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(54) RUNNING TRAINING MACHINE WITH THE VIRTUAL REALITY SYSTEM AND ITS MODE OF WORK

(57) The real inventions group refers to training equipment made for musculature or joints development and strengthening with the help of exercises of overcoming the counteracting force with or without measuring instruments; to a person's movements in a virtual reality modeling system. Declared invention is a complex which consists of an originally constructed running training machine adapted to the current task and having two degrees of freedom at least, hardware and software equipment realizing the functions of user's positioning by controlling both the movement of the treadmill track and the slopes of the treadmill, depending on the terrain of the virtual underlying surface. Positioning system can be built using different sensors and feedback canals. Terrain reading from a virtual model is based on a computing device generating data arrays from the underlying surface elevation field, which can be built, for example, based on photogrammetry data and providing visualization of a three-dimensional model of the world, for example, through virtual reality glasses.

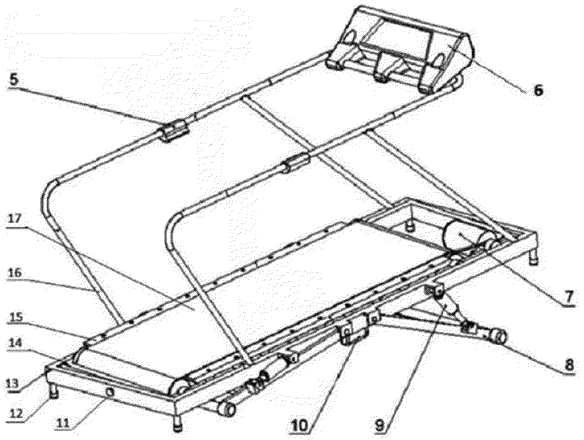

Fig. 3

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Description

FIELD OF THE INVENTION

[0001] The real invention refers to training equipment made for musculature or joints development and strength with the help of exercises of overcoming the counteracting force with or without measuring instruments; to a person's movements in a virtual reality modeling system.

BACKGROUND

[0002] The prior art is known to the patent application of Google, which is based on the robotic Shoe which includes computers and peripheral communication device and the user's positioning to minimize the required space to move around in virtual worlds (EN 20180326286 from 15.11.2018 g).

[0003] The treadmill also known according to the patent KR100483857B1 is connected to the virtual reality system, the patent is selected as a prototype for the device and for the method.

[0004] The disadvantages of the known technical solutions are limited to the speed of the user, and the inability to take into account the changing topography of the virtual space, and respectively transfer the curvature of the terrain to change the load on the muscles of the user. In addition, there is no system of correction of the position of the user in the process of training.

SUMMARY OF THE INVENTION

[0005] The problem to be solved by the claimed invention is the creation of a treadmill with an integrated virtual reality complex visualization in its control circuit, any user's movement is not limited by the dimensions of the room in which the simulator is put.

[0006] The technical result of the device is the possibility of modeling the process of more effective trainings on the treadmill through the creation of trails of any complexity and length, providing a full immersive effect in the virtual world in the conditions of limited space available for training.

[0007] The technical result is achieved due to the fact that treadmill with a virtual reality system, containing a running track, a computing device that renders virtual reality, control system, and is characterized in that the treadmill has at least two degrees of freedom includes a vertical drive channel and the drive channel of the roll, the treadmill is executed with possibility of change of the slope in the longitudinal and in the transverse direction depending on the topography of virtual reality, due to the fact, as the control signals, the voltage applied to the front or rear pair of pushing actuators of the vertical channel if the terrain in the virtual model changes in elevations, while the force on the actuators cause a rotation of the support levers, whereby the external force frame raises the front or rear of his unit, and the control signals include a power relay in the circuit of the roll and the voltage is applied simultaneously, but with reverse polarity on the right and left actuators of a channel Bank, which leads to a rotation of the inner movable frame, if the virtual model of the landscape changes in surface curvature in the transverse direction.

