are applied to achieve a pose comparable to the original pose but one which is suitable for the user. Local changes relate to adjustments of the range of flexibility between consecutive joints/segments to meet a user's range of flexibility, while global changes refine the motion data to preserve the co-ordination of the motion through a weighted least-squares optimisation. Basic
flexibility is assessed by standing in maximum poses, such as maximum left and right spine rotation, and measurement taken by a coach or from the captured images of a user's motion.

Ideal Motion Data

As described above, the user emulates images that are based on subject-specific motion data. In one form, the subject-specific motion data may be ideal motion data. As noted earlier, ideal motion data refers to subject-specific motion data that has been manipulated such that the motion being represented accords with a specified ideal execution of the motion. For example, once the subject-specific motion data is obtained from motion data, the subject-specific motion data is manipulated, either manually or automatically, to accord with a specified ideal execution of the motion. In some embodiments, it may be desired or required for the motion data to be first manipulated to accord with a specified ideal execution of the motion before the motion data is made subject-specific. Taking the sport of golf as a non-limiting example, the ideal motion data may represent the ideal golf swing. The ideal motion data in this case is obtained by: (i) representing a golf swing in three dimensions to produce motion data, (ii) scaling and/or modifying the motion data to produce subject-specific motion data and (iii) manipulating the subject-specific motion data in accordance with rules that define the ideal golf swing. Where necessary or desired, step (ii) may be carried out after step (iii). As step (ii) has been described in detail above, steps (i) and (iii) will now be described in detail below.

Representing a Golf Swing in Three Dimensions

To create data representing the ideal golf swing, one example embodiment of the method provides motion-capturing the execution of a golf swing to produce motion data representing a golf swing in three dimensions, and manipulating the motion data so that the motion captured accords with specified rules. It is, however, not essential for the above two steps to be carried out to obtain ideal motion data. For instance, instead of motion-capturing the execution of a golf swing in the first step, a computer-generated swing may be used. Alternatively, data representing the golf swing may be manually or automatically input into a computer in the first step. Further, using a suitable computer program, the first and second steps may be combined together.
Similar considerations apply for other motions that may be studied by a user. For example, in ballet, there are ideal poses for a dancer to adhere to. In the Cecchetti method, for instance, five principle poses are defined for the dancer's arms, with each pose having a specific relationship with the dancer's body. Such principles define the rules and criteria for the ideal motion.

In one form, the motion data comprises continuous three-dimensional positional information for each relevant human joint as functions of time. The three-dimensional positional information is represented by continuous functions of time using, for example, cubic B-splines. The continuous functions of time are either specified directly or obtained through curve-fitting a continuous function to discrete data-in the form above, specific pairs of joints form individual body segments. For example, the joints of the right knee and the right ankle form the right shank. The set of joints therefore define the body segments to form an articulated skeleton or kinematic chain. This kinematic chain uniquely defines a pose throughout the motion for every instance in time.

In addition, the above form motion data contains orientation frames that comprise mutually perpendicular orientation vectors that define a segment's rotational orientation. A set of continuous functions defining positional and rotational information exists for each joint or segment. These functions allow the forming of trajectories of joint positions and segment rotations throughout the motion and allow the calculation of the three-dimensional pose (articulation) for the kinematic chain for every point in time during the motion.

*Manipulating the Motion Data*

Once data representing the golf swing in three dimensions (i.e. motion data) is available, the data is manipulated to meet one or more rules or criteria specifying an ideal golf swing. Skilled persons will appreciate that the motion data may be first manipulated to make it subject-specific before manipulating to meet rules or criteria of the motion.
There are many rules available that define the ideal golf swing, most of which rely on the
golf swing following certain lines, angles, planes or boundaries. In one form, the ideal golf
swing can be decomposed into a finite number of poses (articulations). As a non-limiting
example, the golf swing can be decomposed into ten poses as shown in Figure 6. The ten
poses each require areas of a user's body or golf club to be in a fixed relationship with
other areas of a user's body or with one or more reference lines. These relationships can
be described mathematically, with the relevant areas of the user's body being represented
by points in space.

