AN EXERCISE APPARATUS SENSOR SYSTEM

TECHNICAL FIELD

[001] This invention relates to a sensor system for assisting a user in using an exercise machine, in particular to check the form of movement, count the repetitions, and track the weights being lifted. The sensors can be mounted on existing exercise machines with little or no modifications, and is free standing that can measure the number of weight plates being lifted as well as the distance.

BACKGROUND

[002] There are various electronic apparatuses that can be added to exercise machines to enhance the user experience, especially in counting the number of repetitions, as well as checking whether the range of movement is sufficient and the form correct. By providing this feedback to the user in real time, appropriate corrections and measures can be taken to ensure that the exercise is done safely and efficiently.

[003] Given the many exercise machines in the various gyms around the world, it would be too costly to redesign the exercise machines to incorporate a device that can count the repetitions, track the weights being lifted, and check the form of movement. And in terms of existing solutions that can be fitted onto a current exercise machine, they either count repetitions only, or involve manipulation of the sensors to ensure a change is registered. Further by requiring installation on the exercise machine itself, the various existing

solutions result in significantly greater wear and tear of both the device and exercise machine.

[004] Hence, there is a need for an exercise apparatus sensor system that is able to count repetitions, measure the amount of weight lifted, check the amount of extensions, calculate calories burnt, measure intervals between repetitions without being intrusive and without changing the user experience in terms of using the exercise machine, and without causing more wear to the exercise machine.

BRIEF SUMMARY

[005] The above and other problems are solved and an improvement in the art is made by an exercise apparatus sensor system in accordance with this invention. A first advantage of the exercise apparatus sensor system in accordance with this invention is that it enables a user to count and keep track of the number of repetitions performed without having to wear extra sensors. This allows for existing exercise equipment to be retrofitted with the system without requiring modifications. A second advantage of the exercise apparatus sensor system in accordance with this invention is that it is able to measure and compute multiple parameters including the amount of weight being lifted, the distance of extensions, calories burnt, intervals between extensions and provide this in a real time manner. This allows the user to adjust accordingly and exercise efficiently. A third advantage of the exercise apparatus sensor system in accordance with this invention is that it is able to adapt to the exercise patterns of the user. This means that users will exercise

at an optimal level without it being too difficult or too easy so as to make the exercise efficient.

[006] According to one aspect of the present invention, there is provided a system for use with an exercise apparatus, the system comprising: a support arrangement; and a sensor module which is carried by the support arrangement, the sensor module comprising a plurality of spaced apart presence sensors, each presence sensor being configured to sense the presence of a respective component of an exercise apparatus when the component is within a predetermined distance of the presence sensor, wherein the system further comprises: a control unit which is coupled for communication with the sensor module, the control unit being configured to receive presence signals from the sensor module which are indicative of an output of at least one of the presence sensors, wherein the control unit is configured to determine a configuration of the exercise apparatus based on the presence signals from the sensor module.

[007] In some embodiments, the support arrangement comprises: a base; and at least one support member which projects outwardly from the base.

[008] In some embodiments, the base comprises at least one retainer element which is configured to releasably attach to part of an exercise apparatus to releasably attach the base to the exercise apparatus.

[009] In some embodiments, the support arrangement comprises two support members which are spaced apart from one another and which are each connected at one end to the base.

[0010] In some embodiments, the base is configured such that, when the base is resting on a surface, the system is freestanding with the at least one support member projecting upwardly from the base.

[0011] In some embodiments, each presence sensor is configured to sense the presence of a respective component in the form of a weight of a stack of weights of an exercise apparatus.

[0012] In some embodiments, the control unit is configured to determine the configuration of the exercise apparatus based on a movement of one or more of the weights beyond the predetermined distance between each weight and a respective one of the presence sensors.

[0013] In some embodiments, the configuration of the exercise apparatus is indicated by a weight value representing the total weight that is moved when the exercise apparatus is in use.

[0014] In some embodiments, the control unit is configured to sample the state of each of the presence sensors and to determine which weight is being lifted depending on the values collated.