[0008] Also the technical result is achieved by the method of simulation of movement in virtual reality in the course of employment of a treadmill, choosing one of the preconfigured driving modes and a virtual model; after the execution of a virtual model, keeping track of the user's position that is initially in the Central part of the fabric of the treadmill; in the process of implementing virtual model change the angle of the power of the machine frame in the longitudinal and transverse directions in accordance with the changing topography of the alignment of the virtual model; while continuously tracking a location of the user in a specified terminal area in the center of the machine and in the event of displacement of the user outside of this zone, change the angles of the load frame and rotates the movable frame and, if necessary, change the speed of movement of the fabric in such a way that, in coordination with the virtual model, lead the user to a specified terminal area; after the correction, the control system returns the position of a cloth of a track in accordance with the topography of the virtual model.

[0009] Positioning system can be built using different sensors and feedback canals. Terrain reading from a virtual model is based on a computing device generating data arrays from the underlying surface elevation field, which can be built, for example, based on photogrammetry data and providing visualization of a three-dimensional model of the world, for example, through virtual reality glasses.

[0010] This problem can be solved due to the fact that the invention allows to move the underlying surface, associated with the three-dimensional virtual track to meet the user's movement, given its spatial position and orientation relative to the center of the treadmill. Forced artificial offset is used in order to eliminate contact with mechanical elements, defining the physical boundaries of the simulator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention is illustrated by drawings:

Fig. 1 - location of the user on a treadmill;

Fig. 2 - model of the virtual world;

Fig. 3 - design of a treadmill;

Fig. 4 - node drives channel Bank;

Fig. 5 is a logical diagram of the operation of the positioning system;

Fig. 6 - functional diagram of a control system for the simulator.

DETAILED DESCRIPTION OF THE INVENTION

[0012] The device of the treadmill is shown in Fig. 3, is a power frame 13, which in the initial state rests on the floor of the gym with the help of four legs 12, having hinged heel with a rubber sole. To the side (long) profiles of the frame 13 are attached to the rails 16, placed on them by position sensors 5, and the front part of the rails mounted display control 6.

[0013] On the outer sides of the lateral profiles of the frame 13 are the attachment points of the actuators of the vertical channel 9 and the housing of the drive channel roll 10. Also, the Central part of the lateral profiles are equipped with lugs for mounting the movable bearings 8, on the lower parts of which there are supportive rollers.

[0014] On the front and rear (short) profiles of the frame 13 there are supportive bearings for mounting the axles 11 through which to force the frame 13 is fixed a movable frame 14. On the movable frame also the traction motor 7 is placed, which via a toothed belt drives the leading roller, moving the canvas of the treadmill 17. For loads from the user to the top of the movable frame 14 is attached to the underlying sheet high strength chipboard 15 through which the canvas 17 slides.

[0015] In the inner cavities of the side profiles of the frame 13 which have a U-shaped cross section, there are the mechanisms used to control the movement of the movable frame 14. The right mechanism is shown in Fig.4. It includes a drive channel roll 10 consisting of a motor and a worm gear. The output element of the gearbox via a spur gear is connected with the shaft 18, forming part of a ball screw transmission, with the longitudinal floating elements made in the form of two sliders 19. Guides for the slides are the inner surface of the U-shaped profiles of the power frame 13. On the ends of the two slides there are the axles with the rollers 20 on them. The rollers 20 are moving on the sides of the positions of the cams 21 which are rigidly fixed on the side surface of the moving frame 14. Such mechanisms are located on both sides of the treadmill, which increases the rigidity of the whole structure.

Implementation of the invention. The mechanism works as follows.

[0016] In accordance with the logic indicated in Fig. 5, the user being on the canvas of the treadmill, selects the desired route and the driving mode using the interface functions on the touch screen. Next, as shown in Fig. 1. the user stands in the center of the terminal area 3 of the treadmill, puts it on flat zone 1 and VR 2. Further, the user using the command interface on the display 4 touch display 6 activate the system of active positioning, using sensors 5 the process of tracking the user's position in the Central part of the canvas in terminal areas 3 of the treadmill begins.

[0017] Using voice interface which is built into the control unit, the user launches the virtual model of the selected tracks and gets a desirable three-dimensional image in his virtual reality glasses as shown in Fig. 1.