Where the above form motion data is used, which includes continuous functions defining
positional and rotational information for each joint/segment, and where the functions
allow trajectories of joint positions and segment rotations to be formed throughout the
motion, the motion being represented can be manipulated to suit certain constraints by
manipulating the trajectory of the joint positions and/or segment rotations. This may be
done by manipulating the underlying B-splines (trajectories) through changes of the control
vertices. These changes can be performed manually, automatically through mathematical
optimisation, or a combination of both.

Once the data is manipulated to meet the specified rules of the ideal motion, it is desirable
to maintain the data as continuous functions to display images of poses in the ideal motion
at an arbitrary desirable frame rate, resolution and smoothness. For example, referring to
Figure 7, ideal motion data has been used to generate two sequential images 700 and 702,
representing part of the downswing stage of a golf swing. To increase the frame rate and
produce a smoother transition between the two images, the present invention allows the
ideal motion data to be displayed at infinite smoothness meaning that additional images
between the two previous sequential images can be shown. In the form illustrated, the
ideal golf club line in the first image 700 is labelled A, while the ideal golf club line in the
second image 702 is labelled B, and between lines A and B, the present invention processes
the ideal motion data to produce two further golf club lines A1 and A2. Although not
shown in the figure, the process may also produce corresponding points and lines for the
remaining portions of the motion (e.g. the golfer's hands, body and legs).

In the form noted earlier, where motion data is represented in the form of continuous
functions of time (e.g. using cubic B-splines), the arbitrary smoothness described above can
be obtained by calculating the positional information for joint centres and the corresponding segment orientation for every instance in time.

Additionally the ideal motion data may be further extended to include knowledge or information relating to the ideal motion. This is done to produce enriched ideal motion data. As an example, the enriched ideal motion data may include information on aspects of the ideal motion that should be highlighted during execution, or information on geometry or lines that should be added to the motion to serve as a guide for a user to emulate the ideal motion. Additionally, the enriched ideal motion data may include comments, notes or other forms of knowledge provided by a human coach (e.g. in the form of video, image, text or audio data).

The User Interface

The user interface relates to the arrangement and function of the information displayed to the user via the display device. A schematic form of the user interface is shown in Figures 2A to 2C. One example form user interface will now be described with reference to Figure 8.

In Figure 8, the user interface is shown generally as 800. The user interface 800 includes a window 802 in which a user's motion 804 and an ideal motion 806 are displayed. A view pane 808 with virtual buttons is provided for the user to select the particular view or views to be displayed. As can be seen, the user has selected the front-on view button 810. The example form user interface 800 also includes image selection buttons 812, which allow the user to view a selected image of the ideal motion. With reference to the example form rules for the ideal golf swing shown in Figure 6, ten image selection buttons 812 may be provided to correspond to the number of poses that compose the ideal golf swing. The user interface 800 may also be provided with a message bar 814, which may display preset comments or knowledge/information that is embedded in enriched ideal motion data.

Referring to Figures 9A and 9B, a schematic of the user interface of Figure 8 is shown. In particular, Figure 9A shows the displaying of a front view 902, a side view 904 and top view 906 of the user's motion 908 and the motion 910. Alternatively, as shown in Figure 9B, the display 902 may selectively display one point of view at a time. Because the present
invention generates images of the motion from motion data, and given that the motion data represents the motion in three-dimensional space (which may be continuous in time), it is possible for the present invention to generate images of the motion from any point of view at an arbitrary frame rate, resolution and smoothness. For instance, the point of view displayed may be a predetermined point of view (e.g. by the processor) or a point of view selected or requested by the user. This ability allows the present invention to generate images of the motion to correspond to the images of the user, as shown in Figure 9A. Also, this ability allows the user to check the posture or motion from another point of view or an unconventional point of view. Further, it is possible for the point of view to be continuously changed throughout the motion to create a fly-through effect.

The Navigation Tool

The navigation tool is referred to as 305 in Figure 3. As described earlier, the navigation tool functions as an input means to allow the user to navigate the user interface as described above.