[0015] In some embodiments, the system further comprises: an add-on weight sensor which is coupled for communication with the control unit, the control unit being configured to determine the configuration of the exercise apparatus based on a signal from the add-on weight sensor which is indicative of whether or not an add-on weight of the exercise apparatus is in use.

[0016] In some embodiments, the system further comprises: an accelerometer which is configured to be carried by a part of the exercise apparatus and to move with the part of the exercise apparatus when the

exercise apparatus is in use, the accelerometer being coupled for communication with the control unit to provide acceleration signals to the control unit which are indicative of an acceleration of the part of the exercise apparatus when the exercise apparatus is in use.

[0017] In some embodiments, the system further comprises: a movement sensor which is configured to sense the distance over which a part of the exercise apparatus moves when the exercise apparatus is in use, the movement sensor being coupled for communication with the control unit to provide movement signals to the control unit which are indicative of an acceleration of the part of the exercise apparatus when the exercise apparatus is in use.

[0018] In some embodiments, the movement sensor is provided with a magnetic mounting arrangement to releasably attach the movement sensor to a part of the exercise apparatus.

[0019] In some embodiments, the control unit is configured to perform a calibration operation to calibrate the system for a user based on a distance sensed by the movement sensor when the user uses the exercise apparatus.

[0020] In some embodiments, the system comprises a plurality of sensor modules which are configured to be positioned end-to-end to sense the presence of a plurality of components of an exercise apparatus.

[0021] In some embodiments, each presence sensor is an optical sensor which is configured to sense light reflected off a component of an exercise apparatus.

[0022] In some embodiments, the control unit is configured to communicate wirelessly with each sensor module.

[0023] In some embodiments, the control unit comprises a network interface for exchanging data with a remote server.

[0024] In some embodiments, the system is configured to calculate an amount of energy which is exerted by a user when the user is using the exercise apparatus.

[0025] According to another aspect of the present invention, there is provided an exercise apparatus comprising the system of any one of the claims as defined hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The invention is illustrated by way of example with reference to the accompanying drawings which show an exercise apparatus sensor system in accordance with the invention. The accompanying drawings, which are incorporated herein and form part of the specification, illustrate various embodiments of the present disclosure and, together with the description, further serve to explain the principles of the disclosure and to enable a person skilled in the pertinent art to make and use the embodiments disclosed herein. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0027] Figure 1 is the overview system of the exercise apparatus sensor system when installed in three exercise machines;

[0028] Figure 2 shows the various components in the exercise apparatus system;

[0029] Figures 3A, 3B, and 3C show various views of the weight stack sensor in the exercise apparatus sensor system;

[0030] Figures 4A, 4B, 4C, 4D and 4E show various views of the sensor base of the sensor in the exercise apparatus sensor system;

[0031] Figures 5A, 5B, 5C, 5D, 5E, and 5F show various views of the sensor top in the exercise apparatus sensor system;

[0032] Figures 6A, 6B, 6C, and 6D show various views of the weight distance sensor holder in the exercise apparatus sensor system;

[0033] Figure 7 is a schematic diagram of a system of some embodiments;

[0034] Figure 8 shows a system flowchart of the repetition counting algorithm used in the exercise apparatus sensor system;

[0035] Figure 9 is a schematic diagram of a system of some embodiments;

[0036] Figure 10 is a schematic diagram of a plurality of sensor modules of the system of Figure 9;

[0037] Figure 11 is a schematic diagram of a weight stack of an exercise apparatus;

[0038] Figure 12 is a schematic diagram of a system in use with a weight stack of an exercise apparatus; and

[0039] Figure 13 is a schematic diagram of an add-on weight sensor of some embodiments.

DETAILED DESCRIPTION

[0040] The various configurations discussed in these non-limiting examples can be varied and are used to illustrate at least one embodiment and are not intended to limit the scope thereof.

[0041] Referring to the drawings, Figure 1 shows an overview of the system 100 with the weights 101 of the weight stack machine or exercise machine 102 shown, along with its possible direction of movement of the weights 101. In this embodiment, the system 100 is configured to sense the movement of one or more components in the form of one or more weights 101 of a weight stack of an exercise apparatus 102. However, other embodiments are configured to sense the movement of another component of an exercise apparatus. For instance, other embodiments are configured to sense the movement of a component in the form of an indicator which is carried by a weight. In further embodiments, the system is configured to sense the movement of a component in the form of a part of another type of exercise apparatus, such as a Pilates machine.