[0018] Virtual world models stocked in the memory of the control unit or downloaded independently by the user made to improve the realism and enhance the effect of exercise (due to changing loads on the leg muscles when driving up a slope) may have routes with varying terrain. This change in the relief is in the form of two arrays of data: the elevations from sea level (the inclination in the longitudinal direction) and the curvature of the surface (the inclination in the transverse direction) can be dynamically read. These digital data as discrete parameters in each moment of time will form work instructions for the PDC of the mechanical part of the simulator in two relevant channels: a vertical channel and a channel Bank.

[0019] In the process of implementing a virtual model work instructions converted in the main controller into the control signals will flow to the power relay circuit in the mechanical part of the simulator which is shown in Fig. 3. The controlling signals, opening the relay will supply voltage to the front or rear pair of pushing actuators (linear actuators) of a vertical channel 9, if the terrain in the virtual model changes in elevations. The efforts on the actuators 9 will cause the rotation of the support levers 8. Due to these efforts of the external power frame 11 (or the simulator in General) will raise the front or rear of your part at a maximum angle relative to the floor surface $\pm 15°$, which would correspond to the maximum possible slope of the slope of the virtual route in the longitudinal direction.

[0020] If the virtual model of the landscape changes along the curvature of the surface (in the lateral direction in Fig. 2), the control signals will include power relays in the circuit of the roll and the voltage will be supplied at the same time, but with reverse polarity on the right and left actuators of the channel Bank 10, which as well as drives a vertical channel are secured to the outer frame 13 of the power simulator. These drives represent a traction motor with reduction gearbox, the output shaft of which is made in the form of high aspect ratio screw 18 in Fig. 4. On the output shaft (on the edge of its threaded section) there is a pair of slides 19 having an internally threaded hole and the side surface of each slide includes a shaft with the roller in a needle bearing 20. When the output shaft rotates, the slider 19 will move along its own rails inside of the outer frame 13, and their rollers will run in the grooves on the profile of the corresponding Cams 21, which are rigidly fixed on the lateral surface of the inner movable frame of the machine. By moving the sliders the rotation of the inner movable frame of the exerciser will be realized in Fig. 3 the maximum roll angles of $\pm 3°$ around the axle 11. This rotation will correspond to the maximum possible change in the curvature of the virtual road in a sideways direction.

[0021] Thus, the bidirectional change of the virtual ter-

rain will lead to an actual change in the spatial position of the treadmill relative to the floor of the gym. Due to this, there will be full compliance with the real changes of load on muscles train to training on difficult terrain.

[0022] Moreover, unlike existing simulators with variable position of the treadmill, and these simulators only allow you to change the track position only in the longitudinal direction and only the positive angles, the proposed solution provides a change in the position of the treadmill in two planes in positive and negative angles.

[0023] To eliminate the offset of the user in the process of training beyond the terminal zone of the treadmill 3 Fig. 1 caused by the effects of immersion in virtual reality, i.e. the user has no visual perception of physical space and to compensate the mobility of the running surface in two planes, the simulator provides an active positioning system of the user. Its work includes continuous monitoring of the presence of a user in a specified terminal area in the middle of the simulator. The algorithm of the positioning system is described in the schematic diagram of Fig. 5.

[0024] In the case of displacement of the user beyond the terminal area, the sensors 5 in Fig. 1 with their active interaction with markers on the touch zone 1 signals are formed errors which are sent on the restraint system as the major ones, the restraint system is shown in Fig. 6 in the main controller. These signals are summed with the operating commands to the controller from the generator of the terrain and generate main control signals to the actuators of the vertical channel and channel Bank, causing them to change the angles of inclination of the treadmill. The actual spatial position of the treadmill in the form of feedback signals are also transmitted to the controller.

[0025] In the case of failure of the correction due to the change of the angles of inclination of the treadmill the speed correction is provided by entering the same correction signals to the traction motor, causing it to spin faster or slower depending on the offset of the user backward or forward relative to the center of the simulator, respectively.

[0026] All of these corrective signals, in coordination with a relief three-dimensional model, but often in the opposite direction, have to move the user to a specified terminal area in the case of withdrawal.