In one form, the navigation tool has one central button and at least four buttons surrounding the central button. The four buttons may be arranged on a tilting outer circle that surrounds an inner circular push button. The buttons are sized to be depressible using an implement used for a sport motion, such as a golf club or a baseball bat.

Analysis and Scoring

In the above described forms, the present invention may be implemented without motion-capturing the user's motion. As such, there are no data representing the user's motion that can be compared with the motion data and thus there is no computer-based analysis of the user's motion. In this case, it will be up to the user to determine how well they emulate the motion displayed.

It may be desirable in some cases to analyse and score the user's motion against the motion displayed. To do this, the user's motion must not only be imaged, but must be recognisable and analysable using computers. One way in which the user's motion may be recognised is by motion-capturing using markers placed on the user. The markers may be
reflective, magnetic, inertia!, optical or a combination of any of these, as will be known to those skilled in the art. The user's motion may also be captured using markerless motion capture technology or using image recognition technology.

Once captured, the user's motion may be compared to the subject-specific motion data. The subject-specific motion data may be data representing an ideal motion, an earlier motion of the user or another user's motion. For instance, the processor of the device may be adapted to receive motion-captured data representing the user's motion that has been captured.

In this embodiment, the user's motion can be compared to the subject-specific motion data because the motions to be compared are represented with comparable information of the body segments throughout the motion. In one form, the subject-specific motion data contains information of the pose and movement of all relevant body segments in the motion. Motion capture will provide details of the pose and movement of a user emulating the motion. The user's captured motion can then be processed against or compared with the motion to allow a detailed comparison of joint and segments. This ideally includes the comparison of global positions against an ideal pose, and the relative positions of body segments between corresponding joint centres forming a segment as defined by the kinematic chain. Taking golf as an example, comparisons that could be made include, but are not limited to; shoulder rotation, club head speed, club head trajectory, trunk rotation, hand positions and the like.

By adapting the present invention to score the user's motion, it becomes possible to provide competitions that are based, at least in part, on the user's ability to accurately emulate an ideal motion, or some other reference motion. For instance, in a golf environment, the present invention may provide virtual golf competitions, where users are ranked based on their accuracy in emulating an ideal golf swing.

The Method

In one form, the method of the present invention begins with the step of generating images of a motion based at least partly on subject-specific motion data. In one example form, the subject-specific motion data is in the form of a matrix containing coordinates of
the motion specific to the user in three-dimensional space. In another example form, the motion data is ideal motion data.

The step of generating images ideally produces sequential images of an animation performing the motion based at least partly on the subject-specific motion data. The animation may be represented simply as a stick figure or an outline of a human or a partial representation or a full body representation of a human character performing the motion. If desired, the animation may be made more realistic by rendering visual features on the animation or its background.

Once generated, the images of the motion are displayed on a display. In another form of the method, the method begins with the step of displaying images of a motion based on subject-specific motion data. This form may be used, for example, where images of the motion have previously been generated and do not need to be altered before use.

Images of the user executing the motion are also displayed on the display. The images of the motion based on subject-specific motion data may be overlaid on the images of the user. It is not essential for the images to be overlaid, however. For instance, the images may be displayed side-by-side. All that is required is for the user to be able to compare its motion to the images of the motion based on subject-specific motion data.

In some cases, the subject-specific motion data is interpolated before images based on the data are displayed. This is done where the images based on the subject-specific motion data are at a lower than desirable frame rate. By interpolating the subject-specific motion data, the images based on the interpolated motion data may be provided at the desired frame rate.

It is also desirable, although not essential, for the subject-specific motion data to be anthropometrically scaled and limited in some way, as described earlier, to take into account the user's physical dimensions and limitations before images based on the data are displayed.

If certain parts of the motion should be observed more carefully by the user, the images of the motion may be made more prominent to the user. In one form, the colour and/or
transparency of the relevant part of the motion, such as the position and motion of the user's leg, is changed. Also, the user may seek to view the motion from some other view than the view corresponding to the user's image. Here, the method of the present invention allows the images of the motion to be generated from another view based on the subject-specific motion data.