[0042] The system 100 of this embodiment comprises a movement sensor or time of flight (TOF) module 110 and a sensor module or weight stack sensor 120, which are shown in this embodiment installed inside the weight stack machine, although the sensor system can also be free standing outside and separate from the weight stack machine. Each weight stack sensor system 120 would then communicate with a gateway 140, such as a router or switch or another networking device. The gateway 140 is connected via computer

network to a Backend Database API 150, which is implemented in a server or another computing device which may be in the cloud.

[0043] The weight stack sensor can either be powered by battery or from power supply. The weight stack sensor 120 can have a control unit (base module) and wireless communication is built into the control unit. Whenever a repetition is detected by the weight stack module, the amount of weight lifted and the distance moved by the weight stack 101 can be transmitted wirelessly to a local gateway 140, before being transmitted to the cloud backend database 150 so that the data collected from the weight stack sensor 120 can be stored, retrieved and visualized. As seen from Figure 1, the gateway 140 can support multiple connections from multiple weight stack sensors.

[0044] Details of the weight stack sensor 200 can be seen in Figure 2, with the weights 201 (and a weight of 30lbs shown being lifted) where there are three main modules: a movement sensor or time of flight (TOF) module 210, a sensor module 220 (proximity module), and a control unit 230.

[0045] The time of flight module 210 can be used to measure the movement of the weight stack 201 and this can determine the amount of work done in moving the weights or weight stack 201. In some embodiments, the time of flight module 210 is an optical sensor which is configured to sense movement of the weight stack 201 by sensing light reflected back from part of the weight stack 201.

[0046] The sensor module 220 can be used to detect the weight 201 being lifted, and this can be achieved through presence or proximity sensors 222

that are installed within the sensor module 220, whereby each proximity sensor 222 can detect a corresponding weight in the weight stack 201 in rest state. Each sensor module 220 comprises a plurality of spaced apart presence or proximity sensors 222. Each presence or proximity sensor 222 is configured to sense the presence of a respective weight or component of the exercise apparatus when the weight or component is within a predetermined distance of the sensor 222.

[0047] A control unit 230 is coupled for communication with the other modules of the system and can be the interface between all the modules, and can also compute the workout data from multiple sensors and aggregate the data accordingly. The control unit 230 comprises a processor and a memory, the memory storing executable instructions which, when executed by the processor, cause the control unit 230 to perform functions. The control unit 230 is also able to communicate with the gateway 140 (not shown in Figure 2), and this can be wirelessly or using wires, or any other communication methods known to those skilled in the art.

[0048] The result is a free-standing system which comprises a sensor unit that can measure the number of weight plates being lifted and the distance moved by the lifted weight plates. The free-standing system can be retrofitted onto existing weight stack machines or exercise machines without contact with any moving parts while the weight stack machine is being used.

[0049] The time of flight module 210 can have a printed circuit board (PCB) that holds the various circuitry to perform its function, and this PCB can be mounted on a holder. In this example, the holder is provided with a magnetic

mounting arrangement which comprises slots for magnets that can be used to attach the time of flight module 210 to the metal body of the weight stack machine. The time of flight module is in communication with the control unit 230, and this communication can be wireless or via wire.

[0050] The sensor module 220 can have a printed circuit board (PCB) for holding the components to perform its function. This can be in the form of a series of proximity sensors mounted on a PCB that would detect the corresponding weight being lifted on the weight stack 201 by the weight moving beyond a predetermined distance from the proximity sensor. Thus in Figure 2, the proximity module can detect the weight being lifted to be 30. As shown, each proximity sensor 222 can correspond to a weight plate in the weight stack 201, and hence detect movement in the weight plate as well as the amount of weights being lifted when the relevant weights are lifted.

[0051] The overall structure of a support arrangement 300 of the system 100 can be seen in Figures 3A-C. The support arrangement 300 comprises a base 314 and at least one support member 312 which projects outwardly from the base 314. In this embodiment, the support arrangement comprises two support members 312 which are spaced apart from one another and which are each connected at one end to the base 314. In this embodiment, the support members 312 are metal beams 312 which are mounted the base 314.