[0027] After the correction, that is, the user's return to the center terminal of a zone, the signals from the correction unit must take zero values, and work crews coming into the controller will have to ensure that the spatial position of the treadmill terrain the virtual model to the next time a user leaves the terminal area.

[0028] During the workout, if the user realizes that he is clearly ahead of or lags behind the speed of the treadmill, a standard set of voice control commands via the voice interface for contactless control of the track is provided.

[0029] After performing the virtual model of the treadmill should gradually stop providing the constant presence of the user in the center of the terminal area.

[0030] For the front and rear boundaries of treadmill, if necessary, a retractable blind can be attached, which will be nominated immediately after starting jogging and working together with handrails will be able to delete the user fall outside of the canvas.

Claims

1. A treadmill with a virtual reality system, comprising a running track, a computing device that provides visualization of virtual reality, a control system, wherein the running track has at least two degrees of freedom, includes a vertical channel drive and a roll drive, while the running track is capable of slope changes both in longitudinal and in transverse direction, depending on a terrain in a virtual model, due to the fact that control signals supply voltage to a front or rear pair of pushing vertical channel drives when the terrain in the virtual route changes in elevation, while efforts on the pushing vertical channel drives cause rotation of support levers, whereby an external force frame raises its front or rear part, and the control signals include power relays in a roll circuit, and voltage is supplied simultaneously, but with reverse polarity to right and left roll drives, which leads to rotation of an inner movable frame when the terrain in the virtual model changes along surface curvature in the transverse direction.

2. A method for simulating a movement in a virtual reality during training on a treadmill, comprising the following stages:

   choosing one of preconfigured driving modes and a virtual model;
   tracking a position of a user after starting an implementation of the virtual model, wherein the user is located initially in in a terminal zone disposed in central part of a belt of a running track;
   changing angles of a power frame of the treadmill during implementation of the virtual model in the longitudinal and transverse directions in accordance with changes in terrain in the virtual model;
   in a case of user displacement outside the terminal zone, changing an angle of inclination of the power frame and rotating a movable frame, and, if necessary, changing speed of movement of the belt in such a way that, in accordance with the virtual model, to bring the user back to the terminal zone;
   after the changes in the previous stage, the control system returning positions of the power frame and the belt in accordance with the terrain in the virtual model.