In another form, where images of the motion have already been generated from ideal motion data, the method of the present invention provides the step of allowing a user to compare an image of the user performing a motion to an image of an ideal motion.

The method may also be a method of a method of providing a competition. In this form, the method include displaying a motion generated from subject-specific motion data and imaging one or more users performing a motion such that the one or more users may emulate the motion generated. The competition aspect of this form may be provided in a step of providing an indication as to the accuracy of the one or more users in emulating the motion generated.

The System

In one example embodiment, the system of the present invention is substantially identical to the device of the present invention described earlier. All of the description relating to the device is therefore applicable to the system. Skilled persons will appreciate that the features of the device may be easily distributed in a system. For example, as described earlier, the storage device 106 of Figure 1 may be provided at a centralised location and be connected to each device via a network, such as the internet. Alternatively or additionally, the step of scaling or limiting motion data to produce subject-specific motion data may be done remotely at a centralised processor, with images of the subject-specific motion data being sent to the devices for display to a user.

In view of the above, skilled persons will appreciate that the present invention provides a coaching solution that does not require motion-capture to work. By displaying images to be emulated and images of the user on a screen, the present invention provides a simple and intuitive way in which a user may emulate the motion. By providing subject-specific motion data from which images are generated, the present invention provides a tool for a
user to emulate a motion that is tailored for the user. This promotes accuracy and repeatability of the motion, which is essential for coaching applications.

The foregoing describes the invention including example forms thereof. Alterations and modifications as will be obvious to those skilled in the art are intended to be incorporated within the scope hereof. For example, while the present invention has been described with reference to golf-related motions, it will be clear that the present invention is not so limited. The present invention could be applied to other sports, such as baseball, tennis, tae-kwon-do and the like. The present invention could also be applied to non-sport motions, such as dancing. Clinical applications, such as physiotherapy, are also envisaged.
1. A motion coaching device comprising:
   a display device;
   one or more video cameras to capture images of a user's motion; and
   a processor to display on the display device images of a motion based on subject-specific motion data, and to display images of the user's motion such that the user is able to emulate the motion based on the subject-specific motion data.

2. The motion coaching device as claimed in claim 1 wherein the subject-specific motion data represents a motion that is continuous in time and wherein the processor is adapted to display images of the motion at one or more of an arbitrary frame rate, resolution and smoothness.

3. The motion coaching device as claimed in claim 1 or 2 wherein the processor is adapted to display an animation performing the motion by displaying a sequence of images rendered from the subject-specific motion data.

4. The motion coaching device as claimed in claim 3 wherein the animation is selected from a group consisting of: a stick figure representation, an outline representation, a realistic representation, a partial representation and a full representation.

5. The motion coaching device as claimed in any one of the preceding claims wherein the processor is adapted to either overlay the images of the motion on the images of the user's motion, or overlay the images of the user's motion on the images of the motion.

6. The motion coaching device as claimed in any one of the preceding claims wherein the processor is adapted to change the prominence of one or more selected portions of the images of the motion depending on the importance of the user emulating the motion at the one or more selected portions.
7. The motion coaching device as claimed in any one of the preceding claims wherein the device is arranged to receive subject-specific information.

8. The motion coaching device as claimed in claim 7 wherein the device is connectable to a network to download the subject-specific information.

9. The motion coaching device as claimed in claim 7 wherein the device includes one or more ports to retrieve the subject-specific information from a portable storage device presented by the user.

10. The motion coaching device as claimed in any one of claims 7 to 9 wherein the processor is adapted to generate the subject-specific motion data by anthropometrically scaling motion data to suit the one or more personal characteristics of the user as determined from the subject-specific information.

11. The motion coaching device as claimed in claim 10 wherein the one or more personal characteristics are selected from the group consisting of: height, gender, age, race, weight and volume.

12. The motion coaching device as claimed in any one of claims 7 to 11 wherein the processor is adapted to generate the subject-specific motion data by manipulating motion data such that the images of the motion show a motion that is limited or modified in some way to take into account one or more physical limitations of the user.