[0052] In this embodiment, the support arrangement 300 comprises a hat 310 which is mounted to the upper ends of the support members 312. The base 314 and the hat 310 can be made using additive printing for ease of design. The sensor module or proximity module PCB can be mounted on acrylic

plates 316 which are carried by the support members 312. The control unit PCB can be mounted on a control unit support 318 which is also carried by the support members 312. The frame of the weight stack sensor 300 would be placed next to the weight stack (not shown in Figures 3A-C).

[0053] In this embodiment, a movement sensor support element 305 is configured to attach to the hat 310 to support the movement sensor or time of flight (TOF) module 210.

[0054] The side, end, top and perspective views of the base 314 can be seen in Figures 4A-E. The base 314 comprises a generally planar base element 401 having two spaced apart projections 402, 403 which project outwardly from an upper surface of the base element 401. The projections 402, 403 each comprise a respective mounting channel 404, 405. Each mounting channel 404, 405 is configured to receive and retain a lower end of a respective one of the support members 312 and to retain the support member 312 in an upright configuration.

[0055] The base 314 of this embodiment comprises two spaced apart recesses 406, 407 which are each configured to receive a respective part of an exercise apparatus. For instance, the lower ends of two spaced apart rails which guide a weight stack of an exercise apparatus may be received within the recesses 406, 407 when the system is in an operative position adjacent to the weight stack.

[0056] In this embodiment, the base 314 comprises a lower support plate 408 which is preferably of metal. The lower support plate 408 is configured to fit beneath the base element 401 and to rest on a support surface, such as a

floor. The lower support plate 408 comprises a mounting arrangement in the form of two spaced apart apertures 409, 410 to enable fixings, such as bolts, to be used to mount the lower support plate 408 to the underside of the base element 401. The lower support plate 408 comprises two spaced apart retainer elements 411, 412 which project outwardly from an upper surface of the lower support plate 408. The retainer elements 411, 412 extend through the recesses 406, 407 to project upwardly from the upper surface of the base element 401.

[0057] In use, the lower support plate 408 is securely fastened to a weight stack machine, with the retainer elements 411, 412 extending upwardly into rails of the weight stack machine. The lower support plate 408 thereby securely retains the system in an operative position adjacent the weight stack machine.

[0058] In other embodiments, it is to be appreciated that the base 314 may comprise only one recess or more than two recesses. In other embodiments, the base 314 may comprise another releasable attachment arrangement for releasably attaching the system to part of an exercise apparatus.

[0059] Various views of the hat 310 can be seen in Figures 5A-F. The hat 310 comprises an elongate hat body 501 which is provided on the underside with two spaced apart recesses 502, 503. Each recess 502, 503 is configured to receive an upper end of a respective one of the support members 312 so that the hat 310 is supported by the support members 312. The hat 310 comprises a side support element 504 which projects outwardly from one side of the hat body 501. The side support element 504 is preferably provided with an

aperture 505 through which wiring from the movement sensor 210 may be routed.

[0060] Various views of the movement sensor support element 305 (the weight distance sensor holder) can be seen in Figures 6A-D. The movement sensor support element 305 comprises a generally planar body portion 601 which is provided with mounting apertures 602 and an outwardly directed support member 603. The mounting apertures 602 and the support member 603 are configured to support the movement sensor or time of flight (TOF) module 210. The support member 603 guides the movement sensor or time of flight (TOF) module 210 into an operative position relative to an exercise apparatus.

[0061] The upper end of the movement sensor support element 305 comprises a wire support 604 which is provided with an aperture 605 through which wiring from the movement sensor 210 may be routed. The movement sensor support element 305 comprises two spaced apart wing elements 606, 607 which are each configured to retain a respective magnet (not shown) for releasably mounting the movement sensor support element 305 to an exercise apparatus.

[0062] Within the control unit, there is a computing device having a processor and a memory that collate the outputs from the sensor(s) 210, 222 and produce a result. For example, in counting the repetitions, there may be false counts or miscounting due to the variations in usage of the weight stack machine.