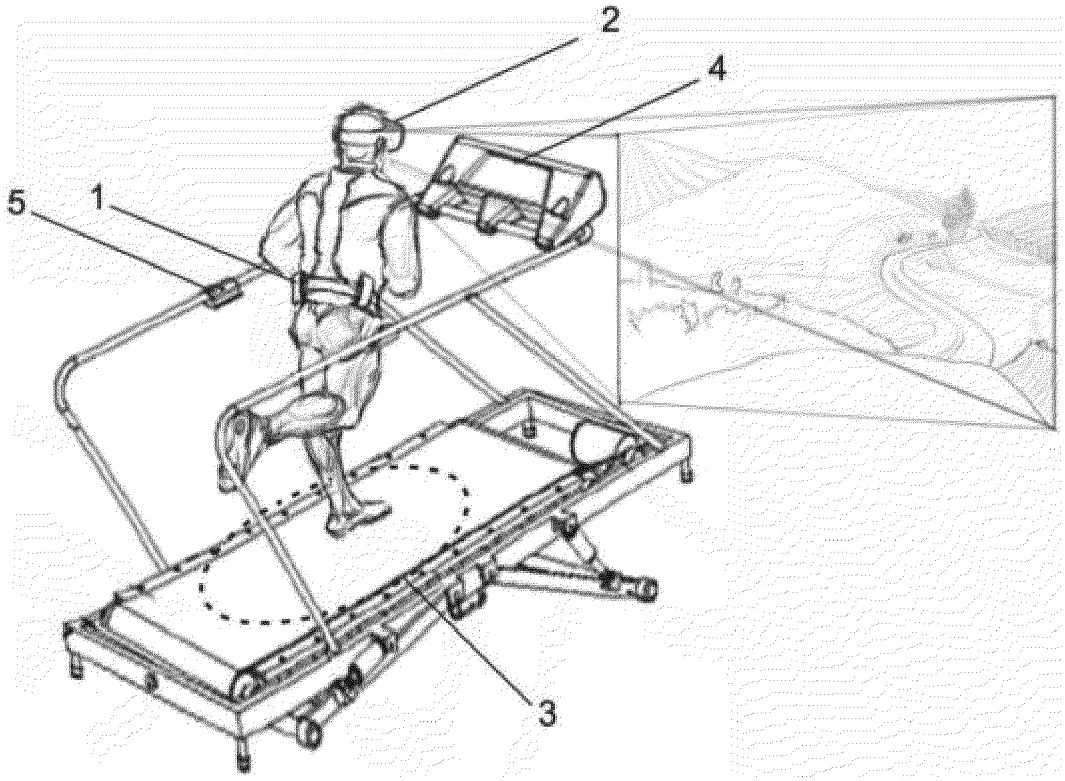

Fig. 1

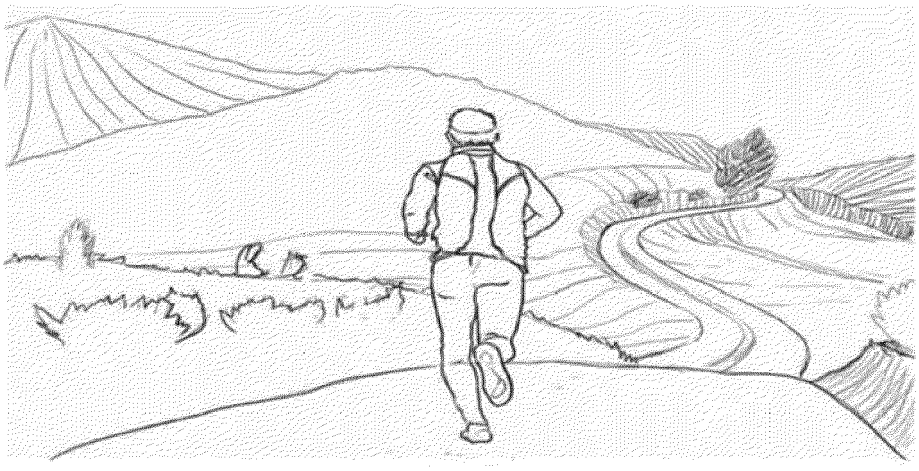

Fig. 2

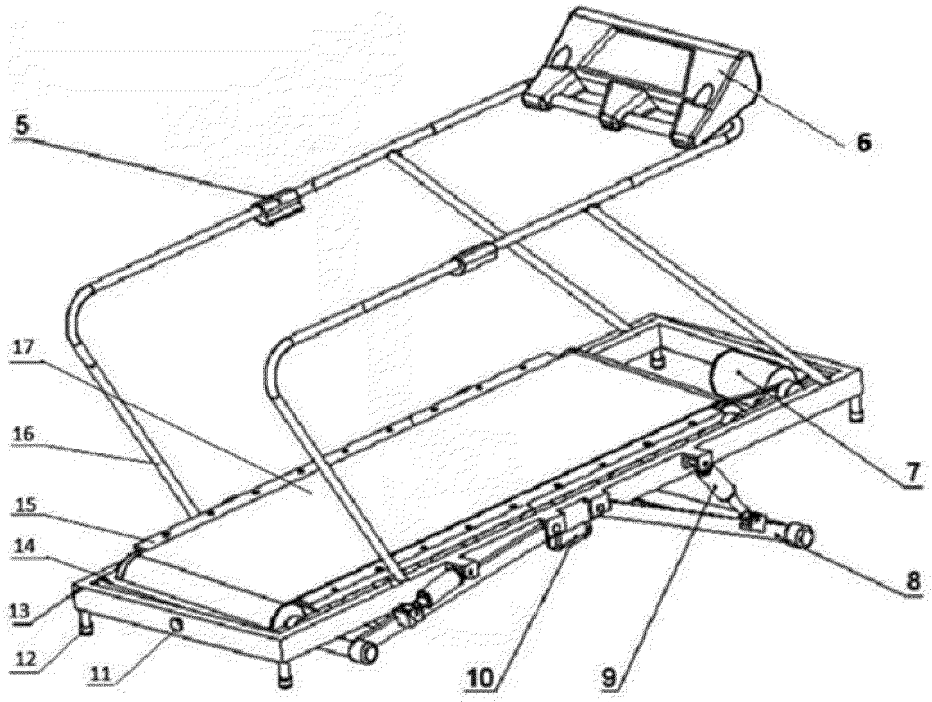

Fig. 3

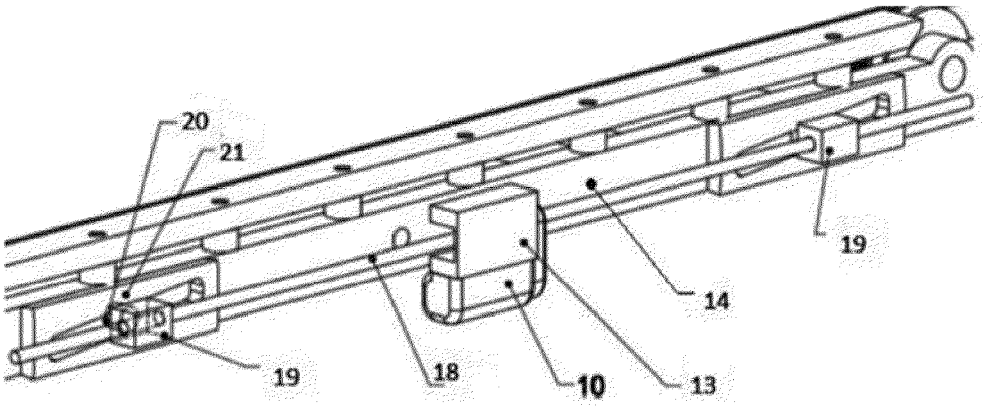

Fig. 4

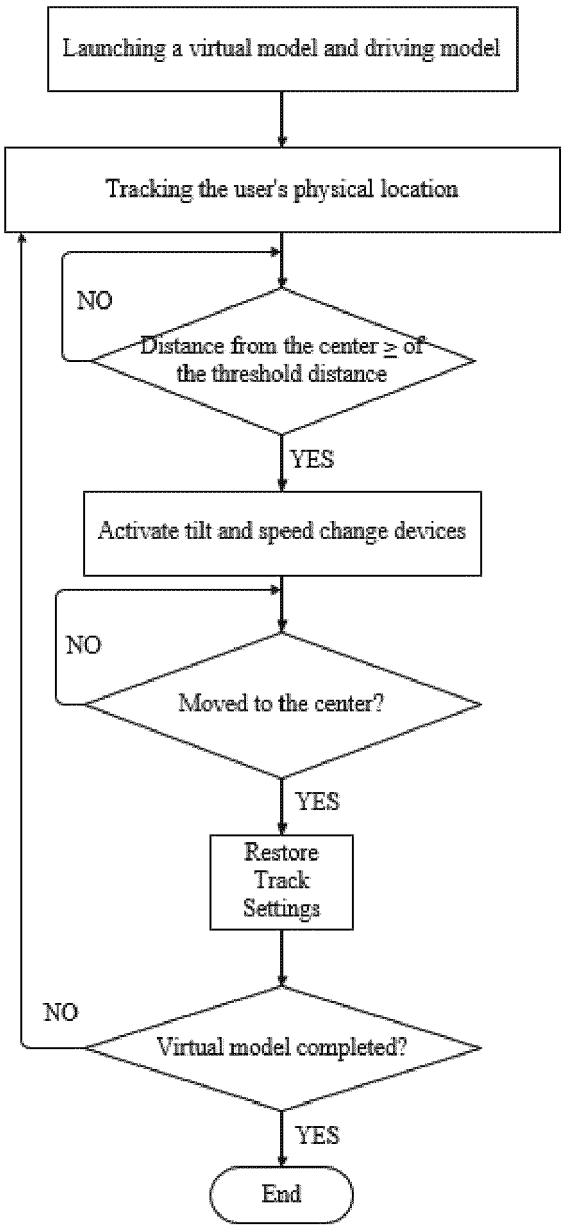
Launching a virtual model and driving model
Tracking the user's physical location
NO
Distance from the center ≥ of the threshold distance
YES
Activate tilt and speed change devices
NO
Moved to the center?
YES
Restore Track Settings
NO
Virtual model completed?
YES
End