13. The motion coaching device as claimed in claim 12 wherein the processor is adapted to manipulate the motion data to take into account the one or more physical limitations after anthropometrically scaling the motion data.

14. The motion coaching device as claimed in claim 12 or 13 wherein the one or more physical limitations comprises one or more of limited flexibility and limited strength.

15. The motion coaching device as claimed in any one of the preceding claims wherein the processor is adapted to generate the images of the motion from one or
more predetermined points of view or from one or more points of view selected by the user based on the subject-specific motion data.

16. The motion coaching device as claimed in any one of the preceding claims wherein the device includes two or more video cameras to image different views of the user.

17. The motion coaching device as claimed in claim 16 wherein the processor is adapted to generate the images of the motion to correspond to one or more views displayed to the user.

18. The motion coaching device as claimed in any one of the preceding claims wherein the device is used for sport motion coaching and includes a navigation tool comprising one central button and at least four buttons surrounding the central button, with the buttons being sized to be depressible using an implement that is used in executing the sport motion.

19. The motion coaching device as claimed in any one of the preceding claims wherein the processor is adapted to receive motion-captured data representing the user's motion that has been motion-captured.

20. The motion coaching device as claimed in claim 19 wherein the processor is also adapted to compare the motion-captured data with the subject-specific motion data to provide an indication as to the accuracy of the user's emulation.

21. The motion coaching device as claimed in any one of the preceding claims wherein the processor is adapted to store images of the user's motion and to customise the device for the user based at least partly on the stored images of the user's motion.

22. The motion coaching device as claimed in any one of the preceding claims wherein the subject-specific motion data is ideal motion data.

23. A motion coaching method comprising:
   displaying images of a motion based on subject-specific motion data on a display;
imaging the motion of a user; and
displaying the motion of the user on the display to allow the user to compare the motion of the user with the images of the motion based on the subject-specific motion data.

24. The motion coaching method as claimed in claim 23 further comprising generating images of the motion at one or more of an arbitrary frame rate, resolution and smoothness based on the subject-specific motion data.

25. The motion coaching method as claimed in claim 23 or 24 wherein the images of the motion based on the subject-specific motion data are sequential images of an animation performing the motion.

26. The motion coaching method as claimed in claim 25 wherein the animation is selected from a group consisting of: a stick figure representation, an outline representation, a realistic representation, a partial representation and a full representation.

27. The motion coaching method as claimed in any one of claims 23 to 26 wherein displaying the images comprises either overlaying the images of the motion on the images of the user's motion, or overlaying the images of the user's motion on the images of the motion.

28. The motion coaching method as claimed in any one of claims 23 to 27 further comprising changing the prominence of one or more selected portions of the images of the motion depending on the importance of the user emulating the motion at the one or more selected portions.

29. The motion coaching method as claimed in any one of claims 23 to 28 further comprising generating the subject-specific motion data by anthropometrically scaling motion data to suit one or more personal characteristics of a user.
30. The motion coaching method as claimed in claim 29 wherein the personal characteristics are selected from the group consisting of: height, gender, age, race, weight and volume.

31. The motion coaching method as claimed in claim 29 or 30 further comprising generating the subject-specific motion data by manipulating motion data such that the generated images of the motion show a motion that is limited or modified in some way to take into account one or more physical limitations of a user.

32. The motion coaching method as claimed in claim 31 wherein manipulating the motion data is earned out after anthropometrically scaling the motion data.

33. The motion coaching method as claimed in claim 31 or 32 wherein the one or more physical limitations comprises one or more of limited flexibility and limited strength.

34. The motion coaching method as claimed in any one of claims 29 to 33 further comprising generating the images of the motion from one or more predetermined points of view or from one or more points of view selected by the user.

35. The motion coaching method as claimed in any one of claims 29 to 34 wherein imaging the motion of a user comprises imaging two or more different views of the user.

36. The motion coaching method as claimed in any one of claims 29 to 35 wherein the images of the motion are generated to correspond to one or more views displayed to the user.