[0063] In some embodiments, the system 100 comprises an accelerometer (not shown) which is configured to be carried by a part of the exercise apparatus and to move with the part of the exercise apparatus when the exercise apparatus is in use. The accelerometer is coupled for communication with the control unit 230 to provide acceleration signals to the control unit 230 which are indicative of an acceleration of the part of the exercise apparatus when the exercise apparatus is in use. In some embodiments, the accelerometer is provided within the control unit 230 and the control unit 230 is configured to be carried by a part of the exercise apparatus and to move with the part of the exercise apparatus when the exercise apparatus is in use.

[0064] Either or both the accelerometer and/or distance (the movement sensor or time of flight (TOF) module 210) can be used to count the number of repetitions of movement of the weight(s) of the exercise apparatus. In some examples, the movement sensor or time of flight (TOF) module 210 is preferred as it provided higher accuracy and required less complex algorithm as signal filtering was not needed. The direct measurement of the weight stack position achieves a higher accuracy, and also allows for the computation of calories burned based on the data collected. In other examples, the control unit is placed on top of the weight stack such that it moves together with the weight stack. Otherwise, a free standing design for the control unit as shown in Figure 3 can also be used.

[0065] Figure 7 shows the system 100 of the embodiments described above assembled in a freestanding configuration. In this embodiment, the control

unit 230 is carried by the two spaced apart support members 312. In this embodiment, the system 100 comprises a single sensor module 220 which is provided with a plurality of spaced apart proximity sensors 222.

[0066] An example of a repetition counting algorithm used with the weight stack sensor system can be seen in Figure 8. The repetition counting algorithm can reside in the processor of the control unit, and this can be a 32-bit ARM cortex m4 processor.

[0067] The algorithm is able to adapt to the exercise patterns of the user by learning from previous iterations. For instance, the threshold can be increased for users who make large arm extensions, and likewise it can also be decreased for users who make small arm extensions. This can help to reduce the cases of missed counts and false counts. The repetition counting algorithm was found to achieve 99% accuracy using data collected from 93 participants. The repetition algorithm can compute the number of repetitions performed by the user in real-time.

[0068] When the system is started 901, the system initialises 902 when the system detects that at least one of the weights of the weight stack has been moved up by a user. The system stores 903 a value which is indicative of the amount of weight which is being lifted, as detected by the sensor module 220. The system computes 904 the up and down step sizes of the weight moved by the user by examining 905 the up or down state of the weights.

[0069] If the weight is up, the system examines 906 the distant travelled by the weight and whether the weight has crossed a predetermined threshold. If so, the system stores 907 the up step size and changes 908 the stage to

down before subsequently applying 909 a forgetting term to reset the threshold.

[0070] If the distance moved by the weight has not crossed the predetermined threshold or the system detects that the weight is in the down state, the system checks 910 whether the weight has crossed a further predetermined threshold and, if so, the system stores 911 the down step size. The system then computes 912 an intensity value by subtracting the down step size from the up step size. The system then adapts 913 the predetermined threshold to the computed intensity before changing 914 the stage to UP and registering 915 one repetition or “rep” performed by the user. The system then reset 909 the predetermined threshold and repeats to count and measure the intensity of further repetitions performed by a user.

[0071] Referring now to figures 9 and 10 of the accompanying drawings, a system 1 of some embodiments comprises the same components as the embodiments described above, except that the system of this embodiment comprises a plurality of sensor modules 1001-1003. Each sensor module 1001-1003 comprises a plurality of respective presence sensors 1001a-1003a. In this embodiment, the first sensor module 1001 is a master module which is coupled for communication with the other sensor modules 1002-1003 which are slave modules. Data is communicated from the slave sensor modules 1002-1003 to the master sensor module 1001 for the master sensor module 1001 to communicate the data on to the control unit 230.

[0072] In the embodiment shown in figures 9 and 10, there are three sensor modules 1001-1003, but it is to be appreciated that there may be a greater or

fewer number of sensor modules in other embodiments. In some embodiments, the system comprises a master sensor module and between 1 and 7 slave sensor modules. The modular configuration enables an appropriate number of sensor modules to be provided for the system to be used with up to 80 weights or, in other embodiments, any number of weights in a weight stack of an exercise apparatus. For instance, sufficient sensor modules may be provided to sense a weight stack having more than 24 weights.