Fig. 5

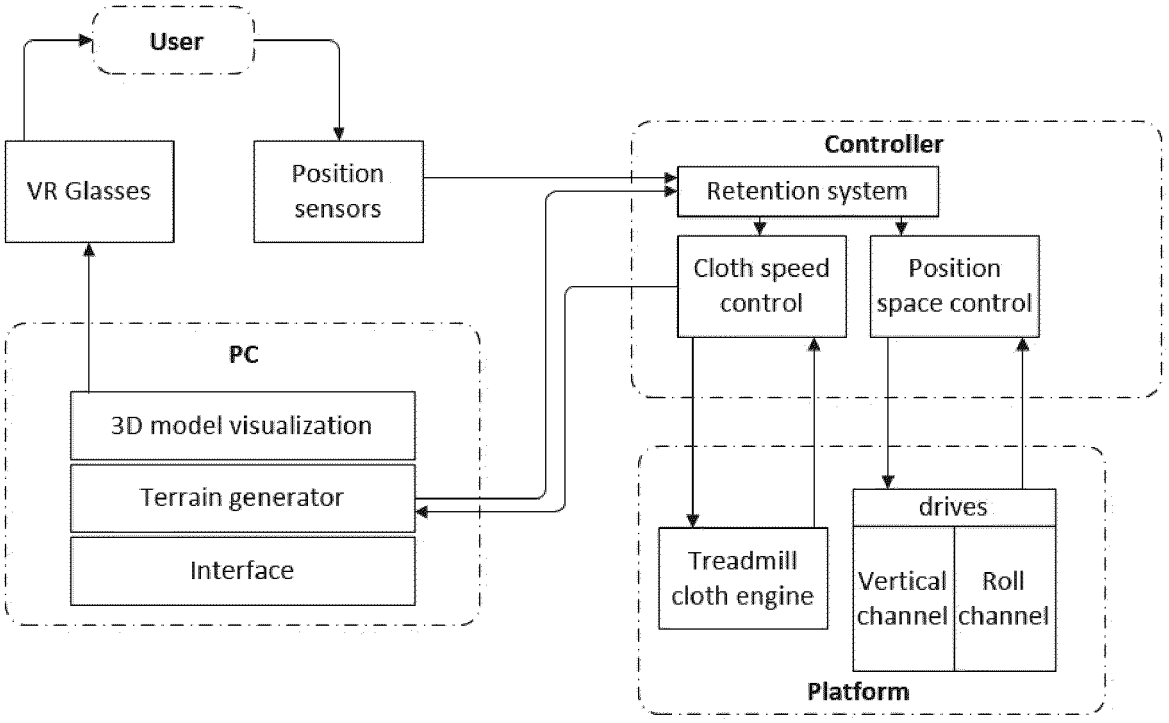
User
VR Glasses
Position sensors
Controller
Retention system
Cloth speed control
Position space control
PC
3D model visualization
Terrain generator
Interface
drives
Treadmill cloth engine
Vertical channel
Roll channel
Platform

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 20 15 6588

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	US 2007/270285 A1 (GILL JAMES G [US] ET AL) 22 November 2007 (2007-11-22) * paragraph [0016]; figures * * paragraph [0034] - paragraph [0036] *	1,2	
X	US 2010/304931 A1 (STUMPF JOHN F [US]) 2 December 2010 (2010-12-02) * paragraph [0009] * * paragraph [0035] * * paragraph [0039]; figures *	2	
A	US 9 586 090 B2 (ICON HEALTH & FITNESS INC [US]) 7 March 2017 (2017-03-07) * column 7, lines 10-20; figures *	1	TECHNICAL FIELDS SEARCHED (IPC) A63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 June 2020	Squeri, Michele

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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17-06-2020

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