37. The motion coaching method as claimed in any one of claims 29 to 36 wherein anthropometrically scaling or manipulating the motion data comprises altering positional information and/or positional change of one or more joint trajectories that are represented by the motion data.
38. The motion coaching method as claimed in any one of claims 23 to 37 further comprising recognising the motion of the user.

39. The motion coaching method as claimed in claim 38 further comprising comparing the recognised motion with the subject-specific motion data and providing an indication as to the accuracy of the motion of the user.

40. The motion coaching method as claimed in any one of claims 23 to 39 further comprising storing images of the user's motion and customising the method for the user based at least partly on the stored images of the user's motion.

41. The motion coaching method as claimed in any one of claims 23 to 40 wherein the subject-specific motion data is ideal motion data.

42. A motion coaching method comprising allowing a user to compare images of the user performing a motion with images based on ideal motion data that are displayed on a display device as the user performs the motion.

43. A motion coaching method comprising:
   overlaying images based on ideal motion data on images of a user performing a motion; and
   displaying the overlaid images on a display device for the user.

44. A motion coaching system comprising:
   a display device;
   one or more video cameras to capture images of a user's motion; and
   a processor to display on the display device images of a motion based on subject-specific motion data, and to display images of the user's motion such that the user is able to emulate the motion.

45. The motion coaching system as claimed in claim 44 wherein the subject-specific motion data represents a motion that is continuous in time and wherein the processor is adapted to display images of the motion at one or more of an arbitrary frame rate, resolution and smoothness.
46. The motion coaching system as claimed in claim 44 or 45 wherein the processor is adapted to display an animation performing the motion by displaying a sequence of images rendered from the subject-specific motion data.

47. The motion coaching system as claimed in claim 46 wherein the animation is selected from a group consisting of: a stick figure representation, an outline representation, a realistic representation, a partial representation and a full representation.

48. The motion coaching system as claimed in any one of claims 44 to 47 wherein the processor is adapted to either overlay the images of the motion on the images of the user's motion, or overlay the images of the user's motion on the images of the motion.

49. The motion coaching system as claimed in any one of claims 44 to 48 wherein the processor is adapted to change the prominence of one or more selected portions of the images of the motion depending on the importance of the user emulating the motion at the one or more selected portions.

50. The motion coaching system as claimed in any one of claims 44 to 49 wherein the processor is arranged to receive subject-specific information.

51. The motion coaching system as claimed in claim 50 wherein the processor is connectable to a network to download the subject-specific information.

52. The motion coaching system as claimed in claim 50 wherein the system includes one or more ports to retrieve the subject-specific information from a portable storage device presented by the user.

53. The motion coaching system as claimed in any one of claims 50 to 52 wherein the processor is adapted to generate the subject-specific motion data by anthropometrically scaling motion data to suit the one or more personal characteristics of the user as determined from the subject-specific information.
54. The motion coaching system as claimed in claim 53 wherein the one or more personal characteristics are selected from the group consisting of: height, gender, age, race, weight and volume.

55. The motion coaching system as claimed in any one of claims 50 to 54 wherein the processor is adapted to generate the subject-specific motion data by manipulating motion data such that the images of the motion show an motion that is limited or modified in some way to take into account one or more physical limitations of the user.

56. The motion coaching system as claimed in claim 55 wherein the processor is adapted to manipulate motion data to take into account the user's one or more physical limitations after anthropometrically scaling motion data.

57. The motion coaching system as claimed in claim 55 or 56 wherein the one or more physical limitations comprises one or more of limited flexibility and limited strength.

58. The motion coaching system as claimed in any one of claims 44 to 57 wherein the processor is adapted to generate the images of the motion from one or more predetermined points of view or from one or more points of view selected by the user based on subject-specific motion data.

59. The motion coaching system as claimed in any one of claims 44 to 58 wherein the device includes two or more video cameras to image different views of the user.

60. The motion coaching system as claimed in claim 59 wherein the processor is adapted to generate the images of the motion to correspond to one or more views displayed to the user.

61. The motion coaching system as claimed in any one of claims 44 to 60 wherein the device is used for sport motion coaching and includes a navigation tool comprising one central button and at least four buttons surrounding the central button, with the
buttons being sized to be depressible using an implement that is used in executing the
sport motion.