[0073] In some embodiments, the system further comprises an add-on weight sensor 1004 which is movably mounted to one of the support elements 312 by an add-on weight sensor mounting arrangement 1005.

[0074] Figure 11 shows an example of a weight stack 1200 in which there is a peg 1201 which is inserted into an aperture in a weight to configure the exercise apparatus with the amount of weight which is to be moved by a user. The exercise apparatus further comprises a lever 1202 which may be activated by a user in order to engage an add-on weight to be moved in conjunction with the or each weight of the weight stack. The add-on weight is typically a weight of 2 kg.

[0075] Figure 12 shows a rear view of the weight stack 1200 of Figure 11 which an add-on weight 1300 in the form of a cylindrical weight which is movably mounted around a shaft 1301. When the lever 1202 is activated, the add-on weight 1300 moves along the shaft 1301 as the weights of the weight stack 1200 are moved by a user.

[0076] Referring to Figure 12 in conjunction with Figure 13, the add-on weight sensor 1004 of this embodiment is configured to sense when a marker 1302 carried by a predetermined portion of the add-on weight 1300 is adjacent to the add-on weight sensor 1004. In some embodiments, the marker 1302 is a reflective band. In some embodiments, the add-on weight sensor 1004 is an optical sensor which is configured to sense light reflecting off the marker 1302. If the add-on weight sensor 1004 senses that the marker 1302 moves a predetermined distance away from the add-on weight sensor 1004 then the system records that the add-on weight 1300 is being moved by a user. The system can thus calculate the total weight which is moved by a user.

[0077] Thus, the present invention has been fully described with reference to the drawing figures. Although the invention has been described based upon these preferred embodiments, to those of skill in the art, certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention.

[0078] Embodiments of the subject matter and the functional operations described herein can be implemented in digital electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them.

[0079] Some embodiments are implemented using one or more modules of computer program instructions encoded on a computer-readable medium for execution by, or to control the operation of, a data processing apparatus. The computer-readable medium can be a manufactured product, such as hard

drive in a computer system or an embedded system. The computer-readable medium can be acquired separately and later encoded with the one or more modules of computer program instructions, such as by delivery of the one or more modules of computer program instructions over a wired or wireless network. The computer readable medium can be a machine-readable storage device, a machine-readable storage substrate, a memory device, or a combination of one or more of them.

[0080] The terms “computing device” and “data processing apparatus” encompass all apparatus, devices, and machines for processing data, including by way of example a programmable processor, a computer, or multiple processors or computers. The apparatus can include, in addition to hardware, code that creates an execution environment for the computer program in question, e.g., code that constitutes processor firmware, a protocol stack, a database management system, an operating system, a runtime environment, or a combination of one or more of them. In addition, the apparatus can employ various different computing model infrastructures, such as web services, distributed computing and grid computing infrastructures.

[0081] The processes and logic flows described in this specification can be performed by one or more programmable processors executing one or more computer programs to perform functions by operating on input data and generating output.

[0082] Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and

any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read only memory or a random access memory or both. The essential elements of a computer are a processor for performing instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Devices suitable for storing computer program instructions and data include all forms of non volatile memory, media and memory devices.

[0083] To provide for interaction with a user, some embodiments are implemented on a computer having a display device, e.g., a LCD (liquid crystal display) monitor, for displaying information to the user and an input device by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input.

[0084] The computing system can include clients and servers. A client and server are generally remote from each other and typically interact through a communication network. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other. Embodiments of the subject matter described in this specification can be implemented in a computing system that

includes a back end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation of the subject matter described is this specification, or any combination of one or more such back end, middleware, or front end components. The components of the system can be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network (“LAN”) and a wide area network (“WAN”), an inter-network (e.g., the Internet), and peer-to-peer networks (e.g., ad hoc peer-to-peer networks).

[0085] In the present specification "comprise" means "includes or consists of" and "comprising" means "including or consisting of".

[0086] The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.