62. The motion coaching system as claimed in any one of claims 44 to 61 wherein
the processor is adapted to receive motion-captured data representing the user's
motion that has been motion-captured.

63. The motion coaching system as claimed in claim 62 wherein the processor is also
adapted to compare the motion-captured data with the subject-specific motion data to
provide an indication as to the accuracy of the user's emulation.

64. The motion coaching system as claimed in any one of claims 44 to 63 wherein
the processor is adapted to store images of the user's motion and to customise the
system for the user based at least partly on the stored images of the user's motion.

65. The motion coaching system as claimed in any one of claims 44 to 64 wherein
the subject-specific motion data is ideal motion data.

66. A sport motion coaching device comprising:
    a display device;
    one or more video cameras to capture images of a user's motion;
    a navigation tool having one central button and at least four buttons surrounding
    the central button, the buttons being sized to be depressible using an implement that is
    used in executing the sport motion; and
    a processor to display images of a motion and to display images of the user's
    motion based on commands received from the user via the navigation tool.

67. A method of providing a competition comprising:
    displaying a motion generated from subject-specific motion data;
    imaging one or more users performing a motion such that the one or more users
    may emulate the motion generated;
    providing an indication as to the accuracy of the one or more users in emulating
    the motion generated.
68. The method of providing a competition as claimed in claim 67 wherein the subject-specific motion data is selected from a group comprising: ideal motion data, subject-specific motion data obtained from the motion of the user, and subject-specific motion data obtained from the motion of another user.
FIGURE 8
INTERNATIONAL SEARCH REPORT

International application No. PCT/IB2007/002410

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.
A63B 69/00 (2006.01)  G09B 5/00 (2006.01)
A63B 69/36 (2006.01)  G09B 5/02 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

DWPI: Keywords (motion or movement or swing+ etc) and (coach+ or correct* or train+ etc.) and (display* or image+ or show etc)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 5947742 A (KATAYAMA) 7 September 1999 . Whole document and in particular Figs., col. 2, lines 47-61 and col. 5, lines 60 to col. 6 line 9, col. 5 lines 48-59</td>
<td>1-42, 44-68</td>
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<td>x</td>
<td>WO 2000/040309 A (TARRY) 13 July 2000 Whole document and in particular Fig. 1-3, second paragraph on page 8 to second paragraph on page 10, Fig. 4, 5A-5C, claim 33; second paragraph, pg. 11</td>
<td>1-65, 67, 68</td>
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<td>GB 2313553 A (KABUSHIKI KAISHA ASOBOU) 3 December 1997 Whole document and in particular Figs., pg. 4 line 16-23, pg. 4, line 16-23</td>
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[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
16 November 2007

Date of mailing of the international search report
17 Dec 2007

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Form PCT/ISA/210 (second sheet) (April 2007)
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<td>As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.</td>
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<td>As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.</td>
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<td>As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:</td>
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<td>No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:</td>
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**Remark on Protest**

- Additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.
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<td>US 6722888 B (MACRI et. al.) 20 April 2004 Whole document and in particular Figs., col. 7, lines 45-60; col. 8, lines 25-32; col. 9, lines 2-45</td>
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<td>A</td>
<td>CA 2340834 A (BOWN) 21 September 2002 Whole document</td>
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• Claims 1, 23, 42, 43, 44, and 67 are directed to device, methods, and system related to motion coaching using subject-specific motion data or ideal motion data. It is considered that the use of subject-specific motion data or ideal motion data comprises a first distinguishing feature. From the specification it is noted that ideal motion data is subject-specific motion data that has been manipulated (pg. 5).

• Claim 66 is directed to a sport motion coaching device comprising a "navigation tool having one central button and at least four buttons surrounding the central button, the buttons being sized to be depressible using an implement that is used in executing the sport motion". It is considered that "navigation tool having one central button and at least four buttons surrounding the central button, the buttons being sized to be depressible using an implement that is used in executing the sport motion" comprises a second distinguishing feature.
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX